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A Comparative Study of Elementary Mathematics Specialists and Mathematics Coaches on Fourth Grade Students' Mathematics Achievement

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COLLEGE OF EDUCATION

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2017

Abstract

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M.Ed., Ashland University, 2006

B.A., Wittenberg University, 2001

Doctoral Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Teacher Leadership

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Federal dollars are utilized to develop instructional programs for students not demonstrating mathematical proficiency on state standardized mathematics assessments, but there is a lack of empirical data on the effectiveness of two different approaches that were used in the local context. The purpose of this quantitative, nonexperimental, casual-comparative study was to determine if state achievement test scores of students in fourth grade who received instruction from a Mathematics Specialist (MS) during the 2007–2009 academic years demonstrated a statistically significant difference from the mathematics state achievement test scores of fourth grade students who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach (MC) during the 2012–2014 academic years. The theoretical base includes two components: National Council of Teachers of Mathematics Standards and Federal No Child Left Behind educational policy, which focus on standards-based education, curriculum, assessment, and instruction to meet students' mathematical needs. Data was collected from a census sample of 13,671 students' state scores from school years 2007–2008, 2008–2009 (MS) and 2012–2013, 2013–2014 (MC). The research question was whether there is a difference in MS and MC scores? An independent samples *t* test was used to compare the means of all the scores. The results show that the MS program produced statistically higher math scores than the MC. This supports the limited literature in favor of MS. Positive social change includes supporting increasing the use of the MS program in the local context to increase mathematics test scores and the potential for redistribution of federal funds to develop MS programs nationwide.

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Dedication

I cried. You listened. I prayed. You supported. I dedicate this dissertation to ***all*** the angels that God has blessed me with while on this transformative journey. I thank you for believing in me and pushing me to work past my own expectations.

Acknowledgments

“Being confident of this very thing, that he which hath begun a good work in you will perform it until the day of Jesus Christ. He will finish what He has started”.

~Philippians 1:6

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Section 1: The Problem

Introduction to the Study

The school district in this investigation, like many in the United States, has been trying ideas for improving elementary mathematics instruction. Two methods, the Math Specialist (MS) and the Math Coach (MC), have been implemented. During the 2006 - 2007 school year, in an effort to improve mathematics teaching and learning in a large urban school district in the mid-west, the curriculum department staff chose to implement the Math Science Leadership Specialist (MS) program at the elementary and secondary level during the 2007–2008 academic year. The MS meant that one highly qualified teacher would rotate to teach the math and science for all of the fourth and fifth grade students in the building. One hundred and forty-five MS were assigned to the 74 elementary schools to support mathematics instruction.

Because of tightening budgets, the MS positions were eliminated after the 2011–2012 school year and the teaching of math and science was returned to the classroom teachers. During the start of the 2012–2013 academic year, the curriculum department staff decided to change directions and implement MC at the elementary level. This meant that the MS teachers would no longer provide mathematics instruction for students. Instead, these coaches would collaborate, plan, and coteach with other teachers. Part of this job would be supporting curriculum and pedagogical concerns in preparation for the implementation of the Common Core State Standards (Math Coach Draft, 2011). The MS and MC models have a variety of benefits and drawbacks but the essential question of which one delivered better student learning is just now being asked with this study.

There is a national consensus that the current state of mathematics is unacceptable and mathematics instruction must improve (Elementary Mathematics Specialists & Teacher Leaders Project, 2015; Fennel, 2011; Trends in International Mathematics and Science Study; 2011). Teacher leaders are being called upon to fill specialized mathematics-related positions, which require specific sets of knowledge and skills (McGatha, 2009; Reys & Fennell, 2003). The district adopted two math reform models: The MS and MC. However, the problem is that the effectiveness of these models have not been explored to determine which model, if any, had a greater impact on improving elementary students' mathematical knowledge as measured by standardized tests. This study compared fourth-grade student test scores under each of these methods, the MS and MC.

This section relays evidence of the local problem, the nature of the problem, the purpose of the study, the framework guiding the study, operational definitions, assumptions, significance of the study, and a summary of the results to determine which models of enhancing mathematics instruction that have been tried in this district, is associated with higher standardized test scores. More detailed discussions on the literature of the mathematics reform, MS and MC reform models, proposed methodology, the results and analysis for the data collection, interpretation of the findings, implications for social change, and recommendations are presented.

The Problem

No Child Left Behind (NCLB) Act of 2001 requirements placed even greater urgency to have all students perform on grade level by 2014 (U.S. Department of Education, 2002; Wong, K., 2003). The problem not only affected underperforming students, but also impacted teacher accountability for student performance on the district assessments. In the district of this study, students identified the need for extensive remediation in mathematics. Past test results for the district under study for years 2001–2005 indicated poor performance in mathematics, especially at the primary level. If math achievement outcomes are not increased at the elementary level, as evidenced by proficiency scores, math deficiency will continue as these students matriculate to the next grades.

In response to the critical deficiency in mathematics, the district implemented two math-instructional models: MS and MC. The goal of the district was to increase mathematical understanding of students through the implementation of content specialists for students (MS) and content specialists for teachers (MC). There should be a direct correlation between teacher expertise, practice, and student performance in order to increase student achievement. Fullan and Levin (2009) described a need to develop and implement instructional practices that are linked to results.

The problem this study addresses is that no one knows if the MS or the MC are associated with higher standardized test scores for fourth grade students as a result of the implemented instructional model. As the district moves forward with dismal mathematic proficiency scores (see Tables 1 & 2), it is prudent to evaluate the past performance under the two different forms of mathematics education enhancement: MS and MC. Administrators are going to have to decide what is next for this district, but they have not examined the State Mathematics Achievement testing data to gain insight into the effectiveness of the MS or the MC programs that were in place from 2007–2014. This creates a potential gap in determining the effectiveness of these specialized programs designed to increase student achievement in elementary mathematics. The independent variable, the mathematics models, is the two conditions of MS and MC is measured at the nominal level. The dependent variable is the student State Mathematics Achievement Test scores measured at the interval scale level.

The Teaching Methods

The National Mathematics Advisory Panel (2008) reported that elementary mathematics specialists are essential to modern schools. This is because a technology rich society requires student opportunities to learn essential concepts and procedures with understanding (Ohio Department of Education, 2004; National Council of Teachers of Mathematics, 2000). Teachers must create an environment where students are trusted to solve problems and work together using their ideas in a student-centered, not teacher-centered, approach to learning (National Council of Teachers of Mathematics, 2000; Van de Walle & Lovin, 2006). There are two common models for this: the math specialist for students and the math coach for teachers. This school district has used both.

The math specialist model (2007-2009). The MS program retained two generalist teachers for literacy, social studies, and writing and a mathematics specialist for each grade level. Students rotated daily with a generalist for half a day and an MS teacher for half of the day. Students received 55 minutes of mathematics instruction and 25 minutes of science instruction during the 80 minutes block. The groups then switched for the second 80 minutes block.

The goals for the MS program at the start of the 2007 school year were to provide professional development to support MS teachers to create experts in their content area (Mathematics and Science Leadership Specialist Draft, 2007). In alignment with program goals, specialists' predominately served to improve science and math test scores, collaborate with other educators, and engage in professional development all to improve student achievement. The MS provided direct math instruction to students.

The mathematics coaching model (2012 – 2014). The federally grant-funded MC position provides support for the entire school staff in the areas of curriculum, professional development, instructional teaching support, implementation of Professional Learning Communities, and assessment leadership. The responsibilities of the MC were divided into three components: Curriculum, Instructional Teacher Support, and Professional Development and Leadership (Math Coach Draft, 2011). The MC did not provide direct instruction to students. Instead, the focus was to serve as an expert content coach for the classroom teacher.

Summary. The previous sections have documented that past test results for the district under investigation indicated poor performance of fourth grade students in mathematics on state achievement assessments. In response, the district implemented two math-instructional models: MS and MC. The goal of these models was to improve mathematical understanding of students and instructional practices so that student achievement in mathematics might improve. The primary difference is that MS had a designated teacher for math and MC had a single expert coaching several regular classroom teachers. The next section provides evidence that mathematics test scores are a problem for the district under study.

Evidence of the Problem

The numbers. At the district of study, students did not meet grade level expectations as determined by the State Mathematics Achievement Test. The intent of the district was to increase the mathematical skills of students through the implementation of two specialized models: Math Specialist and Math Coach. The problem of not knowing which of the two instructional models for mathematics may have resulted in higher achievement scores to narrow the achievement gap is especially important, as 2011 Race to the Top funding opportunities have requested grant applications (US Department of Education, 2011). When applying for a new program, it is helpful to document the success and failures of past programs. The testing evidence for the local problem is essential to the study and thus is displayed in great detail in the following sections. These include an explanation of the numbers per test scores for students, the district level data supporting the problem statement, and importantly the historical data that provides the backdrop for the years that this study covers as illustrated in Table 1 below. Despite the various name changes over the years (Proficiency Test, Achievement Test, Achievement Assessment, PARCC, and AIR), all are standardized tests meeting NCLB requirements that redefine what students need to know and how their knowledge should be tested. See next page for Table 1.

Table 1

Elementary School District Grade 4 Mathematics Student Achievement-Historic Data Percent Proficient Scores

Proficiency Tests	2001-2002	39.9%
	2002- 2003	37.5%
	2003- 2004	43.8%
	2004- 2005	50.0%
	2005 – 2006	52.9%
Achievement Test	2006- 2007	61.9%
Math Specialist Program	2007-2008	61.5%
	2008-2009	62.8%
	2009- 2010	57.8%
	2010 – 2011	58.2%
	2011 – 2012	55.6%
Achievement Assessment	2012 – 2013	49.4%
Math Coach Program	2013- 2014	51.2%
PARCC Assessment	2014 – 2015	40.3%
AIR Assessment	2015 – 2016	No Data
Math Coach Optional		

Data retrieved 3/25/16 from
http://reportcard.education.ohio.gov/Pages/District-Report.aspx?DistrictIRN=043802
Note: Shaded areas are those compared in this study. Partnership for Assessment of Readiness for College and Careers (PARCC)
Association for Institutional Research (AIR)

Table 2

State Proficiency Test Grade 4 Mathematics State and District Proficient Percentages

2001-2002		2002-2003		2003-2004		2004-2005	
ST	DI	ST	DI	ST	DI	ST	DI
62.9	39.9	58.6	37.5	58	43.8	66	50

Note. ST= State and DI = District
Data retrieved 11/25/11 from http://ilrc.ode.state.oh.us/Downloads.asp

Table 3

State Achievement Test Grade 4 Mathematics State and District Proficient Percentages

2005-2006		2006-2007		2007-2008		2008-2009		2009-2010	
ST	DI	ST	DI	ST	DI	ST	DI	ST	DI
76.9	52.9	75.9	61.9	74.6	61.5	78.4	62.8	76.2	57.8

Note. ST= State and DI = District
Data retrieved 11/25/11 from http://ilrc.ode.state.oh.us/Downloads.asp

The purpose of the above tables is to highlight the format change in testing from Table 2 proficiency test to Table 3 achievement tests. It appears that the new tests were easier to attain proficient scores as the jump was almost 3 points from 50 to 52.9. Then, as commonly follows when students and teachers are more familiar with the test, there was another increase that lasted for three years where the scores were about 62% proficient. The unfortunate reality is that scores were all below the state requirement of 75%, which suggest a need for improvement in the area of mathematics. And failure to meet Annual Yearly Progress (AYP) targets has increased the need of this district, requiring technical assistance from the state, as mandated by NCLB (Center of Education Policy, 2009).

The question remains unanswered of what model provides effective instructional strategies better for raising standardized test scores in this district: the Specialist or the

Coach. The State Mathematics Achievement Test was the sole test used when both the Specialist and Coach programs were in place (See Table 1). The State Mathematics Achievement Test scores for the first 2 years of each instructional method will be compared in this study. This is so that the stage of the methods are comparable, both being at the beginning stages. The State Mathematics Achievement Test scores of fourth grade students during the Math Specialists 2007–2009 and the Math Coach 2012–2014 will be compared for each elementary school and across the district.

Evidence of the problem at the district level is measured by weakness in mathematics performance on annual state measures. The statistics are worse for the district this study focuses on as they only met four out of 26 state standards and had a designation of *Continuation Improvement.* Results from the 2011–2012 State Report Card revealed that 56.1% of third graders, 56.1% of fourth graders, 40.9% of fifth graders, 58.0% of sixth graders, 50.0% of seventh graders, 54.4% of eighth graders, and 64.7% of 10th grade students met or exceeded all performance standards in the area of mathematics. The four standards met were based on the analyses of state indicators, performance index, AYP, and Value-Added (ODE, 2011). The data used to create ratings include (StateImpact, n.d):

- The percentage of students passing state tests;
- How well students score on state tests;
- For elementary and middle schools, a calculation showing how much progress students made in a particular school year;
- Attendance rates;
- High school graduation rates; and

- Whether or not the school or district meets federal standards. (Referred to as AYP and include reading and math test passing rates and test participation, attendance and graduation rates.

Table 4 provides an overview of the percentage of students at or above proficient level on the mathematics portion of the State Mathematics and Graduation Tests *after* the transition from proficiency testing to achievement testing.

Table 4

Percentage of Students At or Above Proficient Level in the State of Ohio

	2004–2005		2005–2006	
	ST	D	ST	D
3rd Grade	70.4%	48.0%	74.9%	53.2%
4th Grade	65.5%	50.0%	76.9%	52.9%
5th Grade	Not Assessed	Not Assessed	62.7%	38.5%
6th Grade	62.5%	41.7%	68.4%	40.4%
7th Grade	58.5%	31.8%	63.2%	40.7%
8th Grade	60.1%	33.0%	68.6%	43.2%
10th Grade	81.6%	67.5%	82.7%	72.3%

Note. ST = State, DI = District.
Data retrieved 11/25/11 from http://ilrc.ode.state.oh.us/Downloads.asp

In an era of stringent accountability measures, student learning and ultimately school performance are measured using high-stakes assessments. Schools are confronted with a difficult charge to not only improve mathematics education for all students, but to also produce students that achieve proficient scores on state-mandated assessments (Olsen, L., 1999). These mandates have made it critical for schools to collect evidence that the implemented mathematics program is effective for the continued growth efforts that support the mathematical expertise of elementary school staff and student academic achievement.

Nature of the Study

The data for this quantitative, nonexperimental, casual-comparative study were collected from an analysis of standardized test scores in the area of mathematics for fourth grade students in 74 elementary schools with Mathematics Specialists and Mathematics Coaches. A casual-comparative design was selected as an appropriate method to determine if differences in scores exist between independent and dependent variables after the events have already occurred (Brewer & Kuhn, 2010). Data using descriptive and inferential statistical methods were analyzed. The 2 years of MS data (2007–2009) and the 2 years of Math Coach data (2012–2014) were combined together. An independent samples *t*-test was conducted to determine if there is a significant difference in mathematics achievement outcomes among fourth grade students, as measured by the State Mathematics Achievement Test, who received instruction from a Math Specialists during the 2007–2008, 2008–2009 school years and fourth grade students who received instruction from Grades 1-8 credential teachers supported by a Math Coach during the 2012–2013, 2013–2014 school years. The archival data will come from the Ohio Department of Education (ODE, 2007–2008, 2008–2009, 2012–2013, 2013–2014) through the Office of Accountability.

Research Questions

The research question examined in this study specifically addressed the State Mathematics Achievement Test scores of students in fourth grade. To compare the mathematics student achievement outcomes of fourth grade students, the following research question and hypotheses will guide this study:

Research Question 1: Is there a significant difference in fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, between students who received instruction from a Math Specialists (2007–2009) and Grades 1-8 credentialed teachers supported by a Math Coach (2012–2014)?

$H_0 1$**:** There is no statistically significant difference between fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, in students who received instruction from a Math Specialists and those who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach.

$H_a 1$**:** There is a statistically significant difference between fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, in students who received instruction from a Math Specialists and Grades 1-8 credentialed teachers supported by a Math Coach.

Purpose of the Study

The purpose of this quantitative, nonexperimental, casual-comparative study was to determine whether there was a significant difference between standardized State Mathematics Achievement Test scores of students in fourth grade who received instruction from a Math Specialists during the 2007–2008, 2008–2009 academic years and fourth grade students who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach during the 2012–2013, 2013–2014 academic years. The independent variable of this study was the type of mathematics program used, either MS or MC. The dependent variable was the students' fourth grade test scores on the State Mathematics Achievement Test. The focus was on student mathematics achievement at the fourth grade level after the MS instructional program was implemented for 5 years and the MC for 2 years. Student achievement outcomes were collected and statistically analyzed from the State Department of Education website to determine if there were significant differences in mathematics achievement outcomes among the instructional programs. The school report card data is publicly accessible for all school buildings in the district. Understanding the difference in scores between both programs can help the district in its goal of improving student achievement in mathematics. Furthermore, as states and school districts develop professional improvement models using federally funded dollars, this study can deepen our understanding of how teachers' capacities and dispositions can impact the success of large-scale reform programs (Lieberman & Miller, 2001).

Theoretical Framework

The present study is based on two integrated theoretical frameworks. The frameworks include the role of the NCTM academic content standards and the Federal NCLB accountability movement. The primary focus was the theory of standards-based education, curriculum, assessment, and instruction in meeting the mathematical needs of students.

The guiding framework of The NCTM (2000): that learning mathematics with higher-order understanding can produce more desirable outcomes than repetitive drilling typically observed at the elementary level. Under this standards-based conceptual framework, both the MS and the MC models heavily focused on more meaningful and problem-based instructional practices to lay the foundation for mathematics teaching and learning (NCTM, 2000). To reiterate, both of the models are based upon the NCTM standards and differ only in terms of cost and 1:1 student contact with a highly qualified mathematics teacher (Math and Science Leadership Specialist Draft, 2007; Math Coach Draft, 2011). The MS is more costly and provides the 1:1 contact and the MC is low cost with no student contact but rather serving to improve the math teaching of regular classroom teachers (Markworth, Brobst, Ohana, & Parker, 2016).

In 2010, NCTM presented a comprehensive mathematics reform movement to improve mathematics instruction (NCTM, 2010). During this same year, the new Common Core State Standards (CCSS) were published (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Mandates were still in place requiring the use of research-based instructional practices, with a focus to improve the academic achievement of students (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). The objective of the reform was to analyze the instructional practices of math teachers from a technical structure with a more reflective practice (NCTM, 2010). After some years, the NCTM (2010) connected the practice of teaching math with research. Instructional practices have become more reflective to provide students with the opportunity to conceptualize math content standards at a greater level.

The NCTM Standards are organized around the five content and process standards (detailed in Section 2), the two sets of standards outlined the mathematical topics that should be taught at the elementary (K-4), intermediate (5-8), and secondary (9-12) level (NCTM, 2010). It also described the basic skills and understanding that students need in an effort to provide a high quality mathematics experience for all students to increase student achievement (NCTM, 2000). The placement of specialists, of all types, in elementary schools serves as a catalyst for continued improvement of elementary teachers mathematical knowledge and pedagogy, as recommended by the NCTM (2000).

Federal policy. While the district is currently transitioning from NCLB to the Every Student Succeeds Act, the years that the data were collected (2007–2014) and the reasons the methods were tried were because of NCLB. NCLB supported standards-based education and scientifically based research for programs and teaching methods (Beghetto, 2003). In Ohio classrooms, teachers are required to guide instruction based on the Ohio Academic Content Standards in preparation for all statewide student assessments (ODE, 2001). This was the educational framework used in both models to improve mathematics outcomes during the 2007–2014 academic school years.

NCLB educational policy was indisputably the most rigorous accountability system in the United States and during the time of the MS and Coach models (Hursh, 2007). Signed into law on January 8, 2002, this law reauthorized the Elementary and Secondary Education Act of 1965, and brought test-based school accountability measures across the United States (U.S. Department of Education, 2002) changing the culture of America's schools. The purpose of the act was (a) to increase accountability for student performance (i.e. improvement in performance rewarded, failure will be sanctioned), (b) to spend money on what works (i.e. federally recommended effective research-based programs and instructional practices), (c) to increase flexible funding for states and school districts, and (d) to increase parental involvement and empowerment (U.S. Department of Education, 2002). NCLB has become synonymous with high stakes testing even though other components of the law focus on teacher qualifications and professional development (Pinder, K. A., 2010; Redfield, D., & Sheinker, J., 2004; U.S. Department of Education, 2002).

The NCLB legislation is grounded in the commitment to equity and excellence in education (Pinder, K. A., 2010; Redfield, D., & Sheinker, J., 2004; Riley, R., 1998). The goal is that all students regardless of physical or mental challenges, race, socioeconomic status, or English language proficiency are to have an equal and significant opportunity to attain a high-quality public (U.S. Department of Education, 2002; Wong, K., 2003). More specifically, they are proficient in mathematics and reading by 2014 (NCEE Evaluation Brief, 2009; U.S. Department of Education, 2002). According to Popham (2003), the federal legislation of NCLB mandated public schooling in America to focus reform efforts squarely on curriculum development, especially as related to instruction and assessment (Wong, K., 2003).

However, critics of this legislation believe that the provisions in place have narrowed curriculum by de-emphasizing nontested subjects to make more time for mathematics and reading and unintentionally reallocating instructional efforts to focus on test taking strategies (Dee & Jacob, 2010; Jacobs, 2010; Nichols, Glass, & Berliner, 2005; Olsen, L., 1999). This stance toward education of repetitive drill as learning goes against the NCTM research-based teaching standards for mathematics education of learning through rich authentic problem solving. The increased level of complexity with academic learning standards and the shift from rote memorization of isolated facts to more concrete and sophisticated problems and methods to address students' understanding and application of knowledge was the framework used to inform, modify, and enhance instructional practices through the use of aligned standards (Bender, 2005; Brooks & Brooks, 1999; Grouws & Cebulla, 2000; Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000; Jacobs, 2010; National Council for Teachers of Mathematics, 2000). The objective of both reform models is to provide students with a strong foundation for success in mathematics. One model specifically focuses on specialists working directly with students while the other concentrates on supporting elementary teachers by increasing their content knowledge (Fennell, 2011; Fennell, Kobett, & Wray, 2013). The question is, which mathematical model: MS or MC, is better at improving students' mathematics knowledge and performance on state mathematics achievement test scores required by NCLB?

Increasing federal oversight of school test scores and accountability measures, mathematics teaching practices prompted significant action on the part of the state and school district. In 2002, the state of Ohio adopted Academic Content Standards as part of the mathematics reform movements taking place in the United States (Ohio Department of Education, 2001). The connections between a standards-based curriculum, effective student performance, and accountability are evident throughout the research. Marzano (2003) research on school effectiveness indicated that the "development of a guaranteed and viable curriculum provides the greatest impact on student achievement" (p.22).

Newman (2007) realized standards used to guide curriculum and assessment in the United States are to guarantee that all students have an equal chance to acquire important curriculum content. Schmoker (2006; 2009) stated that an ensured, practical, and sustainable curriculum is the single most important precondition for improving schools.

To address federal and statewide accountability measures, the district created the MS model at the elementary and secondary level during the 2007–2008 academic year reflecting NCTM's vision for the implementation of a standards-based mathematics program. Personal communication from the curriculum department staff stated that the MS ended at the conclusion of the 2011–2012 academic school year because of funding, not because of student score outcomes. In 2012, the program was demoted to smaller numbers of teachers who served as MC, who also embraced the vision set forth by the *Standards* and the shift from students' acquiring proficiency in rote memorization of procedural skills to a deeper understanding of developing children's ability to think and reason mathematically (NCTM, 2000). In 2014–2015, the district eliminated the MC positions, and building principals elected to keep this position using Title I building funds. On a global level, test scores appear to continue to remain stagnant with slight gains. As reported on the 2012–2013 District Report Card, fourth grade students had a progress score of positive 1.1 in mathematics (ODE, 2013).

Operational Definitions

The following terms and definitions are used in this study:

Adequate Yearly Progress (AYP): A system of accountability measures established through the No Child Left Behind (NCLB) Act of 2001 (U.S. Department of Education, 2002). AYP is the minimum performance required of schools based on state mandates. AYP requires schools and districts to meet annual goals, with the expectation that all students will be proficient in reading and mathematics by the 2013–2014 school year (U.S. Department of Education, 2002).

Building Principal: Designates a principal, assistant principal, or other individual responsible for the daily instructional leadership and managerial operations in the elementary school or secondary school building (Clifford, & Ross, 2012).

Collaboration: A systematic process in which people work together, interdependently, to analyze and impact professional practice in order to improve individual and collective results (DuFour, DuFour, Eaker, & Many, 2006).

Departmentalized Classroom: An instructor responsible for a specific content area (e.g., mathematics, science, reading, social studies, language arts) who does not serve as a generalist (Chan, Terry, & Bessette, 2009).

District Curriculum Guides, Pacing Guides and Supplemental Lessons: A variety of instructional strategies aligned to state academic content standards, benchmarks, and grade level indicators (Columbus City Schools, n.d).

Elementary Mathematics Specialist (EMS): Teacher leaders responsible for supporting effective pre-K-6 mathematics instruction and student learning (NCTM, 2011).

Math Coach (MC): District created math coach position implemented in 2010–2011, funded through Title I to provide support for the entire school staff in the areas of curriculum, professional development, instructional teaching support, implementation of Professional Learning Communities, and assessment leadership. The MC did not provide direct instruction to students. Instead, the focus was to serve as an expert content coach for the classroom teacher. (Math Coach Draft, 2011).

Math Science Leadership Specialist (MS): District created mathematics and science position implemented in 2007–2008, funded through Title I to support effective mathematics and science instruction, teacher collaboration and professional development (Mathematics and Science Leadership Specialist Draft, 2007). This specialist provided specific instructional and content expertise in mathematics and science, serving as a building leader in mathematics and science instruction. The MS provided direct math instruction to students (Mathematics and Science Leadership Specialist Draft, 2007).

NCLB: The No Child Left Behind Act of 2001, signed into law in 2002 (U.S. Department of Education, 2002). NCLB requires annual testing to measure student progress in reading and mathematics (U.S. Department of Education, 2002). NCLB requires states to hold schools and districts accountable for the achievement of each student group, including the major racial and ethnic groups, low income students, limited English proficient students and students with disabilities (U.S. Department of Education, 2002).

Ohio Academic Content Standards: K-12 curriculum for the state of Ohio (Ohio Department of Education, 2001).

Professional Development: A life-long, collaborative learning process that nourishes the growth of individuals, teams and the school through a daily job-embedded, learner-centered, focused approach (National Staff Development Council, 2000).

Self-Contained Classroom: An elementary classroom led by an instructor who teaches every content area and serves as a generalist (Markworth, Brobst, Ohana, & Parker, 2016).

School Improvement Status (SI): Every school and district must meet AYP goals that are set for reading and mathematics proficiency and test participation, attendance rate and graduation rate (Ohio Department of Education, 2008). Failure to meet any of the proficiency or participation goals, attendance levels or graduation targets for two consecutive years, results in the district or school missing AYP (Ohio Department of Education, 2008).

State Mathematics Achievement Test: A standardized test used in Ohio primary and secondary schools to assess students' knowledge of reading, writing, mathematics, science and social studies skills required under Ohio academic content standards, with administration to students spread out from third to eighth grade (Ohio Department of Education, 2009).

Title I, Part A: Federal money granted to low-income public schools as part of the 1965 Elementary and Secondary Education Act (ESEA) legislations to provide financial assistance to improve school-wide or targeted assistance educational programs (U.S. Department of Education, 2009).

Assumptions

It is assumed that every child can learn if the educational conditions in and around schools are focused on student learning (Achieve, Inc., 2007; Barth, 2001; Danielson, 2006; National Council of Teachers of Mathematics, 2000; Reeves, 2005; Riley, R., 1998; Schmoker, 2006). It was also assumed that having lessons facilitated by a MS, with deep and broad knowledge of mathematics content, aligned to academic content standards, and accountability measures, is an effective method that would enrich instruction and promote continued student growth on standardized assessments and in classroom practices. Another assumptions is that teachers would implement new strategies for teaching mathematics into their classrooms as a result of collaborative planning opportunities with MC. Moreover, assumptions also included that the State Mathematics Achievement Test is a genuine and valid measure of students' understanding of mathematical content and processes standards.

There is an assumption, inherent in causal-comparative designs, that the two groups of people (in this case students) whose test scores are being compared are equivalent (e.g., with respect to ability, SES, prior knowledge, etc.) and that the only difference is that they experienced different instructional/curricular methods. In this study, two different instructional models will be compared: MS and MC. MS provides content and instructional practices for mathematical learners whereas MC provides content and instructional practices for instructional leaders.

Limitations

The state of Ohio consists of 612 school districts; however, the study focused on a single grade level within one district. Although the school district is the largest school district in the state of Ohio with more than 51,000 students in 116 schools, no other student group or test included in the tested population were analyzed. Several other factors may limit this study. One possible limitation of this study is the short duration of the implementation of the MS and MC program. The MS program had been in place for 5 years (2007–2012), and the MC has been in place for 2 years (20012–2014). While still are a relatively long amount of time in the average lives of education reform, it is a limitation of the study because it only provide five data points for MS and two for MC.

Achievement test results are limited to students' performance (Johnson & Johnson, 2009; Ohio Department of Education, 2009); therefore, analysis of previously derived data may not accurately support the Curriculum Department staff's decision in redesigning the duties of federally funded teachers. The fact that I was a MS teacher during the 2007–2008, 2008–2009 school years and currently a math teacher in the district is a limitation to this study and present a potential source of hidden bias. These factors limit the external validity of the study to school districts in other regions with other populations.

Scope and Delimitations

The scope of this research study confined itself to analyzing 2007–2008, 2008–2009 and 2012–2013, 2013–2014 State Mathematics Achievement Test scores of fourth grade students in a large urban public school district in the Midwestern United States. The public school system services the needs of over 51,000 students from grade Pre-K – 12th grade in 116 schools. Only State Mathematics Achievement Test scores of fourth grade students attending one of the 74 elementary schools with MS and MC were included in this analysis. Findings from this study are not generalizable due to the small sample size and specific criteria. The purpose was to determine if either of these models produced positive gains for students in this district for planning future mathematics instruction.

Significance

American schools are under increasing pressure to produce better results than ever before on standardized assessment measures. The challenge is that public policy is requiring schools to do something that has never been done before: educate all students to high levels (City, Elmore, Fiarman, & Teitel, 2009, p.2) that will "prepare them for a future of great and continual change" (NCTM, 2000, p.8). In order to facilitate this type of student learning, teachers must possess a deep understanding of mathematical content, an understanding about how children think and learn, and establish a challenging and engaging environment to foster students' learning (NCTM, 2000). The results of this study could prove to be an answer to closing the achievement gap in mathematics in this district and beyond through the use of specialized instructional content models. Successful school reform begins when the objective of the school's organizational structures and resources are focused on the improvement of instruction to enhance student learning that will in turn improve student academic achievement (Marzano, 2003; Marzano, Waters, and McNulty, 2005).

Several educational reform movements have targeted teacher professional development to improve student achievement. Race to the Top (RttT), a $4.35 billion federal educational grant program funded through the American Recovery and Reinvestment Act, led by President Obama's administration, was designed to support and compensate states for innovative educational reform measures (Obama, 2009). Ohio was selected one of 10 winners in Round 2 of RttT and was awarded $400 million in grant funds. In the fall of 2011, the U.S. Department of Education offered states the opportunity to request flexibility from specific requirements of the Elementary and

Secondary Educational Act of 1965 (ESEA) as amended by the No Child Left Behind Act of 2001 (USDOE, 2012). In order to receive this flexibility, Ohio has agreed to revise college and career ready expectations, reserve more resources to close subgroup achievement gaps and implement an evaluation system that will support effective instruction and leadership (ODE, 2012). This study has the potential to contribute to the decisions made about this and future grant opportunities. The MS mathematics model under examination produced higher test scores and is worth the commitment of funds that can be provided by grants. Furthermore, the findings of this research enhanced administrators', district math coordinators, teachers', coaches', and other education related practitioners' awareness of specialized mathematics models at the elementary level to support students' ability to reason and communicate mathematically.

Summary

Despite improvement efforts in this district since 2006, the MS and MC programs, has shown little increase in student performance scores. The problem that prompted this study was that it was unclear what impact the MS model or the MC model has had on showing student growth and meeting yearly AYP mathematics targets. Instead of a global analysis, this doctoral study examined, through a focused lens, the State Mathematics Achievement Test scores of fourth grade students who received instruction from a Math Specialists during the 2007–2008, 2008–2009 academic years and fourth grade students who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach during the 2012–2013, 2013–2014 academic years. Specifically, the question examined if there was a significant difference in fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, between students who received instruction from a Math Specialists (2007 – 2009) and Grades 1 – 8 credentialed teachers supported by a Mathematics Coach (2012 – 2014) and were either of them significantly better than the other?

This study targeted only fourth grade students at the elementary level. The MS and MC positions were eliminated after funding changed. Global evaluations of student performance in mathematics show minimal gains. The question this study addressed was, were the MS or the MC model better at producing positive gains on the standardized mathematics assessments? This study provided a statistical comparison of the mathematics achievement outcomes of fourth grade students who received mathematics instruction from a Math Specialists during the 2007-2008, 2008-2009 academic years and fourth grade students who received mathematics instruction from Grades 1-8 credentialed teachers supported by a Math Coach during the 2012-2013, 2013-2014 academic years.

The independent variable was the type of mathematics specialists either MS or MC. A student *t* test compared the means of all the scores across the years of MS and MC. Thus the condition in the model is the independent variable of either MS or MC. The single quality measured, or dependent variable, was the students' fourth grade test scores.

In short, the plan for this quantitative study was to determine if the State Mathematics Achievement Test scores of students in fourth grade who received instruction from a Math Specialists during the 2007-2008, 2008-2009 academic years demonstrated a statistically significant difference from the State Mathematics Achievement Test scores of fourth grade students who received instruction from Grades

1-8 credentialed teachers supported by a Math Coach during the 2012-2013, 2013-2014 academic years.

This section included the background of the problem, the purpose and research questions that guide this study, the theoretical framework, and the significance of this study. The next section of the study reviewed the literature of the mathematics reform movement as well as the MS and MC reform models. The third section will detail the proposed methodology approach and design for this study. In section four, the results from the data collection and analysis are presented. And in section five, interpretations of the findings, implications for social change, and recommendations are offered.

Section 2: Literature Review

Introduction

The culture of teaching and the customs of schools have transformed vastly over the last quarter of the twentieth century in order to meet the great demands placed on educators to prepare all students for the global and technological advancements of the 21st century (Achieve, Inc., 2007; Borek, 2008; Daggett, 2005; Johnson & Johnson, 2009; Kasper, 2005; National Mathematics Advisory Panel, 2008; Sailes, 2008). National testing has focused on literacy and mathematics (Ball, Hill, & Bass, 2005; Hunt, 2005; Hunt, 2008; NCLB, 2001; Schoenfeld, 2004). Science, Technology, Engineering and Mathematics, or STEM, education is seen as essential and lacking in our technology driven world. As a result, Mathematics education from Pre-K-16 has improved, but the change of instruction has been challenging for all teachers (Borek, 2008). In an effort to support effective mathematics instruction and student learning in the United States, the National Mathematics Advisory Panel (2008) recommended that elementary schools implement elementary mathematics specialists (AMTE, 2013). The basic goal of this investigation is to compare student scores that had MS teaching them directly to student scores who had generalist teachers who received support from MC.

In order to fully understand the context of this study, this literature review provided an important contextual historic summary of the mathematics movement in the United States during the 20th century. Specifically, it covered the movement's impact on (a) school reform initiatives, (b) Standards-based education, and (c) current mathematics teaching and learning practices to improve elementary math instruction. Each of these topics has and continues to influence the innovations such as Elementary Mathematics

Specialists (EMS) and MC. These are just two innovations that have been explored as a plausible means aimed at improving the quality of mathematics education in the U.S (National Mathematics Advisory Panel, 2008; Reys & Francis, 2003). These are the two that this school district has explored, but not evaluated for their relative effectiveness. The final sections of this review turn to elucidating how the two methods are similar and different on the three contextual issues for MS and MC of teacher leaders, teacher practices, and professional development school improvement programs.

The first section is a historic overview of the mathematics reform starting in the 1920s to the 1980s. Important periods in that time frame are the industrial revolution, the progressive movement, the activity movement, and the life adjustment movement. Then, the second section focuses on the NCTM Standards including the subsections of: (a) standards-based reform, (b) prelude to national mathematics standards, and (c) opposition to NCTM Standards. In the third section, the two main categories of the MKT framework for teaching mathematics are presented. In the fourth and last section the need for specialized mathematics positions such as MS and MC are highlighted through current research studies. Within MS topics include: (a) the development on MS standards, (b) the call for teacher leaders, and (c) the three critical areas of knowledge needed of MS. Within MC topics include: types of peer coaching roles, (b) role in professional development, and (c) the role of the MC in the professional development learning community. This section concludes with a summary of the literature review.

In order to canvas the research for all related topics, search terms included Booleans *mathematics teaching, mathematics outcomes, teacher preparation, mathematics reform, math wars", mathematics curriculum, student achievement AND* *mathematics, "teacher practices AND student achievement, elementary math coaches, peer coaching, coaching AND student achievement*.

The review of the literature examined the reform movements in mathematics education. After reviewing the literature and research on the industrial revolution, the progressive movement, the activity movement, the life adjustment movement, the new math movement, the back to the basics movement, the standards-based reform movement, and the opposition to NCTM standards, I examined the implications of these movements as related to teacher mathematical content knowledge, the need for specialized mathematics positions at the elementary level, the development of elementary mathematics specialists standards, the evolution of the teacher as leader, and concluded with a detailed description of the MS and MC models to conduct this quantitative, nonexperimental, casual-comparative study.

Historic Overview of Mathematics Reform

It is imperative to examine the history of the mathematical instruction movement in the United States to completely understand the importance of this research study. Despite mathematics reform recommendations dating back to the 1800s designed to strengthen mathematics education of our nation's youth, sustainable mathematics achievement proves to be a challenge for states and districts (Klein, 2003; Leinward, 2012). Various accounts have been made that practicing elementary school teachers are not adequately prepared to meet the demands for increasing student achievement in mathematics (National Council of Teachers of Mathematics, 2000; National Mathematics Advisory Panel, 2008; National Research Council, 1989). In fact, many elementary-level teacher preparation programs do not require extensive work in mathematics content (Ball, Hill, & Bass, 2005; Wu, 2009).

Despite departmentalization suggestions dating back to the 1920s (Becker & Gleason, 1927), the implementation of MS and MC at the elementary level continues to be an emerging practice of innovative professional development to increase the mathematical content knowledge and mathematical pedagogical content knowledge of elementary school teachers (AMTE, 2013; Chval et al., 2010; McGatha, 2010; Rivera, 1993). Although both specialists' positions are needed to address the complexities of elementary mathematics teaching and learning (Fennell, 2011), there is a visible difference between the two models. MS provides content and instructional practices for mathematical learners, whereas MC provides content and instructional practices for instructional leaders (NCTM, 2000). In order to distinguish between the two models, these terms will be used throughout this study. The next section provides a historical account of some of the most influential efforts to improve mathematics education including the emerging roles of MS and MC. This may or may not lead to positive social change in student achievement in mathematics.

Historical Context: 1920 to 1980

The debates on what should be done to improve mathematics in the United States dates back to the colonial times (Klein, 2003). Conflicts in perspectives from the mathematics community have created a culture of quick fix approaches that may have addressed some elements to improve mathematics education, but have failed to provide solutions to critical issues that have perpetuated a system of underachievement in mathematics teaching and learning (Ellis & Berry, 2005; Klein, 2003; Leinward, 2012).

In this section, the impact of the industrial revolution, the progressive movement, the activity movement, and the life adjustment movements had on mathematics education schools are explored in ways that lead up to the current vision of a mathematics teacher. The last two movements in this section- The New Math and Back to the Basics especially influenced this vision.

Industrial revolution. The Industrial Revolution and the influx of immigrants during the late 18th century and start of the 19th century ignited a series of social and political reform initiatives that brought attention to the fragmented and ill-equipped basic arithmetic mathematics curriculum provided in public schools (Klein, 2003; Leinwand, 2012). The main methods of teaching were direct instruction and recitation. As a result, basic skills of addition, subtraction, multiplication and division that should have been developed in school were not being developed, causing the military to provide remedial training for simple arithmetic tasks (Klein, 2003). Despite societal pressures to reform mathematics for the sake of military, science, and technological advancements, limited changes to the mathematics curriculum occurred (Klein, 2003; Leinwand, 2012). The reasons are similar to those that have sparked the MS and MC of today. Teachers had limited mathematical ability, schools were underfunded, and outsiders complained but did little to solve the problems than an hour lecture here and there (Klein, 2003). This meant that the K-12 mathematics programs in the United States remained poorly aligned, fragmented, and incapable of preparing students for the workforce (Herrera & Owens, 2001; Leinwand, 2012; Schoenfeld, 2004).

Progressive movement. Some movement toward the MS and MC positions gained traction in the beginning of the 20th century, when progressive education dominated American schools (Klein, 2003). Teaching practices were encouraged to be more of a facilitator than a drill sergeant, helping students to see patterns in mathematical problem solving (Klein, 2003). This movement had the educational guidance from leaders like Thorndike, Rousseau, Dewey, and Kilpatrick (Becker & Gleason, 1927; Klein, 2003). This movement emphasized child-centered learning experiences, with a limited focus on academic content, which was directly aligned to Thorndike's theory of learning (Klein, 2003). Thorndike proposed that students should engage in sensible learning opportunities where knowledge is derived by the students rather than delivered by a teacher (Klein, 2003). Dewey, and similar progressivists, believed that educational experiences should naturally support the needs and interest of students (Klein, 2003).

Kilpatrick's position was that academic subjects should be taught to students based on practicality or if the student desired to learn more about the subject (Klein, 2003). The publication of the *1923 Report* written on school mathematics was the most comprehensive piece of literature written on school mathematics during this time (Klein, 2003). This report encompassed surveys, mathematics teacher training programs in other countries, curricular recommendations, and presented the psychological and fundamental importance of learning mathematics (Klein, 2003). This focus on the importance of mathematical content knowledge for teachers and the fundamental value of mathematics for school curricula, blatantly objected the writings of Kilpatrick (Klein, 2003). Thus, the battle between content knowledge and instructional practices began that will eventually merge into a consensus that drives the MS and MC positions; both are specialized models to the mathematics education community and not typical in generalists' toolsets.

Activity movement. Despite the influence of *The 1923 Report* written on school mathematics had on public education, the Kilpatrick report exerted greater influence and supported the Activity Movement of the 1930s, which rapidly spread throughout the nation's elementary schools (Klein, 2003). This movement introduced the integration of academic subjects and contested the idea of separate instruction in mathematics and other content areas (Klein, 2003). This would counter the MS and MC approach. The movement was not as successful at the secondary level as content specialists were less willing to abdicate their subjects in support of an ill-defined holistic approach proposed by the movement (Klein, 2003).

Life adjustment movement. Mathematical deficiencies of high school graduates continued. By the mid-1940s a new educational program called the Life Adjustment Movement emerged (Klein, 2003). Advocates of this movement claimed that there was not an equal balance between academics and life skills, thus perpetuating a system of ill-prepared students not suitable for college or even equipped with the skills necessary for skilled occupations (Klein, 2003). With new scientific technological advancements through the 1940s, the importance of mathematics was acknowledged, and the life adjustment education programs under the progressive era received heavy public criticism and eventually ended (Klein, 2003). The desire to prepare students for using mathematics to understand their world did not.

Across the progressive era, several discussions began that have led to the MS and MC positions (Fennell, 2011). First, is the acknowledgement that drilling basic facts were insufficient to prepare students to understand and use math in school or life (Klein, 2003). Despite the increased complexities over the years of elementary mathematics teaching and learning standards, the practice of drilling basic facts persists even today in many schools (Klein, 2003). Next, the focus on students developing their understanding through interaction with real life materials such as base-ten blocks, centimeter cubes, and attributes and pattern blocks, identified the instructional practices that shifted from holding flash cards to setting up manipulatives for problem solving (Van de Walle & Lovin, 2006). Finally, there was an attempt to change to teaching only real life mathematics tasks such as calculating a tip (Klein, 2003). This was dismissed as ineffective to meet the technological demands of the future workplaces (Klein, 2003). Thus, mathematicians contributed to the development of K-12 school mathematics curricula for the first time (Klein, 2003).

New math. The most notable event during the 20th century generating concern for the nation's mathematical prowess was the successful launching of Sputnik I, the world's first artificial satellite to orbit the earth, by the Soviet Union in 1957 (Herrera & Owens, 2001; Klein, 2003; Powell, 2007, Schoenfeld, 2004). Sputnik not only shocked the American scientific community, but also brought attention to inadequate American educational preparation and weakened military control (Herrera & Owens, 2001). The beginning of federally funded reform initiatives in mathematics and science curricula followed, with drastic changes, such as hands on laboratory experiences and scientists' and mathematicians' contributions to the redesign of the curriculum (Abramson, 2007; Powell, 2007; Schoenfeld, 2004). This represented a huge leap toward MS and MC positions because the enthusiasm of math experts to justify expenditures on new textbooks, funding for teachers, and more created the incubator that was necessary to propel mathematics education forward was in place (Schoenfeld, 2004).

Funding and support from national organizations increased. These included the National Science Foundation (NSF), School Mathematics Study Group (SMSG), and the National Advisory Committee on Mathematical Education (NACOME) (Schoenfeld, 2004). They provided extensive financial resources into the advancement and implementation of modernized science and mathematics curricula known as the *New Math* (Schoenfeld, 2004).

During the 10 year span of the new math movement, continued disagreements over the most effective ways to teach mathematics led to the restructuring of mathematics academics, policies, and programs in public schools (Herrera & Owens, 2001; Klein, 2003). Mathematics curricula, textbooks, and assessments at all levels were revised as the writings of psychological theorists also began to capture the attention of the mathematics education community (Herrera & Owens, 2001). Moreover, progressive education, or learning by doing, problem solving, and critical thinking, greatly influenced the academic content in American public schools (Herrera & Owens, 2001; Klein, 2003).

Curricula changes at the elementary level had more challenges with implementation, as teachers were not specialist in the advanced mathematical topics now taught at this level (Klein, 2003). Geometry changes were not as difficult to implement, but more advanced topics such as graphs, algebraic properties, set theory, bases other than 10, and statistics were problematic due to the teachers' lack of content knowledge (AMTE, 2013; Fennell, 2011; Herrera & Owens, 2001; Klein, 2003). The initiative for junior high mathematics intended to prepare students for high school promoted changes in curriculum that emphasized precise mathematical language and applications (Herrera & Owens, 2001; Klein, 2003). With the recommendation from SMSG, The University of Maryland Project, the Madison project, and other national mathematics curriculum committees, many high school and secondary level teachers started to create their own textbooks (Klein, 2003).

Despite drastic curricular changes to K-12 mathematics programs in the United States, emerging reports and publications expressed concerns over the quality of mathematics and science education, as student performance on national assessments and economic ratings decreased or remained stagnant (Herrera & Owens, 2001; Klein, 2003, Schoenfeld, 2004). Mathematics curriculum continued to be heavily influenced by mathematicians and the advanced curricula were not welcomed by parents due to the new way of mathematical thinking and their inability to help their children with their work (Herrera & Owens, 2001). With fear that the next generation would not have the capacity to sustain the country's economic competitiveness and security, a new sense of urgency emerged (Herrera & Owens, 2001; Leinwand, 2012). Critics blamed new math for the devastating outcomes, causing another shift in mathematics that reverted to technical and skill based education (Herrera & Owens, 2001; Klein, 2003; Schoenfeld, 2004). This was a huge setback for Mathematics Specialist and Coach positions: drill did not require any special skills at all; volunteers and noneducators were often given this task.

Back to the basics. Adult dissatisfaction with math teaching and students' performance in basic skills remaining remedial, re-introduced the "back to basic" movement (Klein, 2003). This movement decreased the emphasis on abstraction and concepts, characteristics of the new math reform, and reemphasized drill of basic arithmetic skills (Herrera & Owens, 2001; Klein, 2003; Schoenfeld, 2004). At the primary level, direct instruction was the method to teach mathematics. Teachers traditionally presented lessons in a prescriptive manner with an emphasis on computation and low-level problems lacking the ability for students to connect learning to real world applications (Leinwand, 2012; Schoenfeld, 2004). Topics were taught in isolation and focused on the memorization and the regurgitation of information, homework practice, and frequent testing (Leinward, 2012).

New mathematics concepts reflected current societal changes, initiating a shift of how and why mathematics should be instructed in school. However, despite these changes, textbook and curricular modifications were slow and failed to prepare students for the complexity of the ever-changing mathematics requirements of the workplace (Herrera & Owens, 2001; Leinwand, 2012). Displeasure about mathematics programs were voiced and a sense of failure and national crisis returned during the late 1970's and start of the 1980's, prompting the need to address the restructuring of school mathematics programs through the viewpoint of a mathematics committee appointed by NCTM (Herrera & Owens, 2001).

In the mid-1970s, the majority of states had established proficiency competency tests in basic skills (Klein, 2003). The trending results of national assessments had led to a public outcry for change. It was not until the release of A *Nation at Risk* (Gardner, D. P., Larsen, Y. W., Baker, W., Campbell, A., & Crosby, E. A., 1983), that the federal government became aware of heightened public concerns about the deterioration of public education and the nation's economic competitiveness to produce an educated populace. The commission proposed that an investment in education was vital in securing the strength of the nation. *A Nation at Risk* paved the way for many of the reform initiatives that followed and restructured the current operating framework of schools in the United States. Once again, conversations continued in the education community about the great demand for elementary teachers with mathematics expertise as a viable solution to raise the mathematical proficiency of teachers to positively impact student learning (AMTE, 2013; Fennell, 2011; Wu, 2009). In 1981, the NCTM proposed a teaching credential endorsement for elementary mathematics specialists (Fennell, 2011) further igniting the charge for MS and MC.

These initiatives led to increased academic standards, heightened accountability measures, improved professional development opportunities, modified curricula, extended school days, and enhanced teacher and student standards to assess and measure progress (Borek, 2008; Fullan 2009; Hunt 2008; Gardner, D. P., Larsen, Y. W., Baker, W., Campbell, A., & Crosby, E. A., 1983; Pringle & Martin, 2005). These initiatives still serve as guides for existing educational improvement programs. As a result, rigorous high-stakes assessments, commonly referred to as standardized tests, progressively became the method used in schools to evaluate student academic performance.

This signified an important shift in educational policy, which emerged with the 1994 publication of *Goals 2000: Educate America Act.* This act was designed to increase the capacity of schools to improve standards-based education. The National Educational Goals were developed by the U.S. Congress to establish a framework in which to identify superlative academic standards to measure student progress and to provide support (Goals 2000: Educate America Act, 1994).

Most recently, as the successor to Goals 2000, the United States government signed into law the No Child Left Behind (NCLB) Act of 2001 to continue the national effort to raise the quality of education to prepare students for the twenty-first century. This legislation addressed the need for increased accountability measures for student achievement in the nation's public schools through federally mandated standardized testing and supplemental education programs (U.S. Department of Education, 2012). Under the law, all public schools must administer annual state assessments that measure academic achievement in mathematics and reading in grades 3 through 8 in order to receive federal funding (Johnson & Johnson, 2009; Ohio Department of Education, 2009). With the adoption of state standards with stringent accountability measures, many schools and districts are reallocating finances to support school-based mathematics specialists positions to increase the mathematical outcomes of their students on state assessments (Fennell, 2011).

In summary, over the past century, various reform efforts have emerged from concerns about mathematics teaching and learning. The literature documented the successes and challenges of past reform movements during the industrial revolution, the progressive movement, the activity movement and the life adjustment movements. The industrial revolution influenced by business leaders depicted the start of the movement. Persuaded by business management, the curriculum concentrated on task and firm separations between subject areas. However, as depicted in the literature, progressivism replaced this movement and a shift from social competence to a focus on child-centered education with a limited emphasis on academic content dominated American schools (Schoenfeld, 2004). In opposition to progressivists' ideologies', the *1923 Report* highlighted the importance of mathematical content knowledge for teachers and the significance of mathematics for school curricula. This ignited the "*war*" between content knowledge and instructional practices. The new math reform offered innovative mathematical content and pedagogical methods and spearheaded funding and support from national organizations and federally funded reform initiatives into the advancement and implementation of modernized science and mathematics curricula (Schoenfeld, 2004). Despite the efforts of mathematics scholars and educators, many teachers were not well equipped to deal with the advanced mathematical topics now required of teachers and it has been suggested that in most classrooms reforms were never fully implemented. According to the NCTM (2010), 30% of the 300,000 secondary mathematics teachers across the United States did not major nor minor in mathematics. Even more discouraging, the research of Peske and Haycock (2006) exposed that almost 50% of mathematics classes in high-poverty, high-minority schools are facilitated by unqualified teachers who lack the appropriate teaching credentials in a math related field (Reys & Fennell, 2003). Teachers who do not have the proper certification may in turn display lower expectations, preventing opportunities for students to pursue more advanced and innovative courses in mathematics and science (Flores, 2007)

During this period, the National Council of Teachers of Mathematics (NCTM) became the leader in endorsing a reform agenda in mathematics that became the voice for teachers and the catalyst for new innovative and creative models for mathematics such as the MS and MC models. Although they did not play a significant role in the new math movement, NCTM released documents that emphasized the importance of problem solving, critical thinking, conceptual development and called for a vast set of modifications to school mathematics curriculum, instructional practices, and evaluation measures that established the platform for the present *Standards*-based reform movement in mathematics education intended to help teachers successfully perform these new visions of mathematics teaching and learning. It is logical to assume that the ideas presented in these documents best support the MS model as the importance of having a knowledgeable teacher to provide mathematics instruction to students has been documented throughout the literature. In spite of this, the MC model has the capacity to impact a larger number of students through the peer coaching structure. Currently, it is unknown which model will positively impact student academic achievement in mathematics. The emergence of these two specialized models and the research surrounding the use of these structures will be described later on in this review.

Standards-Based Reform

This section shared the evolution of the first national mathematics standards document in the USA (NCTM, 1989). This document is the foundation for both the MS and the MC positions. Both positions are equally influenced by the Standards. The difference between MS and the MC is the degree of training of the actual instructors of the mathematics (McGatha, 2009). With the MS model the teacher is the expert. Meanwhile with the MC the coach is the expert, and the teacher is learning to teach math well from the coach (McGatha, 2009). These positions are the spear shot toward the classroom to enact the vision it sets forth.

The political, social, and economic shifts in the United States, which were described in the last section, paved a new way to think about teaching and learning mathematics. The release of the National Council of Teachers of Mathematics publication

Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) presented different ideas about mathematics pedagogy (how to teach), content (what to teach) and assessment (Klein, 2003; Schoenfeld, 2004; Van deWalle, 2007). Some believe that the *Standards* re-ignited the ongoing *"Math Wars"* prevalent in the mathematics community documented throughout the last century (Schoenfeld, 2004) and presented in the first section of this review.

In the writing of the *Standards*, various members from the mathematics community: classroom teachers, teacher educators, educational researchers, supervisors, and university mathematicians, were charged with two tasks:

(1) Create a coherent vision of what it means to be mathematically literate both in a world that relies on calculators and computers to carry out mathematical procedures and in a world where mathematics is rapidly growing and is extensively being applied in diverse fields, and

(2) Create a set of standards to guide the revision of the school curriculum and its associated evaluation towards this vision (National Council of Teachers of Mathematics, 1989, p.2)

Essentially, a framework for "what mathematics students need to know, how students are to achieve the identified curricular goals, what teachers are to do to help students develop their mathematical knowledge, and the context in which learning and teaching occur" (NCTM, 1989, p.2) was developed.

Due to the dramatically reformed vision of mathematics instruction, extensive federal funding was needed to produce new mathematics instructional curriculum and materials designed to afford all students opportunities for mathematics excellence (Klein, 2003). Despite the efforts in the past with new math, many teachers were not prepared to deal with the advanced pedagogical approaches found within the new math textbooks

(Klein, 2003). Subsequently, with the *Standards* further federal funds were generated for intensive professional development and specialized mathematics programs as part of the reform efforts to support the new vision of the teaching and learning of mathematics (Fennell, 2011). These were the funds that would support the development of the MS and MC positions.

The next sections will discuss the important prelude of national standards and provide the educational philosophy that established the new vision of mathematics education. Mathematics teachers of today are experiencing significant changes in mathematics content and instructional practices. At the elementary level teachers are called on to provide challenging mathematics instruction to a very diverse student population using transformative learning methods intended to improve understanding. This is an immense charge that combined with the publications of the NCTM *Curriculum and Evaluation Standards for School Mathematics* (1989), *Professional Standards for Teaching Mathematics* (1991), and *Assessment Standards for School Mathematics* (1995) present the foundation for mathematics teaching and learning in grades K-12. The teaching standards are built on the foundation of the content standards but are instrumental in making the content standards achievable. For this vision to exist, the next sections discuss in detail the teaching standards and positions.

Prelude to National Mathematics Standards

In the 1980s, mathematics classrooms around the nation implemented the same instructional practices. Teachers reviewed assignments from the previous day, lectured on new content, and provided opportunities for student practice. Students worked independently, while teachers walked around the room answering questions (Herrera &

Owens, 2001). This back to basics approach left educators discouraged, as technological advancements in mathematics, such as computers, calculators, and the use of manipulatives were not reflective of present instructional practices. The widespread awareness of the lowering of school expectations and the deterioration of math and science education served as the impetus needed for the standards movement (Klein, 2003).

The first product released by NCTM in 1980, to lead the reform movement, was the publication of *An Agenda for Action* (Schoenfeld, 2004). The vision articulated in this report endorsed problem solving as the new mathematics focus with a redefined definition of basic skills to eliminate obsolete practices, and encouraged the use of calculators and computers in K-12 mathematics programs (Herrea & Owens, 2001; Leinwand, 2012). The impact of technology transformed American classrooms and eliminated the need to teach numerous mathematics topics once viewed as important (Leinwand, 2012). This report also stressed that all students should be exposed to a flexible and diverse curriculum, with multiple forms of assessments to measure student learning (2012). Despite the voiced concerns expressed in this and other publications, the reform movement lacked momentum, as the expectations were not reflected (Herrera & Owens, 2001), resulting in minor and insignificant changes to mathematics curricula (Schoenfeld, 2004).

It was not until the release of A *Nation at Risk* (National Commission on Excellence in Education, 1983), that the federal government became aware of heightened public concerns about the deterioration of public education and the quality of teachers and teacher training programs (Klein, 2003). The commission proposed that an investment in education was vital in securing the strength of the nation. Mathematical proficiency, therefore, depended on having and knowing how to use a strong knowledge base in mathematics and being able to construct problem-solving methods in diverse situations (Schoenfeld, 2004). The result of this push for math reform was similar to that from earlier periods. These efforts stressed the benefit of having highly qualified master mathematics teachers such as MS and MC in elementary schools to provide excellence in mathematics education for all students (Klein, 2003; Schoenfeld 2004).

The NCTM Standards

The 1989 publication of the NCTM's *Curriculum and Evaluation Standards for School Mathematics (the Standards),* with recommendations for standards-based mathematics, was a first of its kind, providing a new vision and framework of teaching and learning that challenged existing "back to the basics" beliefs (Herrera & Owens, 2001; Schoenfeld, 2004). This new vision included a mathematics curriculum suitable for all students and one that focused on mathematical content and teacher instructional practices. Some major implications of this change included a shift from curricula dominated by isolated facts and practices, to those that emphasized higher-order thinking, mathematical modeling, real world connection, and the integration of mathematics topics (Herrera & Owens, 2001; Leinwand, 2012). Although clearly defined standards are components of the redesigned mathematics program, neither standards nor evaluative measures alone will increase student achievement (Leinwand, 2012). Mathematics educators have advocated incessantly for the development of elementary mathematics specialists to help create a vision for substantial improvement of K-12 mathematics programs (AMTE, 2013; Fennell, 2011; Leinwand, 2012; National Council of Teachers of Mathematics, 2000; National Mathematics Advisory Panel, 2008; National Research Council, 1989). In 1987, the ExxonMobil Foundation supported this vision by funding projects specifically tailored to support the MS and MC model movement at the elementary level (Fennell, 2011). This was the beginning of a new direction in the mathematics community where sustainable school improvement efforts were solely concentrated in the use of mathematics specialists (Fennell, 2013).

The next charge was to develop a set of standards that fostered a vision of mathematics teaching. This vision was accomplished in 1991, when the NCTM released *Professional Teaching Standards for Teaching Mathematics* (NCTM, 1991). This guide provided a framework for teachers to reach the goal of a quality mathematics education for all students (1991). It also defined the roles that groups such as MS, MC and other school and district personnel played in the standards-based mathematics movement. To continue this goal of a quality education as part of NCTM's reform vision for school mathematics, in 1995, the NCTM released *Assessment Standards for Teaching Mathematics* as a means to monitor quality and progress of student performance to inform instructional practices (Leinwand, 2012; NCTM, 1995). These three documents, also referred to as *The Standards*, establishes the framework for mathematics teaching and learning in grades K-12 in the United States during the standards era.

Unlike previous K-12 mathematics programs in the United States that have been depicted as fragmented, poorly aligned, and unfair, the *Standards* (NCTM, 2004) presented guidelines and provisions for states to use as a framework to align and increase the level of rigor when developing mathematics curricular with an emphasis on mathematics content and instructional experts (Herrera & Owens, 2001; Leinwand, 2012). There are four main components that make up the *Principals and Standards for School Mathematics*: principles, K-12 content standards, process standards, and a detailed progression with fidelity. The following themes are addressed (NCTM, 2000, p.11):

- ***Equity.*** Excellence in mathematics education requires equity- high expectations and strong support for all students.
- ***Curriculum.*** A curriculum is more than a collection of activities: it must be coherent, focused on important mathematics, and well articulated across the grades.
- ***Teaching.*** Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well.
- ***Learning.*** Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.
- ***Assessment.*** Assessment should support the learning of important mathematics and furnish useful information to both teachers and students.
- ***Technology.*** Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning.

NCTM (2000) described 10 standards for mathematics instruction from prekindergarten through grade 12. These standards are equally divided into content (what students should know and learn in number and operation, algebra, geometry, measurement, and data analysis and probability) and process (the application of knowledge to develop mathematical thinking as related to problem-solving, reasoning and proof, communication, connections, and representation). The five process standards recommended by the NCTM to develop mathematical thinking (NCTM, 2000) are:

- *Problem-solving* – Instructional programs should enable students to build new mathematical knowledge through problem-solving; solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems; and monitor and reflect on the process of mathematical problem-solving (p. 53).

- *Reasoning and proof* – Instructional programs should enable students to recognize reasoning and proof as fundamental aspects of mathematics; make and investigate mathematical conjectures; develop and evaluate mathematical arguments and proofs; and select and use various types of reasoning and methods of proof (p. 56).

- *C*ommunication – Instructional programs should enable students to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others; and use the language of mathematics to express mathematical ideas precisely (p. 60).

- *Connections* – Instructional programs should enable all students to recognize and use connections among mathematical ideas; understand how mathematical ideas interconnect and build on one another to produce a coherent whole; and recognize and apply mathematics in context outside of mathematics (p. 64).

- *Representation* – Instructional programs should enable all students to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; and use representations to model and interpret physical, social, and mathematical phenomena (p. 67).

Additional proposed changes for the continued improvement of mathematics education for all students are provided in the last section of the *Standards.* Explicitly defined are the roles and responsibilities that educational stakeholders such as the elementary mathematics specialists, the elementary mathematics coaches, the elementary mathematics instructional leaders and the school and district administrators must embrace when making decisions about the development and implementation of rigorous, yet achievable, standards to successfully reform mathematics education (NCTM, 2000).

These recommendations greatly influenced the changes in content, pedagogy, and assessment practices needed to guide planning, teaching, and assessing mathematics (Herrera & Owens, 2001; Leinwand, 2012). The *Standards* not only revised the framework of K-12 mathematics school programs, but also created instructional materials available to schools that encompassed the goals emphasized in the reform (Herrera & Owens, 2001). The curriculum shift recommended by the NCTM *Standards* appeared to challenge existing instructional practices of teachers, which led to a new controversy in mathematics education (Herrera & Owens, 2001; Leinwand, 2012; Schoenfeld, 2004).

For the first time, teachers were asked to change from the traditional role of transmitter of knowledge, to the new, unfamiliar role of facilitator (Herrera & Owens, 2001). This new charge forced teachers to change how mathematics was presented to students. Teachers were to cultivate a learning environment where students explored, discussed, and challenged mathematical beliefs, while making personal connections to the presented mathematical ideas (Herrera & Owens, 2001; Leinwand, 2012; NCTM, 1991). NCTM (1991), argued:

> Knowledge of mathematics, the curriculum and of students should guide the teacher's decision about the path of the discourse. Other key decisions concern the teacher's role in contributing to the discourse. Beyond asking clarifying or provocative questions, teachers should also, at times, provide information and lead students. Decisions about when to let students struggle to make sense of an idea or a problem without direct teacher input, when to ask leading questions, and when to tell students something directly are crucial to orchestrating productive mathematical discourse in the classroom. Such decisions depend on teachers' understanding of mathematics and of their students-on judgments bout the things that, students can figure out on their own or collectively and those for which they will need input. (Standard 2: The Teachers' Role in Discourse, Elaboration section, para. 5)

Teaching with the *Standards* in mind challenged the traditional ways of teaching and evaluating mathematics. Concerned groups opposed this instructional shift for fear that students would not receive effective mathematical instruction. Teachers were not properly trained for this drastic shift in instructional practices, causing many teachers to now question their ability to effectively deliver mathematics instruction (AMTE, 2013; Herrera & Owens, 2001; Leinwand, 2012; Schoenfeld, 2004). Many states recognize that serious educational reform requires changes in students' thinking and argue that teachers must possess an in-depth knowledge and expertise with regard to teaching elementary mathematics in order to positively impact student achievement (Wu, 2009). Now, more than ever is the work of elementary mathematics specialists needed to support school-wide effective mathematics instruction and student learning (AMTE, 2013; Fennell, 2011; McGatha, 2010).

Riordan and Noyce (2001) utilized a quasi-experimental study using matched comparison groups, comparing 4th and 8th grade student achievement in elementary and middle schools utilizing *Standards*-based mathematics curriculum materials, to similar schools using more traditional texts. In this study, 21 middle schools and 67 elementary schools using the *Standards*-based materials (fourth-grade students using *Everyday Mathematics* and eighth-grad students using *Connected Mathematics*) were selected and then matched with comparison school groups with similar baseline state mathematics test scores and percentages of students receiving free or reduced lunch. At the end of the 1998-1999 school year, state tests scores were used to compare the two groups across differing student populations. Schools that had been implementing Everyday Mathematics or Connected Mathematics (4 to 6 years) outscored their counterparts that used traditional texts. The score differences ranging from 2.5 points to 5.7 points on an 80-point scale that ranges from 200 to 280, with a positive effect size (ES= +0.34). Schools that used the program for 2 to 3 years had a much smaller effect size (ES = +0.15). Results indicated that students in schools using either of these standards-based programs as their primary mathematics curriculum performed significantly better than did students in traditional programs. Therefore, it may be that schools who use the reform curriculums the longest will see the most meaningful benefit (Riordan & Noyce, 2001).

Conversely, results from Huntley, Rasmussen, Villarubi, Sangtong, and Fey (2000) present different research findings. Huntley et al. used a comparative research design to compare the effects of the Core-Plus Mathematics Project (CPMP) *Standards*-based curriculum to the effects of more conventional high school mathematics curricula. The authors identified six U.S. schools, each with two classrooms utilizing *Standards*-based high school curriculum program and comparison classrooms utilizing more traditional textbooks. Each comparison group was paired with a *Standards*-based group in regard to earlier skill levels. Three different instruments were designed to assess students' understanding, skill, and problem-solving ability in algebra. Like Riordan and Noyce (2001), Huntley et al. discovered that students using *Standards*-based curriculum materials were more beneficial at solving algebraic problems presented in real-world contexts using graphing calculators than students learning with more traditional textbooks. The mean score for CPMP students was 57.4%. This is higher, but not statistically significantly higher, than the control group of 53.9%. The results from this study also indicated that students using *Standards*-based curriculum programs might have limited experiences to develop proficiency at traditional, procedural aspects of mathematics. Specifically, Twenty-two of the 28 items on the Part 2 test assessed students' skill with algebraic calculations with out the use of calculator assistances. Control students outperformed CPMP students by a mean difference of 11.2% (2000).

Therefore, CPMP students performed slightly better than control students on real-world problem solving items, but were far below the control students in procedural proficiency.

In summary, the current reform movement in mathematics education has been largely shaped by the NCTM (1989; 1991; 1995; 2000) *Standards*-based mathematics curriculum to improve the quality of math education. Since the release of these documents, a collective vision of mathematics excellence has been articulated through the *Standards* and has greatly influenced the changes in content, pedagogy, curriculum materials and assessment practices (Herrera & Owens, 2001; Leinwand, 2012; Schoenfeld, 2004). The transformation from traditional classrooms that focused on students' attaining competence in repetitive memorization of technical skills to classrooms that lead students to personally create meaningful conceptions of mathematical topics is a chief component of this reform. As is the case with any educational reform movement, the implications for schools that use these *Standards* as a vision for math reform, can vary. As Riordan and Noyce (2001) illustrated the positive impact of standards-based curriculum on their study, Huntley, Rasmussen, Villarubi, Sangtong, and Fey (2000) found a limitation inherent in *Standards*-based curriculum programs. As with all reform efforts, opposition to the *Standards* movement exists and is presented in the next section.

Opposition to NCTM Standards

In light of strong support for the *Standards* movement from three significant educational organizations in the mathematics community (NCTM, NSF, and the U.S. Department of Education), bold opposition to the *Standards* documents and the newly generated curriculum and materials rapidly ascended. In 1999, David Klein, a mathematics professor at California State University at Northridge, composed an open letter to the U.S. Secretary of Education, Richard Riley, insisting him to remove the list of "exemplary" and "promising" mathematics curriculum programs (Klein et al., 1999). Although specific details are not included detailing the inadequacies of the recommended curriculum programs, Klein's letter included websites, reference to letters, and published journal articles from highly regarded scholars in the mathematics field who equally opposed the reform. Further recommendations were made that active research mathematicians should be included in the evaluation process of future mathematics curricula (Klein et al., 1999). Opposition also appeared virtually through the internet-based, instrumental parent organization *Mathematically Correct,* an advocacy group founded by parents in Southern California in 1995 for the improvement of mathematics education in America's schools (Clopton, McKeown, McKeown, & Clopton, 1999).

For the most part, mathematicians have fueled opposition to the *Standards* reform movement. These mathematicians dispute that, while theoretical understanding is important, it cannot be completely comprehended without an emphasis on precision and fluency in basic skills (NCTM, 2000). In addition, opponents have criticized the assembly who wrote the *Standards*- two K-12 educators, no respected mathematicians, with the remaining writers comprised of teacher education professors- and critiqued the reform for advocating instructional practices based on opinion rather than research (Wu, 1997). In 2003, NCTM released the book *A Research Companion to Principles and Standards for School Mathematics* (Kilpatrick, Martin, & Schifter, 2003) that outlined research methods to influence standards for school mathematics.

On April 18, 2006, President Bush created a National Mathematics Advisory Panel, charged with informing the President and the Secretary of Education on superlative scientifically-based research to improve the teaching and learning of mathematics. This task force was made up of mathematicians, mathematics teachers, principals, educational researchers, educational psychologists, and policy researchers. Surprisingly, Francis (Skip) Fennell, the past president of NCTM from 2006 –2008 and one of the strongest opponents of the *Standards*-based reform movement were also a member of this distinguished group (Wu, 1997). As a result, once again, the “math wars” gained national attention.

Another political reflection linked to the current *Standards* reform is the national movement towards high-stakes testing and accountability in education. Effective 2000, all states had at least one form of a statewide assessment (Olson, 1999). American Educational Research Association (AERA) defined high-stakes as test that carry serious consequences for teachers and parents (2000). Many states and school districts mandate testing programs to collect statistics about student achievement over a period of time and to hold schools accountable (AERA, 2000). Achievement tests are termed “high-stakes” if severe penalties for students or for educators are involved. High performing schools may bring public praise or financial rewards; underperforming schools may bring public embarrassment and heavy sanctions (2000). As described by AERA,

> These various high-stakes testing applications are enacted by policy makers with the intention of improving education. For example, it is hoped that setting high standards or achievement will inspire greater effort on the part of student, teachers, and educational administrators. Reporting of test results make also be beneficial in directing public attention to gross achievement disparities among schools or among student groups. However, if high-stakes testing programs are implemented in circumstances where educational resources are inadequate or

> where tests lack sufficient reliability and validity for their intended purposes, there is potential for serious harm. Policy makers and the public may be misled by spurious test score increases unrelated to any fundamental educational improvement; students may be placed at risk of educational failure and dropping out; teachers may be blamed or punished for inequitable resources over which they have no control; and curriculum and instructional may be severely distorted if high test scores per se, rather than learning, become the overriding goal of classroom instruction. (p. 1)

As emphasized by AERA, although with good intentions, the accountability movement also has perilous challenges and many opponents. An essential concern raised in this dispute is that albeit the objectives of NCLB to lessen inequities in our education system, the depiction of such policies actually tends to perpetuate existing inequities especially in low-achieving schools (AERA, 2000; Diamond & Spillane, 2004; Muller & Schiller, 2000).

In summary, jointly, the math wars and high-stakes testing and accountability have placed pressure on researchers to examine the effects of the use of *Standards*-based curriculum materials and the development of specialized mathematics programs designed to improve teaching and learning. Another implication of varying results from studies focused on student achievement can be attributed to the content knowledge of teachers. A brief overview of this research is presented below.

Teacher Mathematical Content Knowledge for Teaching

The curriculum shift recommended by the NCTM *Standards* and policy initiatives designed to improve students' mathematics achievement has placed significant implications for instructional practices of the mathematics regular, teacher, specialist teacher, or coach of regular teachers classroom (AERA, 2000; Ball, Hill, & Bass, 2005; Ball, Thames & Phelps, 2008; Hill, Rowan, & Ball, 2005; Herrera & Owens, 2001;

Leinwand, 2012; Schoenfeld, 2004). Highly qualified requirements placed on core subject teachers from recent legislature (NCLB) coupled with U.S. students' continued meager performance on international assessments, has focused improvement efforts on how to strengthen elementary teachers' knowledge of mathematics content beyond basic skills and procedures (Ball et al., 2008; Ball, Hill, & Bass, 2005; Charalambos, 2010; Hill, Rowan, & Ball, 2005; Li, Y., 2008; Tchoshanov, 2011). In 2011, American fourth grade math students scored lower in math and science and middle and high school student achievement in math has been declining relative to their international counterparts in eight countries (TIMSS, 2011). Many researchers are questioning whether elementary teachers in the United States have the mathematical expertise to effectively deliver mathematics instruction as recommended by the NCTM *Standards* (AMTE, 2013; Ball, Thames & Phelps, 2008; Fennell, 2011; Hill & Bass, 2005; Li, Y., 2008; McGatha, 2010; NCTM, 2000).

In fact, the mathematics knowledge of future teachers in the U.S. were found to be weak when compared to that of future teachers in other countries whose students outperform U.S. students in mathematics (Ball, 1990; Center for Research in Mathematics and Science Education, 2007). Many U.S. teachers, who are products of the same failed system that legislative reforms such as No Child Left Behind continually seek to improve, lack basic mathematical competencies for teaching mathematics (Ball, Hill, & Bass, 2005; Ball, Thames & Phelps, 2008; Center for Research in Mathematics and Science Education, 2007; Hill, Rowan, & Ball, 2005; Peske & Haycock, 2006). The *Standards* also outlined three major beliefs of effective teaching related to mathematics education:

- Effective teaching requires knowing and understanding mathematics, students as learners, and pedagogical strategies.
- Effective teaching requires a challenging and supporting classroom environment.
- Effective teaching requires continually seeking improvement. (NCTM, 2000, pp. 17 – 19)

Rooted in Shulman's (1986) pedagogical content knowledge, Ball (1990) began the development of mathematical knowledge for teaching (MKT). MKT involves having the capacity to appropriately represent mathematics deeply enough and in various ways (Ball, 1990; Charalambous, 2010; Hill et al., 2008; Hill, Rowan, & Ball, 2005). MKT includes an explicit definition of the required expectations of the work of mathematics teachers. Examples includes "explaining terms and concepts to students, interpreting students' statements and solutions, judging and correcting textbook treatments of particular topics, using representations accurately in the classroom, and providing students with examples of mathematical concepts, algorithms, or proofs" (Hill, Rowan, & Ball, 2005, p.371).

In addition to the development of specific domains of MKT, researchers have explored measuring teachings' MKT. Research findings (Ball et al., 2008; Ball, Hill, & Bass, 2005; Charalambos, 2010; Hill, Rowan, & Ball, 2005) discovered that there is a direct link to teachers' mathematical content knowledge and student achievement performance. However, there are two contrasting arguments on teacher effects on student achievement. The traditional measurement of teachers' knowledge consisted of teachers' performance on verbal assessments, content courses taken, and the level of degrees achieved. This viewpoint is in sharp opposition from other groups of scholars who contend that there is a greater correlation between teachers' ability to understand and effectively present content to students and increased academic performance (p. 372). Based on one of their research studies, Hill, Rowan, and Ball (2005) conducted an analysis of 700 first and third grade elementary teachers and approximately 3,000 students using the measure of teachers' performance knowledge questionnaire and students' scores on the mathematics portion of the Terra Nova. This linear mixed-model methodology concluded that students of the teachers who scored in the top quartile demonstrated gains in their scores, which suggests that improving the quality of teachers' knowledge may decrease the mathematics disparity gap in our educational system (Ball, Hill, & Bass, 2005).

Examinations of this specialized knowledge for teaching mathematics became more developed in subsequent studies. In 2008, Ball et al., identified specific domains in MKT. MKT was separated into two main categories: subject matter knowledge and pedagogical content knowledge. Subject matter knowledge includes common content knowledge, horizon content knowledge, and specialized content knowledge. Common content knowledge refers to the mathematical knowledge and skills used in settings other than teaching. This may involve vocabulary and calculations essential for a teacher to know, but not exclusive to the teaching setting. This knowledge may also be valuable in other specialized professions. The term "common" implicates knowledge that most possess (Ball et al., 2008). Horizon knowledge is the attentiveness of how mathematics themes are sequenced and explored throughout the curriculum (Ball et al., 2008). This is the ability of a teacher to not only present content for that specific point in time, but to make connections to future advanced mathematics content. Horizon knowledge is an understanding of the vertical progression across grade levels.

Ball et al. (2008) define specialized content knowledge as the knowledge and skills distinctive to mathematics teaching. These skills and knowledge are not usually observed in other professions. An example would be a teacher providing a deep understanding of the importance of finding common denominators when adding fractions or explaining why a non-standard approach presented by a student may or may not be applicable for all situations (Ball et al., 2008).

The second domain of the MKT model (Ball et al., 2008) is pedagogical content knowledge. Included in this domain are the subcategories of knowledge of content and students, knowledge of content and teaching, and knowledge of content and curriculum. Ball et al., describe knowledge of content and students as a domain that combines knowing about students and mathematics. This also encompasses common student understandings and misunderstandings. Knowledge of content and teaching combines knowledge about teaching and an in-depth understanding of mathematics. Knowledge of content and curriculum and knowledge of programs and instructional materials are the final categories and is derived from Shulman's (1986) views of curricular knowledge (Ball et al., 2008).

Charalambous (2010) used an exploratory mixed-method study examining a series of lessons facilitated by two elementary school teachers with varied levels of mathematical knowledge for teaching. The Mathematical Tasks Framework (MTF); a framework that decomposes teaching in three phases- task selection, presentation, and enactment (Charalambos, 2010) was applied to nine videotaped lessons from each teacher. After further quantitative and qualitative analysis evidence found positive associations between teachers' MKT and the cognitive level in which tasks in their lessons are enacted. Furthermore, Hill (2010) discovered that elementary teachers had more difficulty successfully answering questions specifically related to specialized and pedagogical content knowledge categories of MKT, in comparison to the common content category on number and operations topics on a multiple-choice assessment administered by The Learning Mathematics Teaching Project. Limitations of these studies include the small sample size N= 625, unidentified biases of participants' beliefs about teaching and learning, student demographics and the curriculum materials utilized for comparison (Charalambos, 2010; Hill, 2010).

In summary, these studies provide a snapshot of the increasing body of literature involving measuring teachers' MKT and student achievement (Ball et al., 2008; Charalambos, 2010; Hill et al., 2008; Hill, Rowan, Ball, 2005). While there is considerable research evidence that correlate student performance to teacher mathematics knowledge, as detailed in the aforementioned, there continues to be a lack of agreement in the literature as to what teachers need to know about mathematics to teach it well (Kajander, 2010). This type of mathematical knowledge required of mathematics teachers is different from that of other professions where having a strong mathematical foundation is central (Wu, 2009). The challenge is the ability to address the inadequacies of teachers' mathematical knowledge, making it necessary for teachers to have the skill set to represent mathematics concepts in multiple ways, as well as have the professional capacity to analyze student work and prescribe an intervention that will extend students' knowledge (Ball, Hill, & Bass, 2005; Ball, Thames & Phelps, 2008). Until U.S. teachers are equipped with a level of expertise equivalent to teachers in other higher-performing countries, mathematics specialists must be prepared to support teachers in such content challenges.

The Need for Specialized Mathematics Positions at the Elementary Level

The NCLB educational authorization and similar reform measures have brought about stringent regulations focused on improving the quality of instruction and student achievement (Borek, 2008). This resulted in a redefined focus toward learning and instructional practices to address the urgent need to increase the mathematical knowledge and expertise of elementary teachers (AMTE, 2013; Archibald, Coggshall, Croft, & Goe, 2011; Ball, Hill, & Ball, 2005; DuFour, 2004; Hill, Rowan, & Ball, 2005; Hord, 2004; Killion & Harrison, 2006; Lieberman & Miller, 2001; Richardson, 2003; USDOE, 2002). The curriculum shift recommended by the NCTM *Standards* has placed significant implications for instructional practices in the mathematics classroom (Ball, Hill, & Bass, 2005; Hill, Rowan, & Ball, 2005; Herrera & Owens, 2001; Leinwand, 2012; Schoenfeld, 2004). As a result of the focus on improving scores, changing curriculum, and drastically different instructional practices- new ideas were required to face this challenge. Two of these are the MS and MC in this study. Other similar specialized positions and alternative certifications have also been developed (Chval et. al., 2010; McGatha, 2009).

Policy within No Child Left Behind (NCLB) has prompted many states to create, implement, and concentrate professional development efforts to specialist models to improve reading, mathematics, and science achievement levels of students (Campbell, 2012; Chval, et. al., 2010; Killion & Harrison, 2006; Sailors & Shanklin, 2010; Showers

& Joyce, 1996). Research documented by the U.S. Department of Education (1998) suggest that one effective mean to address the disconnect between teacher practice and state and district mandates, is to restructure federal, state and local resources specifically tailoring these resources to serve as a catalyst for school transformation. Currently, there are 19 states that offer professional designations for elementary mathematics specialists, certification and endorsement programs (AMTE, 2013; EMS&TL Project, 2015). With many states still without endorsement programs, and varying descriptors of elementary mathematics specialists by state, several districts are relying on rubrics, models, and professional standards to improve instructional practices of teachers. In order to support adult learners specific content and pedagogical knowledge and skills are required.

Development of elementary mathematics specialist standards. Despite empirical evidence on how teacher leaders improve instructional practices, several publications and initiatives with clearly defined roles, dispositions, and the necessary knowledge and skills by leaders have been issued. The "Teacher Leadership Skills Framework" (CSTP, 2009) delineated the knowledge and skills, dispositions, roles, and opportunities of teacher leaders. Divided into five main categories of teacher leader knowledge and skills: including working with adult learners, communication, collaboration, knowledge of content and pedagogy, and systems thinking. Some of the dispositions of teacher leaders listed in the framework include, but are not limited to, reflective practitioners, lifelong learners, risk-takers, and a positive and unwavering sense of perseverance that provides consistency to the organizational structure. Also provided in the framework are the various roles of teacher leaders, some of which are instructional coaches, Teacher on Special Assignment, data coach, team leader, and resource provider.

The Teacher Leadership Competencies (Center for Teaching Quality et al., 2014) were created to provide a vision for transformative teacher leadership. Developed by the National Board for Professional Teaching Standards (NBPTS), and National Education Association (NEA) as part of their Teacher Leadership Initiative (TLI) partnership, the standards address three vital pathways: association, instructional, and policy leadership. These competencies serve as a reflective resource for teachers. A rubric-style chart lists the competencies and then provides descriptions of emerging, developing, performing, and transforming qualities for each.

McGatha and Bay-Williams (2013) presented and reviewed a framework called Leading for Mathematical Proficiency. They examined how mathematics specialists employ standards for mathematical practice to modify current classroom practice and teaching skills. Additionally, Fennell, Kobett, and Wray (2013) have created a leadership framework for mathematics specialists, sharing and identifying related components of leadership for elementary mathematics specialists.

It is clear with the influx of EMS endorsement programs, academic coaches and specialists positions have become instrumental in professional development models, designed to systemically improve instructional practices in mathematics and comply with federal and state mandates (Campbell & Malkus, 2009; Kiriakidis & Ash, 2010; Sailors & Shanklin, 2010). The expertise and skills essential of specialists presented in these frameworks advises how specialists might be prepared to handle their duties. MS and MC positions not only support the instructional needs of teachers and students, but also serve in various other leadership capacities within a school (Fennell, Kobett, & Wray, 2013).

Teacher leaders. The mathematics teacher leader has become the most common model for mathematics support in elementary schools (AMTE, 2013; Fennell, 2011; Fennell, Kobett, & Wray, 2013; Gabriel, 2005; McGatha, 2010). Elementary mathematics specialists, as defined by the Association of Mathematics Teacher Educators (ATME) (2013), are “teachers, teacher leaders, or coaches who are responsible for supporting effective mathematics instruction and student learning at the classroom, school, district, or state levels” (p.1). Despite having the mutual goal of supporting the teaching and learning of elementary mathematics, the roles and responsibilities of these teacher leaders differ greatly in schools and districts across the county (AMTE, 2013; Campbell & Malkus, 2008; Fennell, Kobett, & Wray, 2013; Gabriel, 2005; McGatha, 2010).

The placement of mathematics specialists in elementary schools is not a new practice. In fact, specialized positions to support the departmentalization of elementary schools were first recommended in the 1920s (Fennell, 2011).

> Mathematics specialists at the elementary school level are becoming increasingly important as we acknowledge the complexities of elementary mathematics teaching and learning. But how did this all get started, anyway? Calls for mathematics specialists, mathematics coaches, or elementary mathematics instructional leaders are certainly not new to the mathematics education community. (Fennell, 2011, p. 53)

The roles and identities of teacher leaders have evolved over the years. York-Barr and Duke (2004) depict this evolution as occurring in waves. Initially, teachers served in formal roles in addition to their classroom responsibilities. Leadership roles such as grade-level chair or department chair where designed to make day-to-day school operations more effective. In the second wave, there was a shift to capitalize on teachers' instructional expertise to influence positive change. These roles later evolved to staff developers, mentor teachers, and curriculum leaders. In the last wave, teacher leaders became the primary change agents needed to cultivate a collaborative school culture (York-Barr & Duke, 2004).

Reys and Fennell (2003) identified two models of mathematics specialists: the lead teacher and the specialized teaching assignment. In the lead teacher model, the elementary teacher is released from all classroom responsibilities and accepts a mathematics leadership role in which she supports and mentors other educators at the building or district level (Reys and Fennell, 2003). This particular model can involve added resources as the classroom teacher is reassigned in order to fulfill her new leadership responsibilities. In the specialized teaching assignment model, a redistribution of teaching tasks occur, as the teacher is designated to provide mathematics instruction to a specific grade-level. This can be an advantage to a school district as additional personnel is not needed in this model, such as in the lead teacher model (Reys & Fennell, 2003).

The National Mathematics Advisory Panel (NMAP) (2008) reviewed all existing literature on elementary mathematics specialists and identified three types of mathematics specialists: “math coaches (lead teachers), full-time elementary mathematics teachers, and pullout teachers” (p. 43). The panel endorsed the use of elementary mathematics specialists and stated, “The use of teachers who have specialized in elementary mathematics teaching could be a practical alternative to increasing all elementary teachers’ content knowledge (a problem of huge scale) by focusing the need for expertise on fewer teachers” (NMAP, 2008, p. 44).

As Fennell (2011) indicated, specialists' positions are often titled "elementary mathematics coach." MAP (2008) stated, "Math coaches are more common than the other two types, but there is considerable blurring across types and roles" (p. 43). Parallel to Reys and Fennell's (2003) lead teacher model, NMAP (2008) defined math coaches as a resource for other educators, not a teacher who is responsible for direct instruction to students. The notion of a full-time elementary mathematics specialist is similar to Reys and Fennell's (2003) description of the specialized teaching model. These specialists provide mathematics instruction to students. The pullout teacher model has a slightly different approach than the specialized teaching model. In this model, the specialist provides individual or small group mathematics instruction in a different setting other than the regular mathematics classroom (NMAP, 2008). This small group structure can provide a differentiated instructional approach to teaching and learning by gaining a deeper understanding of how students think and learn mathematically. As Fennell (2011) implied, specialists typically are given the designation of elementary mathematics coach. Moreover, McGatha (2010) described MS as one who works primarily with students and a MC as one who works primarily with teachers. For the purpose of this study, I will continue to use the term specialist to refer teachers who provides content and instructional practices for students and coaches to refer to teachers who provides content and instructional practices for teachers. These are each explained in detail in the next two sections.

Elementary Mathematics Specialist

The implementation of elementary mathematics specialists was encouraged by the need for elementary teachers to have a deeper understanding of the mathematical content they are responsible to teach (NCTM, 2000). In order to support the progression of elementary mathematics specialists, it is vital to clearly define the knowledge and skills required. This section will provide information about AMTE's (2013) Elementary Mathematics Standards and the three critical areas a) content knowledge for teaching mathematics, b) pedagogical knowledge for teaching mathematics, and c) leadership knowledge and skills AMTE (2013) needed by elementary mathematics specialists.

The Association of Mathematics Teacher Educators (AMTE) has developed "Standards for Elementary Mathematics Specialists" (2013). These standards identify the fundamental expertise, dispositions, and proficiencies needed for mathematics specialists. This framework is also designed to support states in developing specialists certification programs needed to support "the mathematical knowledge and expertise of elementary staff" (p. 1).

The need for elementary mathematics specialists, MS in this study, is in great demand (AMTE, 2013; Fennel, 2011; Fennell, Kobett, & Wray, 2013; National Council of Teachers of Mathematics, 2000; National Mathematics Advisory Panel, 2008; National Research Council, 1989). It has been recommended by the National Mathematics Advisory Panel (2008) that every elementary school in the United States have access to elementary mathematics specialists. Furthermore, AMTE (2013) "encourages states to address the urgent need to increase the mathematical knowledge and expertise of elementary school staff by establishing an elementary mathematics specialist (EMS) license, certificate, or endorsement" (p. 1). Because of the high qualifications listed below, the costs are higher, the number of schools implementing specialists is lower, and past and current research is scant. This research may contribute to this dearth of research on specialists.

AMTE (2013) has identified three critical areas for these agents of change. These areas are: content knowledge for teaching mathematics, pedagogical knowledge for teaching mathematics, and leadership knowledge and skills.

Content knowledge for teaching mathematics. Elementary mathematics specialists require extensive content understanding specific to the teaching of elementary mathematics (ATME, 2013; NMAP, 2008; Wu, 2009). AMTE (2013) identified two types of essential content knowledge: deep understanding of mathematics for grades K-8 and further specialized mathematics knowledge for teaching.

Deep understanding of mathematics for grades K-8. As reflected in the vision of the NCTM *Standards* (2000), the knowledge for mathematics instruction for grades K-12 are expected to know in the areas of number and operations, algebra, geometry, measurement, and data analysis and probability. In order to support and develop the mathematics proficiency of students, it is crucial that elementary mathematics specialists have strong foundational skills in mathematics content and pedagogy (ATME, 2013; McGatha, 2010).

Pedagogical knowledge for teaching mathematics. Three main areas for pedagogical knowledge for teaching mathematics have been identified by AMTE (2013). These areas are: understanding learners and learning, teaching, and curriculum and assessment. Besides a deep understanding of content, elementary mathematics specialists must possess specialized mathematics knowledge for teaching (AMTE, 2013). Teachers must also be able to provide multiple learning opportunities for students that support learning of new mathematical ideas and practices (AMTE, 2013; NCTM, 2000). Furthermore, teachers must support students' mathematical understanding with both abstract and procedural fluency, identifying mathematical misconceptions and inaccuracies as well as knowing how to provide guidance to support their own meaning and knowledge of the content (AMTE, 2013; NCTM, 2000).

Understanding learners and learning. Elementary mathematics specialists need extensive knowledge of learners and learning of mathematics. This involves identifying, building upon, and justifying students' current knowledge, thoughts, and even misconceptions (AMTE, 2013). The underlying constructivist theories of teaching and learning that undergird the NCTM standards denote a deference for students' thinking. That is, the mathematics specialist is the person who can recognize particular forms of student thinking and help students' to construct accurate understanding using what they are thinking as a foundation. MS guide learners through the construction process described by constructivists theorists.

Teaching. Elementary mathematics specialists must also be experts in the teaching of mathematics. Proficient teaching skills, for any curriculum area, include structuring the diversities present in every classroom, examining and evaluating student opinions and work, and using flexible instructional formats such as whole group or small group arrangements to meet specific learning needs of students. Teaching in mathematics requires knowing when to inquiry more into students' responses, creating and assessing multiple representations of mathematical ideas and practices, and modeling efficient problem solving and mathematical practices. (AMTE, 2013).

Knowledge of curriculum and assessment. Elementary mathematics specialists should understand mathematical learning paths of students. This includes understanding the sequencing and progression of mathematical ideas, using several approaches to measure students' mathematical understandings, selecting and modifying as needed mathematical teaching materials, evaluating the alignment of local and state curricula, selecting and designing student assessment tasks, and analyzing formative and comprehensive assessment outcomes (AMTE, 2013). Formative assessments and other evaluating representations are used to inform instructional practices to gain a deeper understanding about the learners and how they are making connections to the mathematics content. Knowledge of content and instruction combines knowing about teaching and knowing about mathematics (AMTE, 2013).

To summarize, MS need both content knowledge and pedagogical content knowledge. As earlier segments discussed the content knowledge they need has been described as deep knowledge, but also discussed in depth as MKT. In terms of pedagogical knowledge, teachers have three basic areas they need more learning in a) understanding of learners and learning, b) teaching, and c) curriculum and assessment. These criteria for the MS show that the NCTM (2000) presented a coherent vision for mathematics education clearly articulated in the *Standards* that stated boldly that teachers lack the math content knowledge required to best educate 21st students. The constant plea for improvement in the teaching and learning of mathematics has encouraged a number of probable solutions (Reys & Fennell, 2003). With clear expectations reinforced for elementary mathematics, specialized teacher models were created to support this movement: the mathematics coach and the full-time mathematics specialist, and the pullout teacher (Fennel, 2011; NMAP, 2008; National Research Council, 1989; Reys & Fennell, 2003). For two decades, efforts to increase teachers mathematical knowledge has boomed (Ball et al., (2008); Charalambos, 2010; Hill et al., 2008; Hill, Rowan, Ball, 2005).), and more recent recommendations for elementary mathematics specialists license, certificates and endorsements are paving the way forward in improving mathematics instruction (AMTE, 2013; McGatha, 2010; NMAP, 2008).

Mathematics Coaches

In contrast to the use of MS, placement of academic coaches in many K-12 school districts has become part of the organizational structure to improve the quality of education available to all students (Chval et. al., 2010; Killion & Harrison, 2006; Obara, S., & Sloan, M., 2009; Sailors & Shanklin, 2010; Showers & Joyce, 1996). The NCTM's *Principles and Standards for School Mathematics* declares that student knowledge is dependent on the academic proficiencies that teachers provide to students in the context of the learning environment (NCTM, 2000). This requires teachers to have a deeper understanding of mathematical pedagogy that support the diverse learning needs of students. As recommended by the NCTM (2000), the placement of MC in elementary classrooms serves as a means of providing continuous job-embedded professional development necessary to produce more highly skilled mathematics teachers. In this section, general information will be reviewed, but a large portion of this section will investigate an equally important body of research about peer coaching, including implications for professional development and for professional development learning communities.

Historically, interventions in teaching and learning were largely introduced in classrooms without an analysis of what was essential to positively impact student performance and teacher efficacy (Ball & Cohen, 1996). The willingness of teachers to engage in innovative instructional practices and strategies is dependent on if a collaborative structure of support with colleagues becomes part of the structural framework (DuFour & Eaker, 1998; Polly, D., 2012). Recent educational policies and reform programs have urged school districts to consider mentoring and coaching of teachers as a model of professional development to support the implementation of new practices, such as reduced class schedules, teacher mentoring, and team teaching (NCLB [2113(c)(2)(A-B)]; Obara, & Sloan, 2009; Sailors & Shanklin, 2010; Polly, 2012). Ohio, has adopted the Quality Impact Team, a coaching model collaborative partnership between the Center for Essential School Reform and the Ohio Department of Education to support high-needs schools. National Commission of Teaching & America's Future (1996), National Staff Development Council (2001), and other teacher quality organizations have identified a consistent set of effective components for professional development programs, including teacher peer coaching.

Peer coaching provides a mechanism through which teachers can engage in a interactive process to gain deeper understanding of best instructional practices and overall improvement in teaching and learning in schools (Becker, 2001; Obara, S., & Sloan, M., 2009; Polly, D., 2012). The concept of peer coaching is not a new practice in education.

In their analysis of coaching research, Joyce and Showers (1980) concluded that numerous types of support were required to effect improvements or changes in the classroom. In their article entitled, "Improving Inservice Training: The Message of Research", Joyce and Showers (1980) evaluated over 200 students and discovered essentially five modes of training were defined in the literature:

1. Presentation of theory or description of skill or strategy,
2. Modeling or demonstration of skills or models of teaching,
3. Practice in simulated and classroom settings,
4. Structured and open-ended feedback (provision of information about performance),
5. Coaching for application (hands-on, in-classroom assistance with the transfer of skills and strategies to the classroom). (p. 380)

Coaching, as a model within the realm of teacher education, was first presented by Joyce and Showers in the 1980s as an on-site dimension of PD to encourage transference of new learning strategies and curriculum into general practice (Chval et. al., 2010; Joyce & Showers, 1980; Showers & Joyce, 1996). After implementing other coaching models, Joyce and Showers (1982; 1996) concluded that teachers involved in peer coaching could afford teachers with opportunities to investigate and apply newly learned concepts and with consistent coaching could transform existing instructional practices. The researchers wanted to make clear that learning new theories alone did not automatically transfer into the classroom in the form of improved instructional practices. Teachers involved in a coaching relationship applied new skills and strategies more regularly and applied them more appropriately than did teachers who worked in isolation.

More recently, Shidler (2009) applied a marginally different coaching strategy in her research of math coaches as she employed a model of collaborative conversation and observation between coach and teacher with the purpose of addressing what she termed "instructional efficacy" (p. 453) over a three-year period. Shidler (2009) explained:

> It is imperative to build levels of teacher efficacy as they move toward best practices in the classroom. To do so coaches need to focus on specific content model techniques and instructional practices, observe teacher practices, and dedicate consultative hours to working with teachers . . . to better facilitate reflection. (p. 459)

A significant correlation was observed during the first year of the coaching model with a focused instructional goal in place. Specifically a Kendall's τb correlation was calculated at 0.592 with a 95% confidence level. However, during the second and third year of implementation, a significant correlation was not observed. The researcher indicated that during the last two years of implementation, a less specific instructional focus was employed, despite coaches increased time on site (Shidler, 2009). This led Shidler (2009) to recognize that merely increasing the number of hours that coaches spent in the classroom did not always produce positive student achievement by the students but more a function of "the *type and quality of interaction"* (p. 459).

The objective of peer coaching is not evaluative, rather the process is to establish a collaborative structure to encourage collegial reflective practices to address instructional problems, providing instructional support for one another and promote teacher knowledge and skills (Becker, 1996; Latz, Speirs Neumeister, Adams, & Pierece, 2009; Shidler, 2009; Showers & Joyce, 1996). According to the research literature, numerous staff development practices can be identified as a form of peer coaching (Shidler, 2009; Showers & Joyce, 1996).

Types of Peer Coaching Roles

The literature lists several variations of the term *peer coaching*. These variations include, but are not limited to, *technical coaching, collegial coaching, team coaching, cognitive coaching,* and *challenge coaching* (Showers & Joyce, 1996; Wong & Nicotera, 2003). Based on the employed professional development strategies, the identified terms emerge into three distinct categories: *collegial and cognitive coaching, technical and team coaching, and challenge coaching.* Collegial and cognitive coaching is designed to improve current teacher practices in a noncompetitive structure where mutual trust is established through collaboration and reflective practice (Becker, 1996; Showers & Joyce, 1996). The second model, technical and team coaching is a structure where a highly skilled and knowledgeable teacher is paired with another teacher to help refine or develop a new instructional technique (Becker, 1996; Showers & Joyce, 1996). The third type of coaching, challenge coaching, is an action-oriented model that involves a team of teachers who have expertise that can provide a solution to a complex problem that extends beyond the classroom.

Joyce and Showers (1982) theory on peer coaching was used to engage teachers in a form of professional development that would improve their instructional practices in the classroom, and subsequently, student achievement. The peer coaching model has the potential to go beyond Standards, and actually influence a change in student achievement, instructional practices, and teacher knowledge of mathematics because it is action based. The purpose of the peer-coaching model as described by Showers and Joyce (1996) was that the teacher in the role of observer, was not to critique or evaluate the lesson, but rather to learn from it and to coach each other in a reciprocal way. Showers and Joyce

(1996) stressed their precise definition of a coach with italics: *when pairs of teachers observe each other, the one teaching is the 'coach' and the one observing is the 'coached'"* (p.15). According to this particular model of peer coaching, teachers did not offer one another with "verbal feedback" (p. 15). Instead, the objective was to openly engage in more "collaborative planning" (p.15). Rather than one teacher providing another with a review of a lesson, as typically found in formal evaluation, the intent was to have "teachers learn from one another while planning instruction, developing support materials, watching one another work with students, and thinking together about the impact of their behavior on their students' learning" (p. 15). They encouraged a form of peer coaching:

> If we had our way, *all* school faculties would be divided into coaching teams who regularly observe one another's teaching and provide helpful information, feedback, and so forth. In short, we recommend the development of a 'coaching environment' in which all personnel see themselves as one another's coaches. (p. 6)

Despite the differences among the peer coaching strategies, the overarching goal is to develop systems of support to improve teaching and learning. However, it is important to note that objectives for the coaching experience must be clearly defined, established and negotiated between the teacher and the coach in order for the relationship to move from consulting to collaboration (Joyce & Showers, 1980, 1982, 1996; McGatha, 2008).

Overall, the results of studies on peer coaching seem to differ. Most notably recognized by Joyce and Showers (1980, 1982), peer coaching was commonly implemented as a form of professional support to improvement instructional practices. Other researchers discovered teachers' hesitancy to participate in the peer coaching model as a limitation of this research. In their examination of a program that addressed one school's need to differentiate instruction, Latz et al. (2009) found that teachers' active participation with and commitment to the program were key components for the success of the coaching relationship. Many teachers refused to participate in the program due to time constraints, required curricula, and diverse students need deterred teachers' attentiveness in becoming involved in the program.

Latz et al. (2009) described in their grounded theory qualitative research study of a mentoring program parallel in design to the peer coaching model, a system that provided support to teachers attempting to differentiate their instruction in third, fourth and fifth grades, with a specific focus to address the gifted and talented students in their classrooms. The program included seven mentoring teachers observing 30 teachers in their classrooms three times over the duration of three consecutive spring terms. The objective was to provide the mentored teachers with non-evaluative and non-judgmental feedback. As a result of this study, Latz et al. (2009) stated that the teachers and the mentors considered this support program "beneficial within the context of developing differentiation strategies" (Latz et al., 2009, p. 34); however, the teachers voiced many challenges and concerns. Several teachers were afraid that involvement in the mentoring program would require them to stray from mandated state requirements, possibly ensuing in decreased scores among their students on the standardized tests (Latz et al., 2009). Other teachers questioned their capacity in meeting the diverse needs of learners. The chief protest what that there was not enough time to adequately perform these responsibilities in addition to other day-to-day school operations (Latz et al., 2009). Despite the positive mentoring experience reported by teachers, only 36% expressed having greater comfort with differentiation as a outcome of the mentoring program (Latz et al., 2009).

Role in professional development. Professional development has been instrumental in creating systematic efforts to transform instructional practices of teachers, contribute to their professional development, and expand their capacity to effect positive student change (Becker, 2001; Guskey, 2002; Killion & Harrison, 2006). The placement of highly qualified MC in elementary schools has been associated with improving mathematics instructional practices of teachers through continuous on-site job embedded professional development efforts to support instructional practices of classroom teachers (Becker, 2001; Campbell & Malkus, 2013). As Campbell and Malkus (2014) wrote, "The role of the specialist or coach is to support the improvement of mathematics teaching and learning in schools by targeting teachers' understanding and action" (p. 213-214). Math coaching has become more prevalent in educational settings in the U.S., partly because of the lasting ineffectiveness of detached professional development workshops (Chval et al., 2010). Coaches are not only applying their knowledge in their own practice; they are also identifying and supporting other teachers in their knowledge development across time (AMTE, 2013; Latz et al., 2009).

It is perceived that changes in adult behaviors (attitudes, beliefs, and perceptions) will transfer to specific and observable changes in teacher instructional practices organically (Guskey, 2002; Killion & Harrison, 2006; Mudzimiri, R., Burroughs, E. A., Luebeck, J., Sutton, J., & Yopp, D., 2014). However, the rising amount of failing schools, despite an increase in professional development opportunities for teachers, confirmed that fragmented and unaligned professional development experiences would not improve teacher performance and student achievement (Killion & Harrison, 2006). This phenomenon of ineffective professional development has forced districts to closely examine and tailor existing professional learning job-embedded initiatives. Many school districts are depending on highly knowledgeable MC to provide richer learning experiences as an effective model for continuous school improvement (Becker, 2001; Campbell & Malkus, 2013; Guskey, 2002; NCTM, 2008).

Guskey's (1986) model of professional development continues to guide the framework used by many districts in an attempt to create more effective professional development programs. He believes that professional development begins with teachers establishing goals aligned with desired learning outcomes of their students. When teachers are part of the decision-making process they take ownership of the process and are driven to voluntarily engage in training sessions and incorporate what they have learned in the classroom setting. With on-site Mathematics Coaches collaborating regularly with classroom teachers, planning and learning together, and fully engaging in the work, a shared vision gradually developed (Becker, 2001; Campbell & Malkus, 2013). It is important to reference the work of Shidler (2009) again that proclaimed student achievement is dependent on the quality of collaboration more so than the allocated time that coaches spent in the classroom.

Another essential element in Guskey's (1986) model that many professional development programs fail to consider is the progression of teacher change. This perspective of teacher change is based on the notion that change is a learning process for teachers that is developmental and heuristically based. Substantial changes in teachers' attitudes and beliefs towards new instructional practices only occur after implementation of these practices are evident in student achievement results, which is key to the sustainability of these instructional improvement practices (Guskey, 2002; Killion & Harrison, 2006).

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 14 teachers and six coaches. Participating coaches engaged in extensive professional development opportunities both in summer institutes as well as follow-up sessions with skilled mathematical educators. Becker reported her observations of three coaching designs: collaborative, modeling, and directive. All coaches conducted pre-conferences, planned curriculum, modeled, or co-taught during teacher instruction and held a debriefing conference with the teachers to discuss the outcomes of the experience. Independent of the coaching style, the experience was positive for teachers. As a result of the peer coaching experience, teachers changed their instructional practices. They felt more confident in their instruction of mathematics and they developed a stronger understanding of the curriculum. McGatha (2008) conducted two case studies of mathematics coaches and found a positive change in particular instructional practices as an effect of coaching. Noted changes included an increase in detecting students' misconceptions and understandings during lessons as well as improved reflection about the implemented instructional practices.

Olson and Barrett (2004) led three case studies where they conveyed contrasting views of coaching to influence mathematics teachers' instruction. Part of a large scale project of 337 elementary teachers, school district administrators, and mathematics education faculty, the researchers served as coaches in this case study to three first-grade teachers and modeled instructional methods to the teachers that supported students generating mathematical positions. However, the teachers lacked the capacity to dismiss preconceived notions about teaching and learning mathematics to implement with fidelity the demonstrated instructional methods. As a result, the researchers characterized the teachers as resistant to change. The researchers proposed that a different style of coaching than the one used for this study should be investigated to foster the desired professional growth.

Effective professional development that has the capacity to create systemic change must be ongoing, aligned with previous professional learning activities and where teachers are actively involved in the process (Archibald et al., 2011; Becker, 2001; Campbell & Malkus, 2010, 2013; Guskey, 1986; Killion & Harrison, 2006). These learning activities must also be delivered in a way that yields direct improved results, encourage teacher buy-in and establish the opportunity for teachers, school leaders and professional support to better meet the individual needs of students (Archibald et al., 2011; Becker, 2001; Campbell & Malkus, 2010, 2013; Guskey, 1986).

In a three-year randomized control study, Campbell and Malkus (2010) unearthed that teachers who were “highly engaged” (p. 25) with their mathematics specialist differed considerably in their beliefs when compared to the teachers’ beliefs in the control schools without mathematics specialists. The beliefs survey asked participants to answer a 20-item instrument, with 10 additional items addressing equity and directed instruction, by means of a Likert scale (strongly agree to strongly disagree) on items reflecting their perceptions about mathematics curriculum and instruction and their perceptions about the essential needs of students and the nature of students’ mathematical understanding. The reliability of the total 30-item scale as indicated by Cronbach's alpha was .797. Factor analysis of the scale recognized two main belief themes: "traditional" and "making sense" (Campbell & Malkus, 2010, p. 8). Traditional items highlighted directed teaching and making sense items highlighted the progression of students' knowledge through supporting students in "making sense" of the mathematics being taught. Teachers extremely involved with their specialists had limited traditional perspectives and more making sense perspectives when compared with teachers in schools without a mathematics specialist. Conversely, teachers in a school who chose not to engage with a mathematics specialist, displayed minimal changes in their beliefs. Teachers' attitudes and beliefs about professional development in this study were also positively affected by engaging with specialists (Campbell & Malkus, 2010). Teachers in the schools with elementary mathematics specialists were also more inclined to participate in other professional development opportunities focused on improving mathematics content and pedagogy than their education colleagues in the control schools. The researchers continued by stating "Simply allocating funds and then filling the position of an elementary Mathematics Specialist in a school will not yield increased student achievement" (p. 25).

The literature makes it clear that school systems with on-site full-time mathematics support can contribute to a shared professional culture in which teachers capitalize from the content expertise of colleagues. This collaborative relationship not only supports the professional culture of teachers, but also creates a high-quality professional learning environment with increased student achievement over an extended period of time (Archibald et al., 2011; Becker, 2001; Campbell & Malkus, 2010, 2013; Guskey, 1986; Killion & Harrison, 2006).

Role in professional development learning communities. In an attempt to promote collegial discourse that will ultimately increase effective mathematics instructional practices, many schools are moving away from traditional staff meetings and are instead establishing collaborative structures and processes facilitated by MC. Unlike staff development meetings or workshops, professional learning communities are ongoing and meet regularly to thoroughly examine problems specific to their schools and investigate probable outcomes (DuFour, 2004; Glickman, 2002; Helmer, Bartlett, Wolgemuth, & Lea, 2011; Lambert, 1998; Schmoker, 2006; Zambo, & Zambo, 2008).

Most importantly, schools that function as professional learning communities have a focus on student learning and collegiality among teachers to support instructional practices (DuFour, DuFour, Eaker & Many, 2006; Sawyer, 2001; Yopp, Burroughs, Heidema, Mitchell, & Sutton, 2011; Zambo, & Zambo, 2008). Historically, interventions in teaching and learning were largely introduced in classrooms without an analysis of what was essential to positively impact student performance (Ball & Cohen, 1999). The implementation of professional learning communities as a continuous professional development model creates a collaborative structure, allowing MC to serve as agents of change to the culture of teacher isolation. This structure also promotes dialogue among teachers, creating an environment of trust and openness, allowing teachers to be more receptive to modifying their instructional practices collectively (Campbell & Malkus, 2013; Helmer, Bartlett, Wolgemuth, & Lea, 2011; Yopp, Burroughs, Heidema, Mitchell, & Sutton, 2011; Zambo, & Zambo, 2008).

In *Professional Learning Communities at Work Plan Book*, DuFour, DuFour, and Eaker (2006) presented four critical questions of learning to support and guide collegial discourse. The questions are: What is it we expect them to learn? How will we know when they have learned it? How will we respond when they do not learn? How will we respond when they already know it (p. 8)? Schools focused on increasing student achievement are not afraid to ask these challenging questions to help generate data on their learners and to help modify and strengthen instructional practices. Utilizing the expertise of MC to guide collaborative sessions can provide immediate support to teachers with limited understanding of mathematical content and pedagogy.

Before learning communities can address issues of teaching practices, a non-threatening environment must first be cultivated. Specific provisions must be in place for a group of teachers to transform into an effective collaborative team. Research conducted by Dukewits and Gowin (1996), identified the following prerequisites that should be embedded in the organizational design of any team. These characteristics are: (a) shared beliefs and attitudes, (b) high levels of trusts, (c) authority to make decisions, (d) established norms and organizational structures, and (e) ongoing assessment of the function of the team (pp. 120-121). The benefits of this method of coaching have been documented in recent years. Cave and Brown (2010) detailed an account of a "project between a university and a charter school aiming to increase young elementary students' math achievement while providing pre-service teacher candidates meaningful opportunities and rich teaching experiences" (p. 2). These researchers discovered that the mentoring program had a positive effect on both instructional practices and student achievement. Teams that have adopted and embedded these common characteristics within the culture of the community have a greater chance of building and sustaining a positive learning community.

To support this kind of change, content coaches who are experts in their areas are joining collaborative sessions and sharing their expertise with their colleagues (Guiney, 2001; Sawyer, 2001; Thomas, 2008). Although this new shift in thinking has the potential to promote positive change, this task does not come lightly. As chronicled by Guiney (2001):

> This is not the world for the faint-hearted. To do it well requires a calm disposition and the trust-building skills of a mediator combined with the steely determination and perseverance of an innovator. Add to this mix the ability to know when to push and when to stand back and regroup in the long-term proves of adopting new approaches to galvanize a school to function differently. To succeed, a coach must be a leader who is willing not to be recognized as such and, at the same time, who is able to foster leadership among teachers who rarely regard themselves as leaders. (p. 741)

With extensive professional development courses in content and leadership, many MC can effectively navigate this process essential to facilitate growth of reflective practitioners who are able to analyze questions and to grapple with new knowledge independently and collectively (Sawyer, 2001).

Campbell and Malkus (2011) presented the outcomes of a 3-year randomized experimental study designed to investigate whether placing mathematics coaches in elementary schools affected student achievement in grades 3, 4, and 5. Thirty-six schools from five urban and suburban school districts were represented in this study (sets of three schools each). The study controlled for teacher experience, prior school academic performance in mathematics, student demographics, and school size. Twelve school sites served as treatment sites during the first year of implementation involving 24,759 students in the treatment and control groups. Math 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 school placement. Mathematics achievement scores were compared to determine mathematics specialists' influence on student achievement. Findings indicate in all three grades the Cohort 1 coefficients were positive and significant in schools where an elementary mathematics coach was employed over an extended period of time. Mathematics coaches increased student achievement between 0.14 and 0.19 standard deviations. The researchers warned that typical results could not be expected during the first year of implementation of a coach's placement. Furthermore, coaches in this project were required to participate in extensive professional development training in preparation for their specialist/coaching positions. The researchers cautioned that results should not be generalized to elementary mathematics specialists without proper preparation (Campbell & Malkus, 2011).

This framework of continuous job-embedded professional development not only provides a collaborative structure needed to strengthen teacher practice, but also support the feeling that many researchers have about the positive impact associated with having elementary MC to support student performance (Becker, 2001; Campbell & Malkus, 2011; 2013; Guskey, 1986; Mudzimiri, R., Burroughs, E. A., Luebeck, J., Sutton, J., & Yopp, D., 2014).

This literature review on MC explored how this reform structure has evolved as one method of professional development and support in improving teacher mathematical instructional practices through continuous on-site job embedded professional development (Becker, 2001; Campbell & Malkus, 2013; Yopp, Burroughs, Heidema, Mitchell, & Sutton, 2011). The research findings on peer coaching proved positive if clearly defined objectives were established between the teacher and coach (Joyce & Showers, 1980; 1982; McGatha, 2008). The role of professional development is also vitally important in creating systematic efforts to transform instructional practices of teachers and increase their capacity to influence positive student change as part of the mathematics reform process (Becker, 2001; Guskey, 2002; Killion & Harrison, 2006). The results of research findings (Campbell & Malkus, 2013; DuFour, DuFour, Eaker & Many, 2006), on professional development learning communities identified a focus on student learning and collegiality among teachers to support instructional practices as specific functions that must be in place before a collaborative structure of trust and openness is fostered. Overall, MC positions offers a financially viable alternative to high cost MS and was often shown to be effective in supporting teachers' instructional growth and a quality alternative to one-shot lecture professional development.

Summary

School districts in the United States are under pressure to increase state mandated test scores in mathematics. Accountability measures and the creation of *Standards* during the last century have ignited an abundance of school-reform initiatives designed to improve the quality of mathematics education.

An emerging method of professional development to sustain improvement of mathematics teaching and learning on a large scale is the investment in positions such as MS and MC. Although empirical research is limited on the effectiveness of these specialized positions at the elementary level on student performance in mathematics (Fennell, 2011), recent research studies postulate that MS and MC have the unique opportunity to establish, develop and maintain collaborative networks of high quality mathematics teachers. Over a period of time, these networks may result in the ability to improve the quality and equity of teacher professional growth and student academic achievement leading to systemic social change in the field of elementary mathematics (AMTE, 2013; EMS&TL, 2009; Campbell, 1996; Campbell & Malkus, 2010; Fennell, 2011; McGatha, 2010; NCTM, 2000). As McGatha (2008) pointed out, additional studies need to be conducted to determine the effectiveness of these specialized models in the quest of improving excellence among both teachers and students in math education. The basic goal of this investigation is to compare student scores that had MS teaching them directly to student scores who had received instruction from Grades 1-8 credentialed teachers with MC.

Section 2 included a detailed discussion of the historic overview of mathematics reform, standards-based reform, prelude to national mathematics standards, the NCTM standards, opposition to NCTM standards, teacher mathematical content knowledge for teaching, the need for specialized mathematics positions at the elementary level, the development of mathematics specialist standards, the teacher as leader, the MS and MC models, types of peer coaching roles, and role of professional development in creating systematic structures to improve student achievement. Section 3 of this doctoral study presented the research design, the setting and sampling methods, and the treatments that were examined ex post facto. Additional quantitative data sources and their relationship to the study were also described.

Section 3: Methodology

Introduction

A quantitative, nonexperimental, casual-comparative study was used to determine if the States Mathematics Achievement Test scores of students in fourth grade who received instruction from a Math Specialists during the 2007–2008, 2008–2009 academic year demonstrated a statistically significant difference from the State Mathematics Achievement Test scores of fourth grade students who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach during the 2012–2013 and 2013–2014 academic year. These two year- periods were selected because they were comparable as they were the beginning 2 years for each program. The coach program only lasted for 2 years; afterwards coaches were optional for elementary schools. The research question examined in this study specifically addressed States Mathematics Assessment Test scores from the 2007–2008, 2008–2009, 2012–2013, 2013–2014 school years of fourth grade students in mathematics.

Fourth-grade mathematics test scores from 74 elementary schools, in a large urban public school district in the Midwestern United States, were used. The instrument and materials are the state mathematics assessments, which is the annual standardized test mandated by the state to monitor student progress in mathematics and other curricular areas. This chapter includes the research design and approach, the setting and sample, the treatment and instructional condition, instrumentation and materials, reliability and validity, and an overview of the collected data, and the data analysis for this study.

As a reminder, the research question examined in this study specifically addressed the State Mathematics Achievement Test scores of students in fourth grade. To compare the State Mathematics Achievement Test scores of fourth grade students, the following research question and hypotheses will guide this study:

Research Question 1: Is there a significant difference in fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, between students who received instruction from a Math Specialists (2007-2009) and Grades 1-8 credentialed teachers supported by a Math Coach (2012-2014)?

$H_0 1$: There is no statistically significant difference between fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, in students who received instruction from a Math Specialists and those who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach.

$H_a 1$: There is a statistically significant difference between fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, in students who received instruction from a Math Specialists and Grades 1-8 credentialed teachers supported by a Math Coach.

Research Design and Approach

The nonexperimental, casual-comparative design used in this study assisted in determining whether there was a statistically significant difference between the mathematics achievement outcomes of fourth grade students who received instruction from a Math Specialists and Grades 1-8 credentialed teachers supported by a MC. The research was appropriate for a quantitative method over qualitative due to the necessity for descriptive data collection. Casual-comparative studies involve comparison over correlation research in order to identify a cause-effect relationship between two sets of data (Brew & Kuhn, 2010), during different academic years on the fourth grade State

Mathematics Achievement Test. The nonexperimental design is a research methodology in which the researcher examines the archived data ex post facto in order to compare outcomes (Creswell, 2005).

Various research methods were considered to help determine the appropriate design for this study. The traditional use of qualitative data is to focus on a particular concept and to gain a richer understanding of the phenomenon (Creswell, 2003, p. 19). A mixed method analysis was also considered which would have involved interviewing teachers and quantitatively comparing student test scores. Both of these methods were rejected as the MS program ended after the 2011–2012 school year. Previous Mathematics Specialists who taught during the 2007–2008 school year returned to the classroom or transitioned into the new role of Math Coach, limiting the accessibility of these teachers.

A causal-comparative design with a quantitative approach was used to determine if the type of mathematics instruction (the independent variable) is related to mathematics achievement of fourth grade students (the dependent variable). A quantitative approach is best used to test a theory or explanation (Creswell, 2009). The design aligned well with this study because there are current theories available on which this research problem could draw, a MS framework and MC model was implemented and needed to be tested, which could help to understand the impact of these interventions on student achievement.

2007–2009 School Years

The Ohio school district implemented the MS Model. Fourth grade students received instruction from a MS. When students tested on the State Mathematics Achievement Test, the mathematics instruction resulted directly from the MS in the classroom environment.

2012 –2014 School Years

The Ohio school district implemented the MC Model. Grades 1–8 credentialed teachers provided mathematics instruction to all fourth grade students, with instructional support from a MC. When students tested on the State Mathematics Achievement Test, the mathematics instruction resulted directly from the Grades 1–8 credentialed teachers with support from the MC.

Comparing Math Specialists to Math Coaches for Standardized Test Achievement

This study took place after the end of the MS position and the return of Grades 1–8 credentialed teachers providing mathematics instruction to students after 4 years with a focus on reading instruction. This design was appropriate because casual-comparative studies are used to determine if independent variables affected the dependent variables after events have already occurred (Brew & Kuhn, 2010), also referred to as a type of ex post factor research study. This study can be theorized as a nonexperimental, ex post facto study, a slight variation of Creswell's pre-experiment, alternative treatment posttest only with nonequivalent groups design (p. 169). Creswell (2003) identified the pre-experiment as a treatment design without a pretest, followed by a posttest and comparison.

Mathematics achievement outcomes between the two groups of students who were taught under the MS and MC models were compared using descriptive and inferential statistical methods. The independent variable were the type of mathematics professional, either MS or MC. The quantitative non-experimental design was the ideal choice for this research study because the results needed to state if the MS or MC produced a statistically significantly different outcome in students' academic achievement using a *t* test. The test was conducted in QuickCalcs.

The 2007–2008, 2008–2009 spring State Mathematics Achievement Test fourth grade mathematics averaged scores were compared to the 2012–2013, 2013–2014 spring State Mathematics Achievement Test fourth grade mathematics average scores. Scores included only those falling into the proficient to basic range. An independent *t* test compared the combined test scores for the 2-year groupings of fourth graders. Thus the condition in the model was the independent variable of either MS or MC. The single quality measured, or dependent variable, was the students' fourth grade test scores.

Limited qualitative and quantitative studies have focused on the effectiveness of elementary MS and MC to increase student performance on standardized assessments (McGatha, 2009). The gap in the literature, and more importantly in the policy decision-making for this district, suggested that a quantitative study could provide valuable information by determining whether there is a statistically significant difference between the mathematics achievement outcomes of fourth grade students who received instruction from a Math Specialists and Grades 1-8 credentialed teachers supported by a Math Coach.

Setting and Sample

The total population for this nonexperimental, casual-comparative research study consisted of approximately 13,671 fourth grade students in the subject of mathematics. This study took place in a large urban public school district in the Midwestern United States. The mission of this district states that: “Each child is highly educated, prepared for leadership and service, and empowered for success as a citizen in a global community” (District Website). This school district, the largest in the state, is comprised of 23 high schools, including a Virtual Credit Advancement Online Program, 20 middle schools, 62 K-5 elementary schools, four PK-6 STEM academies, two language immersion academies and five K-6 schools, serving a total of more than 51,000 students in 116 schools.

For the purposes of this quantitative nonexperimental, causal-comparative study, a census sample of archived scores were used. The sample size from the MS population consisted of a combined total over the 2 years of 7,079 test scores. For the MC population the sample, it consisted of a combined total over the 2 years of 6,592 test scores. The total census sample is represented as $N = 13{,}671$. This sample size will account for 100% of the population of students who took the mathematics section of the State Mathematics Assessment, and not an alternative version of the test, for school years 2007–2008, 2008–2009 and 2012–2013, 2013–2014. The results from this sample may be generalized to the local population (Gravetter & Wallnau, 2005).

According to the 2011–2012 School Year Report Card on the ODE website, 10.3% of students are Limited English Proficient (LEP), 83.3% are economically disadvantaged, and 17.3% receive special education services. Besides English, more than

89 other languages are spoken through the district. While Black, non-Hispanic students represent 58.1% of the student population, American Indian or Alaska Natives, Asian or Pacific Islander, Hispanic, Multi-Racial, and white, non-Hispanic, represent 0.2%, 2.2%, 6.8%, 5.4% and 27.4% respectively, of the overall enrollment. All teachers have a Bachelor's Degree, 66.2% of teachers have a Master's Degree, and 98.5% of core academic subject elementary and secondary classes are taught by NCLB teachers.

This census sample included different teachers in different elementary school structures. Due to specialized programs within many of the elementary schools, such as language immersion academies, STEM, K-6 and K-8 structural designs, one control method for improving the casual- comparative research design and eliminating threats to validity (Brewer & Kuhn, 2011) was to only compare achievement results of fourth grade students who received mathematics instruction from a Math Specialists during the 2007–2008, 2008–2009 academic years and achievement results of fourth Grade 1–8 credentialed teachers supported by a Math Coach during the 2012–2013, 2013–2014 academic years from the same schools as the Math Specialists.

Mathematics Models for Comparison

This study was an ex post facto study where a treatment was not assigned to groups. In the fall of 2007–2008, the curriculum department reallocated federal dollars to create a MS program at the elementary and secondary level. This study focused specifically on the implementation of the MS position for fourth grade students who received mathematics instruction from a Math Specialists during the 2007–2008, 2008–2009 academic years and fourth grade students who received mathematics instruction from a Grades 1–8 credentialed teachers supported by a Math Coach during the 2012–

2013, 2013–2014 academic years. The purpose of this study was to determine if the mathematics instruction (the independent variable) was related to mathematics achievement, as measured by the State Mathematics Assessment Test, of fourth grade students (the dependent variable). The following is a description of the MS position that the district implemented during the 2007–2008 school year to combat low mathematics achievement of students.

Math Science Leadership Specialist Position (Math Specialist)

All eligible Title I funded schools implemented the MS position (Mathematics and Science Leadership Specialist Draft, 2007). The academic focus for elementary MS would shift from reading to mathematics, leaving the classroom teacher free to focus on language arts and social studies. The MS would be responsible for first-line instruction for mathematics using the district provided curriculum guides. District curriculum guides, pacing guides and supplemental lessons are based on the state academic content standards, benchmarks, and grade level indicators. These guides include a wide variety of instructional strategies that provide MS with aligned lessons that enable students to meet or exceed academic content standards as envisioned by the mathematics framework provided in the *Standards* (2000). In addition, MS collaborated quarterly with other MS to engage in purposeful professional development to improve the quality of mathematics instruction.

The redesigned format with specialist teachers at the intermediate (fourth and fifth grades) elementary schedule, funds through Title I, consisted of two generalists and a MS for each grade level: one classroom teacher in the morning and one in the afternoon. The generalists were responsible for all instructional content except mathematics and science.

During reading instruction, students were divided into two small groups. Half of the students remained in a generalist's classroom for reading instruction that included all components of the district's reading program, while the remaining students received 55 minutes of mathematics instruction and 25 minutes of science instruction during the 80 minutes block. The group then switched for the second 80 minutes block. In the afternoon, the MS worked with the second generalist utilizing the same rotation. The objective was for the generalists and the MS to become highly knowledgeable in their content matter, while providing effective instruction and enrichment support services to address the various learning modalities of students. One goal of reform-based education was the improvement of learning for all students.

Mathematics Coaches

The federally grant-funded MC position provided support for the entire school staff in the areas of mathematics curriculum, instructional teaching support, implementation of Professional Learning Communities, professional development, and assessment Leadership. District curriculum guides, pacing guides and instructional strategies were provided to MC with aligned lessons to support the implementation of the new Common Core State Standards and Next Generation Assessments for Mathematics. Specifically, Coaches supported generalist teachers in various ways, including co-planning/co-teaching lessons, analyzing student artifacts, gathering resources, and providing continuous job-embedded professional development. Similar to the MS with fourth grade students, MC engaged in purposeful professional development with mathematics teachers to support teachers in making positive changes to their instructional practice.

Instrumentation and Materials

The State Mathematics Achievement archival data stored by the Ohio Department of Education for school years 2007–2008, 2008–2009 and 2012–2013, 2013–2014 was used for this study. Because archival data was used, human participants were not needed nor were treatments administered, as these data have been previously collected and do not include individually identifiable student information. Confidentiality is extremely important to ensure that I cannot identify students, teachers, and schools.

The State Mathematics Achievement Test data is a criterion-referenced, state-mandated, end-of-year assessment that is administered annually in the spring that assesses the content outlined in Ohio Academic Content Standards. Test outcomes from the State Mathematics Achievement Test do not determine if students in grades 3 through 8 are promoted to the next grade or retained. This assessment measure measures where students score in comparison to other Ohio students and if the students meet or do not meet the Ohio standards.

The contractor who developed the State Mathematics Achievement Test, American Institute for Research (AIR) (2010), and Pearson, the contractor who scores the State Mathematics Achievement Test, provided paper and electronic disaggregated reports at state, district, and school levels. These reports provided student performance information for the following categories: All Students, Economically Disadvantaged, Students with Disabilities, Limited English Proficient, Gender, Race/Ethnicity (Ohio Department of Education, 2012).

The data are reported for all content areas and measured how well students attain the skills and knowledge as described in the Ohio Academic Content Standards. In mathematics, this included the following standards: Number, Number Sense and Operations, Measurement, Geometry and Spatial Sense, Patterns, Functions and Algebra, and Data Analysis and Probability. Multiple forms of test booklets are assigned to each building. Students have two and a half hours to complete the paper and pencil mathematics assessment, which included a combination of multiple choice and constructed response questions. For the fourth grade mathematics assessment, students answered 32 multiple choice test items (1 point), six short answer items (2 points), and two extended response items (4 points), totally 40 operational items (ODE, 2013). The scores for this test are reported as criterion-referenced scores. The criterion-reference scores described students' measure of performance on specific performance standards (Linn & Gronlund, 2000). The State Board of Education has adopted performance for the Ohio Achievement Assessment using the following performance levels: Advanced (452–above), Accelerated (432-451), Proficient (400-431), Basic (377-399) and Limited (Below 377), which are expressed as a scaled score (ODE, 2013). Scaled scores are standard scores calculated from the raw scores that are used to communicate students' test performance (Ohio Department of Education, 2009). The State Mathematics Achievement Test multiple-choice items are scored by computer, and constructed-response items are scored by trained scorers in central locations. The scaled mathematics percentage scores of fourth grade students performing at and above the proficient level on the State Mathematics Achievement Test were used for the study. At the time of this study, the state proficiency level requirement was 75%.

Analysis included the State Mathematics Achievement Test scores from the 2007–2008, 2008–2009, and 2012–2013, 2013–2014. During the 2007–2009 academic years, Math Specialists provided mathematics instruction to all fourth grade students. During the 2012–2014 academic years, Grades 1–8 credentialed teachers supported by Math Coach support provided mathematics instruction to all fourth grade students. The mathematics student achievement outcomes of fourth grade students were compared.

The casual-comparative design using archived test data (ex-post facto) was appropriate for the non-experimental study because it was a simple and valid way to assess the fourth grade students' academic achievement in mathematics. This design can determine which model, if any, increased mathematics scores of fourth grade students.

Validity and Reliability

Criterion-referenced tests, such as the State Mathematics Achievement Test, are designed to directly measure learning outcomes and skills that students are expected to demonstrate set forth in a specific curriculum. All questions written for the State Mathematics Achievement Test are reviewed and go through an extensive review process, including a series of internal review by a Fairness and Sensitivity Review Committee and Content Advisory Committee prior to field-testing (ODE, 2013). Committee members are professionally trained to write or select tested materials according to specific specifications and to extricate any questions that may adversely affect or bring bias toward or against any particular group. Following approval, test items are scrutinized again to ensure that all questions are properly aligned to content standards and accurately measure intended content. A linear transformation of the Rasch ability estimates (theta scores) is also used to determine test items on the assessment (ODE, 2013). For each test item, an item analysis examining all questions is conducted. Correlations for multiple-choice and constructed-response items are also computed.

Reliability of the State Mathematics Achievement Test scores are scaled and divided into portions and a mid-range score band is used to classify student performance and indexed by Cronbach's alpha (ODE, 2007–2014). The reliability of the States Achievement Test during the 2007–2009 academic years as indicated by Cronbach's alpha is 0.89 and 0.90 during the 2012–2014 academic years.

Data Collection and Analysis

The purpose of this non-experimental quantitative casual-comparative study compared the first two years of the MS program with the first two years of the MC program. The independent *t* test determined if the State Mathematics Achievement Test scores of fourth grade students who received instruction from a Math Specialists during the 2007–2008, 2008–2009 academic years demonstrated a statistically significant difference from the mathematics the State Mathematics Achievement Test scores of fourth grade students who received instruction from Grades 1–8 credentialed teachers supported by a Math Coach during the 2012–2013, 2013–2014 academic years.

The type of mathematics instruction (MS and MC) was the nominal independent variable of this study. The mathematics achievement on the State Mathematics Achievement Test, which used an interval level of measurement, was the dependent variable of this study. Nominal scales data indicated categorical data without order, while interval scale data indicated scaled data of ordered categories and with equal interval differences (Gravetter & Wallnau, 2008).

Data Collection Procedures

Institutional Review Boards and researchers are instructed to complete human protection training before collecting data (Walden, 2012). Prior to conducting research, I received approval (09-12-16-0125986) to conduct this study from the Institutional Review Board (IRB) and received permission from the Superintendent of the local school district. After approval, I requested the 2007–2008, 2008 –2009, 2012–2013, 2013–2014 mean math scores for 4th grade students in the entire district excluding special education students.

The specific State Mathematics Achievement Test data collected for each school was the calculated percentage score of students at and above the proficient level. State Mathematics Achievement Test scores of all participants are available through the state's department of education website at http://webapp2.ode.state.oh.us/reportcard/archives/RC_IRN.ASP?irn=043802. The data provided from a district-sponsored database were presented in the form of mean scores and not the entire data set.

Data Analysis Procedures

From the data results, I used inferential statistics to draw on the sample of 13,671 test scores to make generalizations about the performance of fourth grades students. An independent samples *t* test compared the means of all the scores comparing between the years of MS and MC. QuickCalcs, a statistics software website provided by GraphPad was used to analyze the data and to investigate if there were any statistically significant differences in the mean scores of fourth grade students who received instruction from Math Specialists and fourth grade students who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach.

Protection of Participants and Researcher's Role

It is clear that I would not influence the data collection and analysis of this data although I am employed with the public school system in which this study was completed, and I was a fourth grade Math Specialists during the 2007–2009 academic years. My current and prior positions within the district would not have an effect on the data collection practices. This is because the data was presented to me already collected, archived, and anonymous. The analysis was holistic and does not attend to specific schools or grades that could compromise the anonymity of scores. My office was located in one of the central administration buildings but I did not have any influence over the testing investigated in this study. As the researcher, I only retrieved and analyzed archival data from the Ohio Department of Education's website from the statistics personnel in the district. All collected data have been previously collected and do not include individually identifiable student information. Participants' anonymity was preserved. In terms of the Belmont principles, all three of, respect for persons, beneficence, and justice have been met. In terms of respect for persons the data collection was part of regularly scheduled academic testing. In terms of beneficence, none of the individual student scores nor scores associated with any teacher was collected or considered and so there is a strong unlikelihood that the study would do any harm to the participants. Finally there were no costs or benefits to the students who completed these tests so justice was observed. The benefit of the study was to ascertain the relative effectiveness of the MS and MC programs for producing higher test scores. This benefit was worthwhile to pursue with all participants' rights being protected.

Summary

The purpose of this nonexperimental, quantitative, casual-comparative research study compared the State Mathematics Achievement Test mathematics achievement outcomes among MS and Grades 1-8 credentialed teachers with MC for fourth grade students from a large urban public school district in the mid-western United States. Archival data were used in order to compare results (Creswell, 2005). Both MS 2007–2008, 2008–2009 spring scores and MC 2012–2013, 2013–2014 spring scores were analyzed to compare outcomes. I used descriptive statistical measures to determine the difference, if any, between the MS and MC models. The population consisted of 4th grade students. This section discussed the research design, the setting and sampling methods, and the treatments that were examined ex post facto. Quantitative data sources and their relationship to the study were also described. This section concluded with the researcher's role in this study. The next section details the results from the data collection and analysis.

Section 4: Results

Introduction

The purpose of this research study was to determine whether there was a significant difference between State Mathematics Achievement Test scores of students in fourth grade who received instruction from a Math Specialists during the 2007–2008, 2008–2009 academic years and fourth grade students who received instruction from Grades 1–8 credentialed teachers supported by a Math Coach during the 2012–2013, 2013–2014 academic years. The data used in this study consisted of archival standardized test scores provided from the administration of the standardized State Mathematics Achievement Test scores of students in fourth grade from academic years 2007–2009 and academic years 2012–2014 of all students who took the assessment, omitting all alternatively assessed fourth grade students. An independent samples *t* test was used to determine if a significant difference existed between State Mathematics Achievement Test scores of fourth grade students. The research question that framed this study was as follows:

Research Question 1: Is there a significance difference in fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, between students who received instruction from a Math Specialist (2007–2009) and Grades 1–8 credentialed teachers supported by a Math Coach (2012–2014)?

Section 4 explains the research tools, data analysis, and findings of this quantitative study.

Research Tools

Due to archival standardized test scores used in this study, it was not necessary to design a data-collection instruction. All standardized-test data used in this study was collected and analyzed from a district-sponsored database. I used QuickCalcs, a statistics software website provided by GraphPad, to conduct an independent samples *t* test.

After receiving IRB approval to conduct this research study from Walden University, I requested permission from the district to conduct this study. The study population included a combined 13,671 fourth grade students who received instruction from a Math Specialists or Math Coach during the 2007–2009 and 2012–2014 academic school years. Student data included the fourth grade State Mathematics Achievement Test scores of the study population.

Data-Analysis Procedures

The math mean scores from the spring 2007–2009 and 2012–2014 administration of the fourth grade State Mathematics Achievement Test were used as the quantitative data in this study. The type of mathematics model were used to distinguish students who received instruction from a MS from those who received instruction from a MC. This allowed for the formation of two comparison groups: MS and MC.

Research Question 1 tested the hypothesized difference that there is a statistically significant difference between fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, in students who received instruction from a Math Specialists and Grades 1–8 credential teachers supported by a Math Coach Using GraphPad's, QuicksCalcs software, the use of the independent samples *t* test was appropriate. An independent samples *t* test is used in hypothesis testing that evaluates mean differences between populations (Gravetter & Wallnau, 2008).

Data Analysis

Mathematics Models for Comparison

Research Question 1 tested the hypothesis that there is a significant difference in fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, between students who received instruction from a Math Specialists (2007–2009) and Grades 1–8 credentialed teachers supported by a Mathematics Coach (2012–2014)?

$H_0$1: There is no statistically significant difference between fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, in students who received instruction from a Math Specialists and those who received instruction from Grades 1–8 credentialed teachers supported by a Math Coach.

H_a1: There is a statistically significant difference between fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, in students who received instruction from a Math Specialists and Grades 1–8 credentialed teachers supported by a Math Coach.

A district-generated data report provided the math mean scaled scores for all fourth grade students, minus alternatively assessed students, who took the State Mathematics Achievement Tests during the 2007–2009 and 2012–2014 academic years.

An independent samples *t* test was used to determine if the State Mathematics Achievement Test scores of students in fourth grade who received instruction from a Math Specialists during the 2007–2008 and 2008–2009 academic year demonstrated a statistically significant difference from the State Mathematics Achievement Test scores of fourth grade students who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach during the 2012–2013 and 2013–2014 academic years. The descriptive statistics of the scores used to compare the 2007–2008 MS group with the 2012–2013 MC group are provided in Table 5. Table 5 also indicates that the mean scores were higher for the MS students. Table 5 also demonstrates that the n, standard deviations, and standard errors were reasonably equivalent thus the comparison was justifiable. The independent samples *t* test statistics for Research Question 1 (2007-2008 – 2012-2013) are provided in Table 6.

Table 5

Group Statistics Math Mean Scores MS 2007–2008 Compared to MC 2012–2013

Math Models	*N*	Mean	Std. deviation	Std. error mean
Math Specialist	3,607	406.11	33.16	0.55
Math Coach	3,220	402.69	33.84	0.60

Table 6

Independent Samples t Test Statistics for MS 2007–2008 Compared to MC 2012–2013

					95% confidence interval	
T	*Df*	Sig. (2-tailed)	Mean difference	Std. error difference	Lower	Upper
4.22	6825	0.0001	3.422	0.81	1.83	5.02

An independent samples *t* test in Table 6 indicated that the 2007–2008 MS group (M = 406.11, SD = 33.16) had higher math achievement scores than the 2012 –2013 MC group (M = 402.69, SD = 33.84), $t(6825) = 44.22$, $p < .001$, $d = 0.10$. This indicates that the students with a MS performed significantly higher than the students with a MC when you compare the years 2007-2008 to 2012-2013.

The descriptive statistics of the scores used to compare the 2008–2009 MS group with the 2013–2014 MC group are provided in Table 7. Table 7 also indicates that the mean scores were higher for the MS students. Table 7 also demonstrates that the n, standard deviations, and standard errors were reasonably equivalent thus the comparison was justifiable. The independent samples *t* test statistics for Research Question 1 (2008–2009–2013–2014) are provided in Table 8.

Table 7

Group Statistics Math Mean Scores MS 2008–2009 Compared to MC 2013–2014

Math Models	*N*	Mean	Std. deviation	Std. error mean
Math Specialist	3,472	412.89	32.64	0.55
Math Coach	3,372	403.12	35.44	0.61

Table 8

Independent Samples t Test Statistics for MS 2008-2009 Compared to MC 2013-2014

					95% confidence interval	
T	*Df*	Sig. (2-tailed)	Mean difference	Std. error difference	Lower	Upper
11.87	6842	0.0001	9.77	0.82	8.16	11.39

This finding held true again in Table 8 when comparing the 2008-2009 to the 2013-2014 cohorts; students with an MS teacher performed significantly higher than those with MC. An independent samples *t* test indicated that the 2008–2009 MS group (M = 412.90, SD = 32.64) had higher math achievement scores than the 2013– 2014 MC group (M = 403.12, SD = 35.44), $t(6842) = 11.87$, $p < .001$, $d = 0.29$.

Based on these results, we can reject the null hypothesis and conclude that there is a significant difference between the mean scores as measured by the State Mathematics Achievement Test and those students who received instruction from a Math Specialists performed significantly better than those who received instruction from Grades 1–8 credentialed teachers supported by a Math Coach. These significant differences between the MS and MC groups were found in both mean comparisons, and the effect size of these differences was larger in the comparison of the 2008–2009 MS group with the 2014–2015 MC group. Therefore, not only did the directionality of the differences persist across the analyses, but the effect of these differences grew in the comparison of the more recent groups.

Summary and Transition

The purpose of this study was to determine whether there was a significant difference between standardized State Mathematics Achievement Test scores of students in fourth grade who received instruction from a Math Specialists during the 2007–2008, 2008–2009 academic years and fourth grade students who received instruction from Grades 1–8 credentialed teachers supported by a Math Coach during the 2012–2013, 2013–2014 academic years. An independent samples *t* test determined that there was a significant difference between the mean score attained on the fourth grade State

Mathematics Achievement Test. The MS scores were significantly higher than the MC scores. There were a total of 13,671 students and test scores used for this study. The students were categorized based on the implemented Math Model: MS and MC.

Based on the results of the independent *t* tests, I reject the null hypothesis and conclude that there is a significant difference between the mean score as measured by the State Mathematics Achievement Test, by those students who received instruction from a Math Specialists and those who received instruction from Grades 1-8 credential teachers supported by a Math Coach. The effects of these differences grew in the comparison of the more recent groups by almost three times the amount ($d = 0.29$), indicating an impact on test scores of students taught by a MS.

Section 4 included a brief introduction, a description of the study population, categorization and data-analysis procedures, and a summary of the findings in this quantitative study using a causal-comparative research method, which included a nonexperimental design. In addition, data results demonstrated that a significant difference exist between the mean score as measured by the State Mathematics Achievement Test, by those students who received instruction from a Math Specialists and those who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach.

Section 5 will provide interpretations of the findings and how to contribute to the extant literature, implications for social change, recommendations for future research studies, and a summary.

Section 5: Discussion, Conclusions, and Recommendations

Introduction

Despite the long history of school improvement initiatives to increase students' mathematics performance, only modest achievement gains have been recognized (National Center for Educational Statistics, 2009). American students continue to fall behind and struggle. One suggestion for the improvement of elementary mathematics is to have mathematics specialist (MS) positions. In 2007, administrators of a large urban public school district in the Midwestern United States, concerned by poor performance in student mathematics achievement, began major systemic reform that included a decision to implement two mathematics models: The content expert for students Math Specialist approach, compared to the elementary teachers supported by a Math Coach. Refining the teaching of mathematics was seen as critical in the effort toward improving student achievement.

The quantitative, nonexperimental, causal-comparative research study examined the impact of two instructional models: the MS for students and the MC for teachers. The study was conducted to determine whether there was a significant difference between State Mathematics Achievement Test scores of students in fourth grade who received instruction from a Math Specialists during the 2007–2008, 2008–2009 academic years and fourth grade students who received instruction from Grades 1-8 credentialed teachers supported by a Math Coach during the 2012–2013 and 2013–2014 academic years. In order to conduct this study, archival data was collected. In this section, a brief summary of findings, interpretations of the findings, implications for social change, recommendations for future research studies, and a summary.

This study was guided by the following research question:

Research Question 1: Is there a significance difference in fourth grade mathematics scores, as measured by the State Mathematics Achievement Test, between students who received instruction from a Math Specialists (2007–2009) and Grades 1–8 credentialed teachers supported by a Math Coach (2012–2014)?

An independent samples *t* test was used to analyze the data and revealed a significant difference between the math models (MS and MC) and academic achievement in mathematics.

Interpretation of Findings

Students who were taught using the MS model had significantly higher mean scores on the State Mathematics Achievement Test for both comparisons (2007–2008 to 2012 –2013 and 2008 –2009 to 2013–2014) as depicted in Section 4. The independent samples *t* test indicated that the 2007–2008 MS group (M = 406.11, SD = 33.16) exhibited statistically significantly differences with higher math achievement scores than the 2012–2013 MC group (M = 402.69, SD = 33.84), $t(6825) = 44.22$, $p < .001$, $d = 0.10$ and the independent samples *t* test indicated that the 2008–2009 MS group (M = 412.90, SD = 32.64) exhibited statistically significantly differences with higher math achievement scores than the 2013– 2014 MC group (M = 403.12, SD = 35.44), $t(6842) = 11.87$, $p < .001$, $d = 0.29$. Thus, the analysis of data revealed higher student achievement in mathematics with the MS model. The results indicated that this research rejects the null hypothesis and concluded that there is a significant difference between the mean score as measured by the State Mathematics Achievement Test, by those students who received instruction from a Math Specialists and those who received instruction from Grades 1–8 credentialed teachers supported by a Math Coach.

Despite limited qualitative and quantitative studies focused on the effectiveness of elementary MS, several prominent mathematics education organizations, including the National Mathematics Advisory Panel (2008), the Association of Mathematics Teacher Educators (AMTE, 2013), and educational researchers (Campbell, 2009; Campbell & Malkus; 2009, 2010, 2011; Fennel, 2011; Fennell, Kobett, & Wray, 2013) emphasized the importance of every elementary school having a MS to ensure that students receive mathematics instruction from teachers who understand mathematics content. As the math scores of fourth grade students from this study suggest, students receiving instruction from a MS contributed to the overall success of students' math achievement.

Implications for Social Change

The implementation of specialized math positions at the elementary level was encouraged in response to the significant curricular changes to K-12 mathematics programs in the United States and by the vision set forth by the Standards (NCTM, 2000). With the shift from students' acquiring proficiency in rote memorization of procedural skills to a deeper understanding of conceptual mathematical knowledge and problem solving (NCTM, 2000), many researchers have agreed that knowledgeable teachers with a thorough understanding of mathematics have the capacity to improve student achievement (Ball et al., 2008; Ball, Hill, & Bass, 2005; Charalambos, 2010; Hill, Rowan, & Ball, 2005). The research is consistent with the mean test scores of students in the present study. Based on the results of this study, the mean scores of students who were taught by a Math Specialists scored higher on the State Mathematics Achievement

Test than students taught by a Grades 1–8 credentialed teachers supported by a Math Coach, indicating that there was a direct correlation to students' understanding based on the content expertise of the MS teachers.

The current study informed educational stakeholders about what to consider when implementing systemic reform concentrated on the improvement of elementary mathematics and teaching. The findings showed that there was a significant difference between the two mathematics models, with the Math Specialists reform model students having a higher overall mean than the Grades 1–8 credentialed teachers supported by a Math Coach. These findings suggest that the primary advantage of the MS model is supporting increased levels of mathematics performance for student learners. This is highly valued by administrators and politicians who may be convinced by these findings that an MS approach is more likely than an MC approach for improving test scores. This may be true in the local setting and beyond. This research will be presented to the district of this study, and may inspire the district to reinvigorate the MS model at the elementary level in the future. The results may empower educators with a strong mathematics background to consider a specialized mathematics position such as an MS working with students to provide a more in depth understanding of mathematics. As a result of increased student achievement, social change may occur by directly improving the learning of elementary mathematics students through the reallocation of federally funded dollars. Redistribution of funds to develop programs such as the MS model, specifically designed to address the needs of students, can have a positive influence on student achievement.

Recommendation for Action

This study focused on the academic impact of two mathematics models: MS and MC on fourth grade students' achievement on a State Achievement Test. There are three recommendations for action as a result of this research study from the archival mathematics data. First, this school district should explore possibilities for reinstituting the MS positions to increase student test scores district-wide. Currently, there are some buildings implementing the MS instructional model voluntarily.

Second, education practitioners would benefit from the use of this data in pursuing grant money to support district-wide implementation of the Math Specialists position using federal funds. For smaller districts with limited resources and the inability to implement Math Specialists positions, monies can be allocated for continuous professional development to provide greater knowledge and skills competencies in math education for the regular classroom teachers. Variations to the Math Specialist and Math Coach positions can also be created. A Math Coach with extensive math knowledge can provide support for the regular classroom teacher and deliver math instruction to small groups of students or in 1-on-1 structures with specific learners in need of intervention or enrichment in mathematics. The ultimate goal is to increase math proficiencies levels of adult and student learners through the expertise of someone with Math Specialist qualifications.

Third, research findings should be disseminated through district-approved email to administrators, teachers, and staff regarding the Math Specialists position and the influence on student achievement. District and school leaders need to understand the positive impact of having specialized teachers in the classroom and its potential not only to increase state achievement tests, but also in the effort toward improving student achievement and narrowing the achievement gap in mathematics. As part of this framework it is vital that continuous professional development opportunities are provided as teachers make the difficult process of pedagogical shifts of being a Math Specialists in the classroom.

Recommendation for Future Research

During the course of this study it became evident that mathematics expertise in the form of MS teachers in elementary schools is beneficial. Several recommendations for future research may add to the body of literature regarding the effects of specialized elementary mathematics models on elementary students' academic achievement. The results of this study raised questions about the MC model in the area of elementary mathematics achievement.

There are other aspects of this study in need of further research. Additional empirical studies should be conducted on these schools using the Math Specialists model and the effect on student academic achievement. Future research also needs to investigate elementary teacher preparation, endorsement, and certification programs on how to support current and future mathematics teachers. If teachers are to support student academic achievement in mathematics and comply with state mandated laws, such as NCLB, additional research on the effectiveness of specialized math models at the elementary level need to be conducted. As noted previously, there is limited literature in the area of MS teacher effectiveness (McGatha, 2009). This research will add to it.

A delimitation of this study noted earlier was that this study was limited to fourth grade elementary school students. In addition, the data was representative of only one large urban public school district in the Midwestern United States. Therefore, it is recommended that this study be conducted with larger sample sizes and a broader population to support the findings of the present study. Such a study may determine the effectiveness of the MS model verses the MC model in a variety of school contexts. This could include comparisons between public and private schools. It could also be a study comparing urban, suburban and rural students' achievement data. Private schools with fewer teachers at each grade level may benefit from the MC structure, as there are fewer teachers to train. However, urban and suburban schools with multiple teachers at each grade level may benefit from a content expert providing instruction for the improvement of mathematics achievement for all students. The current study used archival data, but school districts considering the use of the MS or MC models could implement both structures and compare the student data after one or two years of implementation. The reason for conducting these studies will provide more support that the MS model is essential for student achievement in all of these contexts.

It is also recommended that this study be replicated as a longitudinal study for more than two school years during the same academic years. This would allow for greater comparison and time to analyze the results, both qualitative and quantitatively, which may yield deeper and more informative data. In my school district, research can be collected from the schools voluntarily using the MS and MC programs to provide more evidence to support the use of the MS program.

Based on the results of this doctoral study, it was not determined precisely what conditions of the MS model potentially lead to higher student achievement on the state assessment. Could it have been the extended hours of professional development offered to MS? Or the frequent collaborative sessions with other MS teachers to discuss instructional practices, to analyze student artifacts, and to create formative assessments designed to increase student achievement? Was it the departmentalized structure of the MS model that provided 75 minutes daily of uninterrupted time focused on mathematics? These questions and other factors support the recommendation for future research studies.

Summary

The purpose of this doctoral study was to determine the potential impact of two specialized instructional models on fourth grade student academic achievement. The findings of this study lend support to the benefit of using a MS. Based on the results of the independent *t* tests, I rejected the null hypothesis and concluded that there was a significant difference between the mean score as measured by the State Mathematics Achievement Test, by those students who received instruction from a Math Specialists and those who received instruction from Grades 1–8 credentialed teachers supported by a Math Coach. Not only did the directionality of the differences persist across the analyses, but also the effect size of these differences grew in the comparison of the more recent groups by almost three times the amount.

The implications of this study included recommendations for this and other school districts that may provide evidence for the MS program as federal dollars are utilized to develop instructional programs designed to improve student achievement in mathematics. This section also provided recommendations for future research to explore the actual instructional methods used by MS.

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