The Effect of Professional Development on Student Mathematics Achievement by Gender, Socioeconomic, and Individual Education Plan Status

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Submitted to the Graduate Department and Faculty of the School of Education of Baker University in partial fulfillment of the requirements for the degree of Doctor of Education in Educational Leadership

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Date Defended: November 12, 2018

Abstract

This study was conducted using the Missouri Assessment Program (MAP) mathematics assessment percentages of third, fourth, and fifth-grade students achieving at the proficient category to address three main purposes. The first purpose was to determine if district-provided professional development led to a significant change when compared to student scores in later consecutive school years. The second purpose was to determine if there was a difference in the change in the percentage of students from the year prior to mathematics professional development to the years after mathematics professional development between School District A and the state of Missouri. The third purpose was to determine the effect that gender, socioeconomic status, or the presence of an Individualized Education Plan (IEP) had on the change in the percentage of students in the proficent or not proficient categories. The results of the hypothesis testing, using chi-square tests of independence, indicated there was evidence to suggest that professional development was effective in changing the percentage of third, fourth, and fifth-grade students who achieved at the proficient category on the matheamatics Missouri Assessment Program. When gender was added to the analysis, more female students tended to score in the proficient category in the second year of the professional development cycle. When socioeconomic status was added to the analysis, a change in the number of students scoring in the proficient category was not evident. When Individualized Education Plan (IEP) status was added to the analysis, students with an IEP tended to score in the proficient category the first year of the professional

development cycle, and students without an IEP tended to score in the proficient category the second year of the professional development cycle.

Dedication

This work is dedicated to my parents, Terry and Sue Shannon. In my young life, they were the first to model and teach the importance of working hard to achieve great things. My brother and I were always encouraged to reach for the stars and pursue our dreams. They taught us to persevere when the path became rocky and were always supportive along the way. My parents also modeled the importance of family, being ethically grounded, having strong core values, and that kindness toward others goes a long way.

Acknowledgements

I would like to first acknowledge my advisor, Dr. Sharon Zoellner. Thank you for continuing to check in on me throughout this long journey. I appreciate your gentle nudges to continue with my work, thoughtful responses, and guidance.

Additionally, I would like to acknowledge my remaining dissertation committee members. Dr. Susan Rogers, thank you for the specific and purposeful feedback you provided for my research study. To Dr. Danelle Marsden: I have always admired your dedication to the profession and leadership. Your insight into this process was extremely beneficial as you have lived this instructional world with me for the past five years. Dr. Peg Waterman, thank you for your support and guidance with the data analysis for this study. I truly appreciate you taking the time to set up the templates, teach me how to use them, and check my analysis statements.

Finally, I would like to acknowledge those who have sacrificed the most over these past few years. Karson, Klaire, Kal, and Kauffman, thank you for your support and love. I hope that I have demonstrated the importance of perseverance and commitment during this process. The late nights I spent working on my dissertation were never easy but I knew would be worth it in the end! I hope you see how important furthering your education is, and that it is important always to learn, ask questions, and expand your horizons. To my husband, Kyle, throughout this entire process, you always believed in me and my ability to finish strong. You have set the bar high when it comes to leadership. I admire all that you have accomplished professionally in our short eighteen years together. You have inspired me, as an educator, in so many ways. You will always be my greatest mentor!

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Chapter 1

Introduction

The National Council of Teachers of Mathematics (NCTM, 1989) recognized that a shift in the approach to the expectations and instruction of mathematics was needed. In 2014, NCTM recommended that mathematics teachers "embrace the transparency of their work, their accomplishments, and their challenges, and they share ideas, insights, and practices as they collaborate in ways that build on individual strengths and overcome individual challenges to ensure mathematical success for all students" (p. 99). It became clear that instructional practices such as timed tests, repetitive practice, and memorization of facts were no longer thought to be effective or important to the development of student mathematical needs (Parrish, 2010). A shift away from past methods of mathematics instruction was also acknowledged by The National Research Council (2002), which outlined five areas of necessary development in order for students to become mathematically proficient: "conceptual understanding…, procedural fluency…, strategic competence…, adaptive reasoning…, productive disposition" (p. 5).

In 1999, Adelman reported that a mathematics hierarchy of courses existed in American high schools, suggesting that graduation requirements move beyond the number of credits a student must receive in mathematics to participation in specific course levels, thus leading to a later successful college graduation. The Six Principles for School Mathematics (Equity, Curriculum, Teaching, Learning, Assessment, and Technology) were introduced in 2000 as an outline of necessary requirements to consider when identifying mathematics instruction as high-quality (NCTM, 2000). Additionally, Moses and Cobb (2001), suggested that algebra was the "…gatekeeper for higher math and the priesthood who gained access to it, now is the gatekeeper for citizenship; and people who don't have it are like the people who couldn't read and write in the industrial age" (p. 14).

Rose and Betts (2001) confirmed the connection of earning potential post high school to the additional algebra or geometry courses students successfully complete in high school. Rose and Betts (2001) used human capital theory to demonstrate that through rigorous mathematics courses, students were developing other skills that would make them more marketable and productive in the workforce: logic and reasoning skills, as well as the general ability to learn. Furthermore, Carnevale and Desrochers (2003) later analyzed data and reported that students studying math at the highest levels, Algebra 2 and beyond, went on to hold successful careers in the top half of the earnings distribution.

Educators help students establish qualities that will eventually lead to their becoming productive citizens who have the ability to discuss probable solutions and make sense of numbers, as well as determine if the numbers make sense in specific situations (Parrish, 2010). In 2015, Seeley referenced research that indicated being able to think mathematically and solve mathematical problems was just as important as having the ability to compute accurately. Seeley further shared that students who were able to think mathematically and solve problems were more likely to achieve in rigorous mathematics courses. According to Seeley, the mathematics courses a student takes matter in leveling the playing field for all students regardless of their plans to go on to mathematics courses in college or enter the workforce immediately after high school. Khan Academy (n.d.) identified a quality mathematics program as one that began with a foundation built on Algebra 1 and Geometry through Algebra 2, Trigonometry, Pre-calculus, and Calculus.

NCTM (2014) updated the Six Principles for School Mathematics to include access to a rigorous curriculum with high expectations and excellence for all students, the ability to use mathematical tools to create new understanding, and the idea of professionalism in order to "hold themselves and their colleagues accountable for the mathematical success of every student and for their personal and collective professional growth toward effective teaching and learning of mathematics" (p. 5). School leaders understand all students must achieve high levels of mathematical proficiency to compete in and excel as individuals in the global world. Society can no longer accept that some students are good at mathematics while others are not and never will be. Changing teacher pedagogy to provide students with the tools to apply and thrive in unknown situations, future mathematics courses, and life must be addressed to give all an equal chance. Therefore, district leaders must think differently about how best to prepare mathematics teachers to instruct at high levels and ultimately achieve extraordinary results from all students.

Darling-Hammond, Hyler, and Gardner (2017) posited several critical aspects to consider when planning for teacher professional development. They concluded that effective professional development commonly included one or more of seven essential components (Darling-Hammond et al., 2017). The seven components included:

- a specific focus grounded in instructional strategies connected to content familiar to the teacher;

- an opportunity to actively learn and engage in the material they would later use to instruct students;
- an opportunity to collaborate with like-minded individuals who would also be instructing their students with similar strategies;
- strong examples that guided teachers in their development and implementation of lessons and instructional strategies;
- an opportunity to connect with coaches and other content experts;
- specific feedback and purposeful reflection, and finally;
- teacher learning that went beyond the one workshop but was carried out and further developed for teachers over time. (Darling-Hammond et al., 2017)

Background

In the fall of 2011, District A leaders began to take note of discrepancies that existed between state and district elementary yearly Missouri Assessment Program (MAP) assessment results (Assistant Superintendent PreK-8, personal communication, September 29, 2016). Ineffective instructional practices were believed to be a contributing factor. District leaders noted an inconsistent approach to the overall instruction of mathematics (Assistant Superintendent PreK-8, personal communication, September 29, 2016). The use or non-use of manipulatives, resources, professional development, and inconsistent daily time allocations to the subject of mathematics were also noted (Assistant Superintendent PreK-8, personal communication, September 29, 2016). Furthermore, it was recognized by District A's Assistant Superintendent PreK-8 that to submit students to timed tests as a method to build computational fluency within the basic operations was an ineffective instructional method and did not produce lasting results.

District leaders further recognized that to increase student mathematics achievement, an investment must first be made in the professional development provided annually to classroom teachers. Hargreaves and Fullan (2013) reminded educators that "capital is something that adds value to net worth. If you want to get a return, you need to make an investment" (para. 3). Without this investment, leaders worried that instructional practices in School District A would not be positively impacted, and therefore, not lead to increased achievement for all students.

In 2012, teachers at nine elementary buildings, identified in the district as Title I, began working with consultants from the company Math Solutions, which provided professional development to build teacher pedagogy and instructional practices in mathematics (Assistant Superintendent PreK-8, personal communication, September 29, 2016). Effective district-provided professional development for teachers might increase mathematical pedagogy and create a solid conceptual understanding of mathematical underpinnings, thus leading to an increase in mathematics achievement. Specifically, the research in School District A demonstrated the consistent and disciplined approach to professional development, in partnership with consultants from Math Solutions, aimed to:

1. Increase the amount and quality of productive math discourse in all math classrooms.
2. Increase the level and amount of mathematical sense-making of all students.
3. Infuse the Missouri Learning Standards and Standards of Mathematical Practice in every mathematics lesson.

4. Actively engage teachers in changing the level and quality of math discourse in their classrooms.
5. Introduce and expand upon the questioning strategies of teachers and students.
6. Connect discourse and questions to deepen student sense-making.
7. Assure that the use of purposeful planning in making discourse and sense-making are key components of every lesson. (School District A, 2016, para. 1)

Additionally, in 2012, teacher teams were created in each of the Title I elementary buildings to work with an identified math consultant, view and reflect on lessons, and share information with their grade level teams. Mathematical discourse was introduced, which Parrish (2010) recommends as an instructional strategy that allows for students to verbalize their mathematical thinking and increases their ability to make sense of numbers (Parrish, 2010). "Effective mathematics teaching engages students in discourse to advance the mathematical learning of the whole class" (NCTM, 2014, p. 29). Teams generally consisted of teacher representatives from each grade level, which Schlosser (2015) shared creates an environment that fostered collaboration. Schlosser (2015) further shared that "when vertical teams are most successful, the curricular changes they initiate create support structures that make high achievement a reality for more students because they institutionalize a continuum of knowledge and skills that build from grade to grade" (para. 9).

In 2013, all 21 elementary buildings, kindergarten through fifth-grade, mathematics teacher teams were created to participate in professional development provided by Math Solutions consultants (Assistant Superintendent PreK-8, personal communication, September 29, 2016). The intent was to build capacity and further strengthen math pedagogy throughout the entire district. Number Talks, which according to Parrish (2011), intended to be short, but purposeful conversations between students and teachers centered on mental math computation, were introduced as strategies to increase computation. Through Number Talk exchanges, Parrish (2011) suggested that students gain confidence in their personal mathematical mindset, as well as develop their ability to produce correct responses, choose efficient strategies, and think flexibly about number patterns and relationships. Boaler (2016) similarly stated that "Number Talks are the best pedagogical method I know for developing number sense and helping students see the flexible and conceptual nature of math" (p. 50).

Avery (2015) shared that to increase the likelihood of positively impacted teacher practices, learning should be connected to the content or subject matter most connected to the teacher. Furthermore, this allows for differentiation and learning experiences to be scaffolded (Avery, 2015). By 2014, the individual building K-5 format was changed to a district model where teachers received mathematical professional development from a consultant with their grade level colleagues throughout the district (District Instructional Coordinator, personal communication, February 28, 2018). The K-5 structure of individual grade level professional development allowed teachers to become immersed in common curriculum resources and have a collaborative discourse about specific mathematics instruction and content (District Instructional Coordinator, personal communication, February 28, 2018).

In 2014, there was a district-wide expectation that elementary teachers would include Number Talks as part of the classroom daily schedule (Assistant Superintendent PreK-8, personal communication, September 29, 2016). However, there were not tight expectations as to which strategies would be taught or where, in the curriculum, they would be introduced. The addition of Number Talks to the district Instructional Alignment Guide in 2015 provided a scope and sequence to introducing and teaching strategies during the Number Talk block. This resource provided district alignment and teacher guidance in the instruction of a Number Talks that was intentional and connected to unit mathematics goals, as well as mathematical foundations previously established in a prior grade or mathematics unit. Parrish (2010) shared that the building blocks of early mathematics were the "…composition and decomposition of numbers, our system of tens, and the application of properties" (p. 5). Furthermore, it is important to choose problems for students to solve that prompt "…specific strategies that focus on number relationships and number theory" (Parrish, 2010, p. 5).

To further support teachers in their mathematics instruction, professional development modules, coaching with district Teaching and Learning Coaches, and feedback from principals was provided (Assistant Superintendent PreK-8, personal communication, September 29, 2016). Hord and Sommers (2008) stated that "the role of the principal is paramount in any endeavor to change pedagogical practice…" (p. 6). In addition, Avery (2015) shared that through principal feedback, an opportunity to learn together is established, thus resulting in a teacher's strengthened professional learning.

As of 2016, School District A (n.d.-b) was a larger suburban school district in the state of Missouri. The district served approximately 19,000 students (Missouri Department of Elementary and Secondary Education, n.d.-a). Three elementary school configurations existed within the district: K-1, 2-5, and K-5. Overall buildings throughout the district ranged in size from approximately 200 to almost 800 students.

Nineteen elementary buildings operated on an August to May school calendar, while the remaining two elementary buildings in the district had an additional thirty days of instruction due to a district prescribed extended calendar (School District A, n.d.-a). In School District A, 48.6% of the students were eligible for free or reduced lunches (Missouri Department of Elementary and Secondary Education, n.d.-a). The district profile indicated that 10.2% of the student population qualified for special education due to a disability, 2.6% under the state total population percentage (Missouri Department of Elementary and Secondary Education, n.d.-b). Furthermore, School District A was a melting pot of cultures and ethnicities. At the time of the study, 872 elementary students qualified as English Language Learners, and 110 languages were spoken amongst the student population (School District A, n.d.-c).

Statement of the Problem

The problem addressed in this study was that School District A student state assessment scores were low in mathematics. Experts have provided suggestions for why this has been happening. For example, Seeley (2014) suggested that there is a difference between memorizing mathematical processes and application in the real world. Students who go beyond the superficial memorization of facts have the ability to create pictures and understand the purpose of place value and regrouping (Seeley, 2014). The quality of instruction students receive is connected to their teacher's understanding and often reflects the teacher's personal perceptions (Burton, 2012). Boaler (2016) shared that, as students, elementary teachers did not always have positive interactions with mathematics. This lack of knowledge has led to elementary teachers focusing on procedures and memorization rather than embracing mathematics as a social subject grounded in exploration and creativity (Boaler, 2016).

Specifically, in School District A during the 2011-2012 school year, the problem was students in grades three through five earned low state mathematics assessment results when compared to students throughout the state of Missouri, indicating that student mathematical needs were not being met. District leaders became concerned about current teaching practices being utilized throughout the district. Therefore, leaders in School District A began the process of aligning teacher mathematics professional development to strengthen pedagogy and to build teacher confidence to implement the curriculum effectively.

Purpose of the Study

This study was conducted to address three purposes. The first purpose was to determine to what extent district-provided professional development, beginning in the 2012-2013 school year and continuing into 2013-2014, 2014-2015, and 2015-2016, led to a change in the percentage of third, fourth, and fifth-grade students who achieved at the proficient category on the MAP assessment when compared to student scores in 2011-2012. For this study, student scores were categorized according to two levels, proficient and not proficient. The proficient category included students who earned either proficient or advanced on the state assessment. The not proficient category included students who earned either basic or below basic on the state assessment. A second purpose of this study was to determine to what extent there was a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the years after mathematics professional development (2012-2013, 2013-2014, 2014-2015, 2015-2016) between School District A and the state of Missouri. The third purpose of this study was to determine the effect that gender, socioeconomic status, or the presence of an Individualized Education Plan (IEP) had on the change in the percentage of students who achieved at the proficient category in 2011-2012 on the MAP assessment when compared to student scores in each of the following school years: 2012-2013, 2013-2014, 2014-2015, and 2015-2016.

Significance of the Study

The results of this study provide information about a plan for professional development that would lead to greater student success in mathematics. The results of this study might provide leaders direction in the creation of professional development for teachers that could solidify a strong mathematical foundation in computation and allow students to build upon their knowledge as they progress through the grades. Additionally, the results of this study provide district leaders guidance in systemic professional development, strategically delivered, to increase teacher proficiency in mathematics instruction, in the third through fifth-grade. The findings could contribute to a body of research about effective instruction in mathematics to change pedagogical practices of teachers to increase the mathematical abilities of all students.

Delimitations

According to Lunenburg and Irby (2008) “delimitations are self-imposed boundaries set by the researcher on the purpose and scope of the study” (p. 134). To best understand the relationship between student achievement and teacher professional development, the following delimitations were established:

1. Data were collected from School District A, a suburban community located in western Missouri.
2. Data were collected during the 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016 school years. The dataset was selected to include one year prior to district provided professional development, as well as the next five years to demonstrate the progression of improvement due to the mathematics professional development.
3. Data for students in the third, fourth, and fifth-grade were analyzed.
4. Mathematics achievement was measured using the Missouri Assessment Program (MAP) mathematics assessment.

Assumptions

Assumptions were identified about professional development and mathematical pedagogy.

1. Elementary classroom teachers had a basic understanding of mathematical conceptual underpinnings.
2. Elementary classroom teachers used the strategies learned from the professional development and implemented them with fidelity.
3. Elementary building administrators conducted walk-throughs during the Mathematics and Number Talk blocks to provide feedback, hold teachers accountable, and create fidelity in district expectations.
4. All elementary students throughout the district were exposed to the district outlined Number Talks each day.

5. All elementary students were encouraged to practice mental math strategies when solving computational problems presented by the classroom teacher.

Research Questions

To better understand the connection between district provided teacher professional development that began in 2012, with the purpose of strengthening instructional practices and changing student achievement, this study addressed the following research questions:

RQ1. To what extent is there a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to

- the year after partial district implementation of mathematics professional development (2012-2013) between School District A and the state of Missouri;
- the year after whole district implementation of the mathematics professional development (2013-2014) between School District A and the state of Missouri;
- the year after mathematics professional development included Number Talks (2014-2015) between School District A and the state of Missouri; or
- the second year after mathematics professional development included Number Talks (2015-2016) between School District A and the state of Missouri?

RQ2. To what extent is there a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to

- the year after partial district implementation of the mathematics professional development (2012-2013);
- the year after whole district implementation of the mathematics professional development (2013-2014);
- the year after mathematics professional development included Number Talks (2014-2015); or
- the second year after mathematics professional development included Number Talks (2015-2016)?

RQ3. To what extent is the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to

- the year after partial district implementation of mathematics professional development (2012-2013) different based on gender, socioeconomic status, or Individual Education Plan status;
- the year after whole district implementation of the mathematics professional development (2013-2014) different based on gender, socioeconomic status, and Individual Education Plan status;
- the year after mathematics professional development included Number Talks (2014-2015) different based on gender, socioeconomic status, and Individual Education Plan status; or
- the second year of mathematics professional development included Number Talks (2015-2016) different based on gender, socioeconomic status, and Individual Education Plan status?

Definition of Terms

Definitions were included to establish a common mathematical vocabulary. These are familiar terms in the mathematical world but can have a variety of definitions depending on past professional development and mathematical underpinnings.

Flexibility. Parrish (2010) defined flexibility as having confidence in the use of number relationships when computing. Furthermore, "flexibility in mathematical thinking develops as we push ourselves and our students to reason through different approaches to problems" (Parrish, 2010, p. 21). According to NCTM (2014), students should be able to demonstrate the "flexible use of strategies and methods while reflecting on which procedures seem to work best for specific types of problems" (p. 47).

Fluency. The speed at which a student can compute a given problem is often how fluency is defined in mathematics. However, NCTM (2014) stated that "being fluent means that students are able to choose flexibly among methods and strategies to solve contextual and mathematical problems, they understand and are able to explain their approaches, and they are able to produce accurate answers efficiently" (p. 42).

Organization of the Study

The background, statement of the problem, purpose of the study, delimitations, assumptions, research questions, and definition of terms were introduced in Chapter 1. Chapter 2 includes a review of the literature related to mathematics instruction in the early 20th century when compared to instruction in the early 21st century. The methods utilized in the study, including research design, selection of participants, measurement, data collection procedures, data analysis and hypothesis testing, and limitations are included in Chapter 3. Chapter 4 contains the results of the study. Specifically, descriptive statistics and hypothesis testing are included. Chapter 5 begins with a study summary, that contains an overview of the problem, purpose statement and research questions, provides major findings related to the literature, and conclusions focused on implications for action, recommendations for future research, and concluding remarks.

Chapter 2

Review of the Literature

A review of the literature was conducted to compare the origins and early purposes of mathematics to effective mathematical pedagogy in the 21st century. Research was conducted related to professional development. Research was also conducted to determine if instructional practices built teacher capacity and confidence, changed beliefs, and increased student achievement.

The narrative is divided into three main sections. The first section includes research regarding past beliefs and philosophies about mathematics instruction, as well as societal and cultural changes that impact classroom instruction. The second section contains the current mathematical pedagogy and beliefs to understand the best and most effective practices for student achievement. Included in this section is information that describes the pedagogical strategy of Number Talks and how it would be utilized to increase mathematical confidence, number sense, and general mathematical abilities. The third section incorporates research that describes professional development practices adopted by school districts with the intent to increase teacher ability to instruct at high levels, thus raising student achievement.

Past Beliefs About Mathematical Learning

During the early 20th Century, the theory of Connectionism was introduced (Learning Theories, n.d.). Brownell (2007) brought forth the idea that real learning occurred when connections were established through the ability to add on, omit, and organize one's thinking. This idea was also grounded in the belief that once the correct connections had been linked, accurate responses would inevitably be made.

Piaget's (1936) cognitive development study made a major contribution to the field of psychology as it provided insight into how young children inherently mature and interact within their environment. Piaget believed that children passed through stages of development from birth through childhood, which allowed the child to eventually become an individual able to formulate hypotheses through the process of thinking and reasoning. Piaget's stages of development are as follows: (1) the sensorimotor stage includes children from birth through the age of two, (2) the pre-operational stage includes children from two to the age of seven, (3) the concrete operational stage includes children from seven to the age of eleven, and (4) the formal operational stage includes children from eleven into adulthood.

According to Ojose (2008), Piaget's theory of Cognitive Development, specifically quantitative development, has contributed to the field of mathematics and allowed educators to have a better understanding of how children learn mathematically. Ojose suggested that in the sensorimotor stage children began to learn early number concepts and counting skills. He shared that in the preoperational stage children developed language and thinking skills. Additionally, Ojose believed that how a child talked about the mathematics they were immersed in indicated his or her personal understanding of the concept. According to Ojose, in the concrete operations stage, students were encouraged to use multiple representations and manipulatives to experience mathematics at the concrete level. Finally, Ojose suggested that in the formal operations stage students were able to reason mathematically, construct their own mathematical understanding, and were exposed to abstract problems.

The theory of Cognitive Development and its impact on mathematics was important for educators to consider when designing professional development and curriculum. Opportunities for students to make connections from the learning in one stage to the next was essential. Boaler (2016) summarized Piaget's beliefs that when ideas were connected or linked together, and memorization was absent from the mathematical process, real learning occurred.

Mathematics Instruction of Past Decades

Experts in the field of mathematics, including Parrish (2010, 2011), Seeley (2014, 2015), and Boaler (2002, 2016), suggested that students in mathematics classrooms of the past were not required to think and reason. They were spectators in the learning process and expected to comprehend and apply mathematical processes just as their teacher had demonstrated. The instruction of mathematics was constantly evolving and reflected important aspects of society. Nearly every decade experienced cultural shifts or new philosophies that impacted pedagogy and how students best learned mathematics.

Early textbooks and instructional practices. Baggett and Ehrenfeucht (1997) shared that teacher-centered mathematics textbooks became widely used for vocational studies during the 1800s. According to Baggett and Ehrenfeucht, heavy emphasis was placed on the ability to execute algorithms and various other applications, while little emphasis was directed at mental mathematics. They suggested that students in the 1800s were immersed in activities requiring paper and pencil, extensive drill on arithmetic, and memorization of the multiplication table. Furthermore, Baggett and Ehrenfeucht indicated that manipulatives were not common mathematical tools, and when used, were more directly related to the tools of the trade being studied.

In the early 1900s, the United States was recognized as a world leader but had a significant number of students not able to graduate with a high school diploma (Seeley, 2015). Manipulatives were not widely used in the classrooms as a mathematical tool (Brownell, 2007). During the 1940s, textbooks were closely aligned with student career paths (Brownell, 2007), which included common jobs such as a shopkeeper, farmer, or factory worker (Nesmith, 2008). However, in the 1950s, the space race was entered, and many began to realize that American students were behind in both science and technology when compared to Soviet Union students (Nesmith, 2008), which led to changes in the textbooks in the 1960s. There was also a prevalent belief that mathematics should entertain, which led to games and other fun activities being added to textbooks, ultimately increasing the overall volume (Baggett & Ehrenfeucht, 1997). Mathematics instruction became more process driven and allowed students to have an opportunity to learn through a hands-on approach (Nesmith, 2008). However, these new mathematical ideas and activities often led to underprepared teachers and parents, thus leaving students without the necessary support to excel at high levels (Seeley, 2015).

During the 1970s, a laboratory concept became popular, which led to classrooms being set up as labs and included materials, manipulatives, and hands-on opportunities (Nesmith, 2008). At the same time, the back to basics movement was established (Nesmith, 2008; Seeley, 2015), which led to an increased emphasis on basic computation (Seeley, 2015). However, basic instruction often led to low-level job preparation (Seeley, 2015). By 1989, basic arithmetic was no longer a major focus in curriculum and textbooks, and opportunities to problem solve were on the increase (Baggett & Ehrenfeucht, 1997). According to NCTM (1989), problem solving in mathematics required students in kindergarten through fourth-grade to

- use problem-solving approaches to investigate and understand mathematical content;
- formulate problems from everyday and mathematical situations;
- develop and apply strategies to solve a wide variety of problems;
- verify and interpret results with respect to the original problem;
- acquire confidence in using mathematics meaningfully. (p. 23)

Students in fifth-eighth grade built upon earlier problem-solving foundations to

- use problem solving approaches to investigate and understand mathematical content;
- formulate problems from situations within and outside mathematics;
- develop and apply a variety of strategies to solve problems, with emphasis on multistep and non-routine problems;
- verify and interpret results with respect to the original problem situation;
- generalize solutions and strategies to new problem situations;
- acquire confidence in using mathematics meaningfully. (NCTM, 1989, p. 75)

Shifting instructional practices. Classrooms of the past were often teacher-centered, which included large amounts of teacher talk or lecture, and often consisted of teachers telling students what procedure or step was next (Bono, 2002). A common instructional practice was for the teacher to tell, show, and then have students do (Brownell, 2007). The structure was also implemented at a rapid pace and without the necessary tools or manipulatives being offered to students (Brownell, 2007). According to Kohn (1999), teachers spent a great deal of time telling facts and providing step-by-step procedures for students. Brandt (1988) interviewed Resnick, who shared her concern that student perceptions of mathematics were misguided as students were led to believe that mathematics was a subject of questions that were usually answered quickly and at other times remained unsolved.

These practices did not promote student thinking or discourse. Teachers often provided too much guidance and support (Seeley, 2015). Due to this lack in thinking, students were unaware of the mathematical processes behind the facts and procedures, as well as why the processes were important to becoming a strong mathematics student (Kohn, 1999). Educators were too often concerned with the product or answer and not focused on the process of how that answer or product was calculated (Brownell, 2007). The final answer became more important than the thinking and processing students were committed to when completing the work. A lack of thinking also led to students being unable to adapt when conditions changed (Brownell, 2007). Furthermore, the practice of telling students led to internalizing rules, which led to misconceptions and never allowed students an opportunity to build a conceptual understanding.

The instructional practice of repetitious drilling of basic facts and procedures did not require students to think and often led students to see concepts in isolation rather than as a connection of ideas. Brownell (1928) suggested that students did not need a high intelligence level for repetitious drill or rote memorization. He further cautioned educators that there was not a clear correlation between repetition and the reality of what students were capable of mathematically (Brownell, 1928). Furthermore, Boaler (2016) has shared that repetitive practice has proven to be a poor learning experience for low achieving students. According to Brownell (2007), the instructional practice of repetition created a low-level understanding of mathematics and often prohibited a student from progressing to more complex and abstract concepts. It often led to false student perceptions about his or her mathematics ability. Repetition in mathematics did not allow students to practice the skills necessary for application in unknown situations. Furthermore, Brownell shared that drill and repetitive practice often resulted in meaningless learning. If students were not allowed opportunities to think, they would not discover personal paths to solutions or have opportunities to create meaning (Kohn, 1999). It had become evident that through personal discovery, real learning in mathematics occurred.

Brownell (2007) firmly believed that students did not make errors in mathematics because they had not learned the appropriate symbols. He believed that errors were made because students did not have a firm understanding of the mathematical processes and were not able to accurately utilize procedures (Brownell, 2007). Kohn (1999) shared that "analysts of NAEP data for the Educational Testing Service observed that students can 'recite rules' but often don't 'have any idea whether their answers are reasonable'" (para. 9). Students were not able to acquire a conceptual understanding of the mathematics they were practicing and therefore unable to apply it in unknown situations.

By 1977, NCTM began to pay careful attention to societal shifts and changes (Seeley, 2015). However, it was not until the late 1980s that necessary shifts in accountability, the need for higher standards, and education reform in mathematics became widely publicized (Seeley, 2015). The 1980s was often referred to as the Era of Realization (Nesmith, 2008). The authors of the publication, *A Nation at Risk,* indicated that students received a mediocre education in the United States and expressed frustration at the lack of progress made since the Sputnik challenge (National Commission on Excellence in Education, 1984). Through the publication of *Everybody Counts*, a rationale was provided for all students being exposed to more complex expectations, as well as mathematics reform that better prepared students for paths outside of calculus (Mathematical Sciences Education Board, Board on Mathematical Sciences, Committee on the Mathematical Sciences in the Year 2000, & National Research Council, 1989).

The changes that came about in the late 1980s were also related to the growing use of technology and were influenced by ideas grounded in constructivism (NCTM, 1989). Amit and Fried (2002) shared that constructivism was grounded in the belief that students should construct their own meaning using their prior knowledge to understand new concepts. The ability to construct personal meaning or connect new learning to prior knowledge was important to students being successful at applying the information in unknown situations.

Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) was instrumental in beginning the movement to decrease memorization and drill of basic facts, as well as the importance of students using multiple strategies and representations when solving problems. NCTM leaders called for an increased awareness in the areas of number sense, estimation, and reasoning (NCTM, 1989). Educators were encouraged to provide students with learning opportunities that went beyond surface level instruction (Henderson Pinter, 2016), as well as increased thinking and calculator usage when presented with complex problems (NCTM, 1989). Furthermore, NCTM outlined a comprehensive list of standards and recommendations (Seeley, 2015), promoting mathematics as a social subject (Boaler, 2016), as well as encouraged discourse and making connections between numbers and the literacy strands of reading, writing, and listening (NCTM, 1989). Recommendations were also made to encourage the use of multiple representations and manipulatives (NCTM, 1989).

In the 1990s, a dialogue began on how to use the recommended NCTM standards. Five mathematical goals for student success were established:

1. Students would be presented with opportunities to see the value in math.
2. Students would confidently begin to make mathematical connections to their daily lives.
3. Students would be presented with opportunities to problem solve.
4. Students would learn to communicate through mathematical symbols, ideas, and vocabulary.
5. Students would develop the ability to reason when solving mathematical problems. (NCTM, 1989)

As the 20th Century ended, a solid mathematics foundation was established that would hopefully allow students to be successful mathematical thinkers and problem solvers in future years.

Mathematics Instruction in the 21st Century

Seeley (2015) shared that a renewed sense of urgency occurred in the 21st Century with the need for higher expectations and achievement in both mathematics and science. Seeley stated that adults working in the 21st Century are faced with more complex problems than those working during the age of agriculture and industrialism. Seeley further suggested that successful individuals today required a strong understanding of mathematical concepts and abilities when compared to those of the past.

Instructing students with mastery at the surface level only prepares students for the lowest tier of available jobs (Seeley, 2015). According to Fortune 500 reports, employers in the 1970s were looking for individuals with strong computation skills (Boaler, 2016). In fact, this skill was rated the second most desirable skill when hiring new employees, while teamwork lagged far behind at tenth place (Boaler, 2016). Fast forward to 1999, teamwork moved into the number one slot, while the desire for employees skilled in computation drastically decreased to twelfth place (Boaler, 2016). Pedagogy has been transformed to meet the shifting demands of the workplace. Recent adaptations in technology have played a major role in these shifting skills, thus making some math, such as tedious and complicated calculations, less important (Seeley, 2015).

Successful employees in the 21st Century should be able to reason mathematically (Boaler, 2016). According to Baroody (2006), the ability to reason mathematically is one of the three phases of having number sense. The first phase is grounded in counting strategies, followed by reasoning strategies, and concluding with mastery (Baroody, 2006). However, Wolfram (2010) cautioned educators in a TEDGlobal2010 talk that instruction at the basic calculation phase and the ability to calculate well does not necessarily connect to math in the real world. Wolfram (2010) believes that mathematics instruction should be about asking and answering questions that are brought forth through experiences in the real world and connected to the computation that allows for solutions to be reached and explained. Students must be presented with opportunities to relate and connect their learning to the mathematics they would encounter in the real world.

Instruction in mathematics during the 21st Century has allowed students to create a new understanding (Seeley, 2015), engage in inquiry (Baroody, 2006), and increase discourse amongst students (Parrish, 2010). According to Achieve the Core (n.d.), a student's mathematical foundation would need to consist of a "solid conceptual understanding, a high degree of procedural skill and fluency, and the ability to apply the math they know to solve problems inside and outside the math classroom" (para. 1).

In 2010, the National Governors Association and Council of Chief State School Officers released the Common Core State Standards (CCSS) (Seeley, 2015). The standards in English Language Arts and Mathematics were outlined in this document (National Governors Association Center for Best Practices, & Council of Chief State School Officers, 2010a), and created consistency for student expectations (Seeley, 2015). Specifically, the CCSS for Mathematics has established direction for educators and clarified outcomes to ensure commonality (NCTM, 2014). Students are given the opportunity to explore early algebraic concepts beginning in grade 3 (Henderson Pinter, 2016). Past standards documents have included mathematical topics a mile wide, while the CCSS aimed to achieve depth through focusing on fewer topics (National Governors Association Center for Best Practices, & Council of Chief State School Officers, 2010a). The adoption of the CCSS by "forty-two states, the district of Columbia, four territories, and the Department of Defense Education Activity" (p. 1) has led to an increased awareness of procedural skills, fluency, and concepts (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010b). Furthermore, the standards have called for speed and accuracy with computation, as well as application when encountering unknown situations (National Governors Association Center for Best Practices, & Council of Chief State School Officers, 2010a). The document, acting as a K-12 progression for educators, has offered less overlap in content from previously released standards (Henderson Pinter, 2016). It is imperative that teachers understand the progression of learning to allow students to build upon foundations already established in previous grades and math courses. The CCSS (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010a) were created to not only build upon earlier topics of mastery but also to establish connections between the grade levels. Depth in mathematical thinking is created when students are able to connect or link concepts and ideas (Seeley, 2015).

The idea that "less can be more" was established once the repetition of standards was eliminated from grade bands (Seeley, 2015). Seeley has also recommended a purposeful review of material linked to new learning and quality teacher interactions. Seeley has further shared that quality mathematics teaching in one year can lead to students having stronger mathematical ability the following year rather than becoming caught in the yearly cycle of review and practice at the most basic level.

Seeley (2015), a leader in supporting educators with the refinement of mathematical pedagogy, has acknowledged that "while computational recall is important, it is only part of a comprehensive mathematical background that includes more complex computation, an understanding of mathematical concepts, and the ability to think and reason to solve problems" (p. 120). Twenty-first century classrooms throughout the United States have continued to emphasize rote memorization and fast recall of facts, procedures, and specific mathematical formulas. However, students, teachers, and parents still believed that memorization and fast fact recall was of primary importance in the mathematical hierarchy (Kohn, 1999). Past research has indicated that memorization has not been found to build number sense, nor does it correlate to a student's ability or math potential (Boaler, Williams, & Confer, 2015).

> If a student memorizes a rule without getting it, when it works, any limitations in using it, and so on – he or she may eventually forget or misunderstand all or part of the rule and may misapply it. Memorization can be a useful tool, but it's only part of getting it – the student needs to internalize what the rule is all about and recognize when it's helpful and when it's not. (Seeley, 2014, p. 37)

Furthermore, Boaler (2016) pointed out that speed does not equate to having number sense. Seeley (2015) believed that if too much emphasis is put on fast fact recall with little to no attention to problem solving and conceptualization, students will continue to have a misguided view of the purpose of mathematics and their personal ability to compute mentally. Students may incorrectly have perceived they were not good at mathematics because they could not recall facts as quickly as their classmates (Boaler, 2016). Thus, a fear has existed that students might inadvertently be funneled into unnecessary interventions and remedial courses.

Educators across the country have reflected on whether it is important for mathematical thinkers to be molded and formed or to act as human computers. Current leaders in the field of mathematics are calling for a de-emphasis in rote memorization and use of fact tables (Boaler et al., 2015). If memorization is to be emphasized, meaningful memorization, using patterns and relationships, must be of primary focus (Baroody, 2006).

Furthermore, advocates for mathematics reform have pointed to the importance of a balanced approach. Burns has echoed this approach, suggesting that number sense, computation, and problem-solving skills were combined to create balance in mathematics (Seeley, 2015). This approach allows students to (a) make sense of the problem, (b) do the necessary computation to solve the problem, and (c) use the mathematics in unknown situations (Seeley, 2015). NCTM (2014) has argued that students do need time to practice a strategy or mathematical process as this is key to committing the strategy to memory. Students who are able to solve problems in isolation are often able to complete the necessary mathematics but may have struggled to apply the mathematical concepts to an unknown situation.

Boaler (2016) highlighted the 2012 student perceptual data from the Programme for International Student Assessment (PISA) team at the Organisation for Economic Co-operation and Development (OECD). Data indicate that students scoring the highest in mathematics throughout the world "are those who approach mathematics looking at and thinking about the big ideas and the connections between them" (Boaler, 2016, p. 47), while those students with the lowest scores are tied to memorization strategies. Students of the information age have developed an enduring understanding of the mathematics they are faced with, including the "ability to reason about quantitative information, possess number sense, and check for the reasonableness of solutions and answers" (Parrish, 2010, p. 4).

Early 21st Century best practices. Educators in the 21st Century are still overemphasizing or prematurely introducing procedures and algorithms. Unfortunately, this premature focus continues to create passive learners rather than active learners able to make sense of numbers and patterns (National Council of Teachers of Mathematics

Commission on Standards for School Mathematics, 1989). Educators fail to recognize authentic learning occurred from experimenting and playing with numbers.

> Many people believe there is a developmental stage students must go through before they are ready for certain mathematics topics. But these ideas are also outdated, as students are as ready as the experiences they have had, and if students are not ready, they can easily become so with the right experiences, high expectations from others, and a growth mindset. (Boaler, 2016, p. 8)

Negative perceptions associated with mathematics continued to be prevalent for both students and teachers (Boaler, 2016). A false understanding of mathematics, its purpose, and its application to life could be attributed to negative beliefs associated with worksheet overload and repetitive practice (Boaler, 2016). Furthermore, "most practice examples give the most simplified and disconnected version of the method to be practiced, giving students no sense of when or how they might use the method" (Boaler, 2016, p. 42). Students are left to believe that math, in its current state, is a dead subject and irrelevant to their personal lives (Boaler, 2016). Furthermore, Kohn (1999) shared evidence that when students fall in love with the subject of math, they are much more likely to persist through difficult problems, as well as celebrate the successes of one another.

However, the ability to compute fluently and show ease and confidence with numbers has the potential to change students' negative perceptions of math (Humphreys & Parker, 2015). Many of these negative views, set in motion with earlier generations, have to be broken for current and future generations to pave new paths in the field of mathematics (Seeley, 2015). Kohn (1999) believes that a movement away from traditional approaches in the instruction of mathematics is key to shifting negative views strongly held for so many years. Typical classrooms of the past were teacher-centered where students were required to memorize basic facts and perform tricks the teachers taught aimed at making the mathematics process more simplified (Karp, Bush, & Dougherty, 2014). However, these tips and tricks did not create mathematical thinkers with a solid foundation in conceptual understanding (Karp et al., 2014). Students found that the rules expired as they progressed in their mathematical abilities and did not promote the precise use of mathematical vocabulary (Karp et al., 2014). This lack of conceptual understanding created misconceptions and often led to calculation errors. Furthermore, instructing through tips and tricks did not encourage the use of multiple strategies for solving problems in unknown situations. Boaler (2016) shared:

> It is this approach to early learning about numbers that causes damage to students, makes them think that being successful at math is about recalling facts at speed, and pushes them onto a procedural pathway that works against their development of a mathematical mindset. (p. 37)

Boaler (2016) indicated that low-achieving students do not necessarily have less knowledge of mathematics but engage differently with the mathematics knowledge they have when compared to high-achieving students. Further synthesis of the research by Boaler (2016) led to the realization that students "who learned through strategies achieved 'superior performance' over those who memorized; they solved test questions at the same speed and showed better transfer to new problems" (p. 39). Students who demonstrated flexibility went against the rules and procedures to find solutions (Humphreys & Parker, 2015).

In contrast, students continuing to approach numbers without flexibility were more dependent on previously learned formal procedures, precisely followed each step of the procedure, and when situations occurred where it made sense to abort the steps of a procedure, students were less confident in doing so (Boaler, 2016). Low achieving students were "identified as struggling with math and therefore given more drill and practice – cementing their beliefs that math success means memorizing methods not understanding and making sense of situations" (Boaler, 2016, pp. 35-36). A lack of flexibility was connected to lower mathematics achievement (Boaler et al., 2015). Students who lacked flexibility with numbers often relied heavily on procedures and immediate application of isolated facts (Boaler, 2016).

A shift in mathematics pedagogy became evident. The subject was evolving to be more student-centered with the teacher acting as a facilitator (U.S. Department of Education, 1996; Henderson Pinter, 2016). Teachers encouraged collaboration in the classroom (U.S. Department of Education, 1996), as well as incorporated instructional activities that allowed students to put mathematical thinking into words (Kohn, 1999). Educators had found that the use of manipulatives and tools was an effective instructional strategy (Humphreys & Parker, 2015). Bono (2002) found the use of manipulatives positively impacted students of lower ability. Furthermore, manipulatives and tools allowed students the opportunity to build a mathematical foundation at the concrete level. Research from a 2007 publication by Fuson and Mata was cited by NCTM (2014) to argue the case that "math drawings and other visual supports are of particular importance for English language learners, learners with special needs, or struggling learners, because they allow more students to participate meaningfully in the mathematical discourse in the classroom" (p. 25). Furthermore, strong mathematical understanding was demonstrated through "…drawing diagrams and using words to show and explain the meaning of fractions, ratios, or the operation of multiplication" (NCTM, 2014, p. 24).

Teachers in the 21st century strived to create fluent students who used efficient strategies to solve problems accurately. Educators began to realize that past methods in mathematics instruction were not making a lasting impact on students, nor was previous mathematics instruction best preparing students for more difficult courses in high school and college. In 2006, the National Mathematics Advisory group shared two areas of focus for all elementary students, specifically centered on the importance of being mathematically fluent: (a) to be fluent with whole numbers, and (b) to be fluent with fractions (National Education Association [NEA] Education Policy and Practice Department, n.d.).

Researchers found that as students developed number sense, they became more efficient mathematicians (Baroody, 2006). Students who had number sense often demonstrated flexibility with numbers and could learn math facts through an understanding of how numbers connected to and related with one another (Boaler et al., 2015). With flexibility came the ability to compose and decompose numbers and use that information to efficiently solve unknown problems (Boaler et al., 2015). In 2000, NCTM promoted the creation of a solid mathematics foundation for all students, which was grounded in both number sense and computational fluency (Godfrey & Stone, 2013). Fluency was important to a student being described as mathematically proficient (Baroody, 2006), and having number sense created a foundation for one to achieve at high levels, as well as the ability to understand and solve mathematically rich problems (Boaler et al., 2015).

Kohn (1999) suggested that when students think in mathematics classes, personal paths to a solution are uncovered. Kohn (1999) further believed that students able to create their own paths to the solution of a problem provided a teacher more information regarding which skills the student had mastered, and which skills needed further teacher support. According to Boaler (2016), "the best and most important start we can give our students is to encourage them to play with numbers and shapes, thinking about what patterns and ideas they can see" (p. 34). The ability to play with and think about numbers indicates that a student has flexibility and will not solely be tied to mathematical rules and step-by-step procedures. When a task becomes too difficult, these students are able to use other strategies and build upon previously learned content to persevere and achieve goals. Furthermore, student motivation often increases through productive struggle with concepts found in complex problems (Seeley, 2015). Number Talks is a pedagogical structure that offers students opportunities to mentally solve problems through a variety of strategies, ultimately increasing their ability to persevere through difficult computation problems.

Boaler (2016) suggested that students with a growth mindset are motivated by and persist through challenging problems that lead to mistakes and frustration. She believed that students and teachers operating with a growth mindset welcome mistakes as they recognize that mathematics is not about getting everything correct the first time. Boaler further shared that mistakes allow the brain an opportunity to grow and the student to become a stronger mathematician.

Resnick shared in a 1988 interview that errors in mathematics are important to the learning and sense-making process (Brandt, 1988). She also expressed the belief that students must see themselves as capable of doing complex things (Brandt, 1988). These messages are important to creating a positive image and message about mathematics.

Number Talks and Talk Moves. Humphreys and Parker (2015) have built on the original platform of Number Talks, originally created by Parker and Richardson in the early 1990s (Humphreys & Parker, 2015). Both Parker and Richardson were instrumental in leading teachers toward the most effective implementation tied to their individual grade level (Humphreys & Parker, 2015). According to Humphreys and Parker (2015), Number Talks encourages the use of multiple strategies to reason and solve complex problems, as well as offers support for students to build mental computation.

In 2009, Celski completed a research study connecting increased student achievement in mathematics to strategies and practice with mental computation. Students in the district had poor number sense and lacked ability with even the most basic computation (Celski, 2009). Teachers in this district learned of the Number Talks strategy through a presentation delivered by Parker (Celski, 2009). Therefore, Number Talks became a specific strategy studied by Celski (2009) to establish a positive correlation between fluency, number sense, and an improved ability to compute.

According to Parrish (2010), an effective Number Talk encompasses five key elements. A classroom community must first be established that allows students to take risks in their learning (Parrish, 2010). She shared that all students in this environment are looking to grow and progress in their mathematical abilities together (2010).

Second, discourse is essential to the Number Talk process (Parrish, 2010). Students must have time to think and process multiple pathways to solving a problem (Parrish, 2010). An opportunity is then provided for students to share solutions and make justifications that support thinking (Parrish, 2010). Boaler (2016) suggested that mathematical proof is often achieved through the act of convincing others of a solution's reasonableness. It is imperative that students have the opportunity to explain the why behind the computation and not solely be provided an opportunity to perform procedures by mindlessly submitting to the motions of solving a problem (Bono, 2002). Parrish (2010) stated that the right solution is not as important as the learning that occurs due to discussions that bring forth common misconceptions and mistakes. Baxter, Olson, and Woodward (2001) stated that to be successful in mathematics, the ability to listen and explain are key components to constructing a personal understanding of the mathematics. NCTM (2014) suggested that discourse should provide students with the opportunity to "share ideas and clarify understandings, construct convincing arguments regarding why and how things work, develop a language for expressing mathematical ideas, and learn to see things from other perspectives" (p. 29).

In a Number Talk, the role of the teacher is that of the facilitator (Parrish, 2010). "Keeping the discussion focused on the important mathematics and helping students learn to structure their comments and wonderings during a number talk is essential to ensure that the conversation flows in a meaningful and natural manner" (Parrish, 2010, p. 12). Teachers utilize Talk Moves to structure and encourage conversation. Talk Moves support discourse through opportunities to build on the thinking of others, repeat what they heard another classmate say, or explain another's solution in a different way (Chapin, O'Connor, & Canavan Anderson, 2013).

Another major component of Number Talks is the focus on mental mathematics (Parrish, 2010). Mental mathematics eliminates the procedures students have memorized to solve problems in the past (Parrish, 2010). Number Talks is an opportunity for "students to focus on number relationships and use these relationships to develop efficient, flexible strategies with accuracy" (Parrish, 2010, p. 13). She defined accuracy as a student's ability to compute a correct solution to a problem. Number Talks offers students a natural way to commit facts to memory, but without the damaging practice of timed tests, memorization, and drill of the multiplication tables (Boaler et al. 2015). In fact, Number Talks is a strategy, that when used consistently and with fidelity, has the power to allow basic facts to be learned and committed to memory through conceptual engagement (Boaler, 2016). A strong sense of mental computation should not be confused with rote memorization but instead perceived as a way for students to think about possible solutions and approaches (Seeley, 2015), suggesting that a student has flexibility with numbers, a conceptual understanding, and a solid foundation based on mathematical principles (Boaler et al., 2015; Seeley, 2015). Furthermore, requiring that students mentally solve problems during a Number Talk also strengthens their understanding and ability to utilize place value (Parrish, 2010).

A final important component of Number Talks is thoughtful planning (Parrish, 2010). Teachers must have a firm understanding of their goal and the strategies that will elicit mastery of this goal when planning an effective Number Talk (Parrish, 2010). According to Parrish (2010), "crafting problems that guide students to focus on mathematical relationships is an essential part of number talks that is used to build mathematical understanding and knowledge" (p. 14).

Number Talks contains an important instructional framework to consider for several reasons. NCTM (2014) suggested that students exposed to mathematical reasoning at an early age would be linked later to reasoning in algebra. Students exposed to and able to utilize multiple strategies were more likely to achieve at high levels (Boaler, 2016). Furthermore, students who could utilize and explain multiple strategies in mathematics demonstrated a higher level of number sense (Boaler, 2016).

> We need citizens who are able to discern whether numbers make sense and are applicable to specific situations and who can communicate solutions to problems. Today's mathematics curricula and instruction must focus on preparing students to be mathematically proficient and compute accurately, efficiently, and flexibly. (Parrish, 2010, p. 5)

If teachers are to instruct students using the best mathematical structures of the 21st Century and implement effective Number Talks with ease, they must have access to quality professional development. Teacher professional development is crucial to instruct at levels that would lead all students to grow in their mathematical abilities. It is therefore imperative that districts spend time researching frameworks that develop quality professional development that could change teacher pedagogy, thus positively changing student achievement.

Professional Development Frameworks that Work

According to Amit and Fried (2002), there is a growing dissatisfaction with student abilities and the lack of preparation for mathematical careers. All students deserve instruction and access to highly skilled teachers in mathematics (Seeley, 2015), as well as an opportunity to learn from a well prepared and licensed educator (NEA Education Policy and Practice Department, n.d.). Teachers need to be prepared not only in their instructional practices but also in their content area (NEA Education Policy and Practice Department, n.d.). Ball (2003) pointed out that to teach mathematics effectively, teachers require a different mathematical foundation than that of mathematicians. According to NCTM (2014), "mathematics teaching demands subject-specific understanding and insight so that teachers can skillfully carry out their work in mathematics classrooms" (p. 12).

Yoon, Duncan, Lee, Scarloss, & Shapley (2007) reported that "professional development affects student achievement through three steps" (p. 4). Professional development should be aimed at increasing the teacher's knowledge and craft (Yoon et al., 2007). If a teacher's knowledge and craft are enhanced, overall instruction in the classroom will improve (Yoon et al., 2007). Finally, if instruction is improved, ultimately an increase in student achievement will occur (Yoon et al., 2007). "If one link is weak or missing, better student learning cannot be expected. If a teacher fails to apply new ideas from professional development to classroom instruction…, students will not benefit from the teacher's professional development" (Yoon et al., 2007, p. 4).

Murphy-Latta (2008), determined that both teachers and students benefit from quality professional development. Specifically, the study aimed to determine if there was a difference in achievement between school districts recognized in the state of Missouri for excellence in professional development and comparison school districts. The participants in this quantitative research study were students in Missouri's public education system, kindergarten through twelfth-grade (Murphy-Latta, 2008). According to Murphy-Latta, 2008, there was no statistical difference between recognition schools and comparison schools. Ajjawi's (2015) findings concurred with the previous study indicating that student achievement is directly impacted by mathematics focused professional development. The participants in Ajjawi's (2015) research study were 8th graders in the Kingdom of Bahrain. According to Ajjawi (2015), student achievement in mathematics is positively impacted through professional development connected to programs associated with mathematics.

Carillo, Maasen van den Brink, and Groot (2016) analyzed 20 different studies to determine the impact of professional development on reading and mathematics in order to make conclusions about effective structures and practices. In their findings, they reported "there is more evidence about the positive effect of professional development on math than on reading. 58% [*sic*] of the estimates that focus on students math performance find a positive and statistically significant impact on teachers' training" (Carillo et al., 2016, p. 15). Researchers determined that when comparing elementary schools to middle schools, professional development more positively impacted instruction at the elementary level (Carillo et al., 2016). The study compared two types of professional development to determine which had a greater impact on mathematics (Carillo et. al., 2016). It was determined that "88% of the estimates about the effect on math of a content-based training find positive and significant results vs 50% of positive results when the program is focused on pedagogy" (p. 16). Finally, researchers determined that the longevity of professional development was an important factor when considering effectiveness (Carillo et al., 2016). In fact, "62% of estimates that examine the effect of professional development programs that have more than 60 hours of duration find positive and significant evidence of the effect of the training. This result is around 12 percentage points higher than the programs that contain less than 60 hours" (Carillo et al., 2016, p. 16).

According to Boaler (2016), when asked what the subject of mathematics entailed, students have often responded that the subject of mathematics mostly consists of mathematical rules and procedures, as well as basic computation. However, a mathematician's response would more likely be that the subject of mathematics is a subject of beauty, encourages creativity, and requires one to have the ability to utilize patterns (Boaler, 2016). It has become important for students to view themselves as mathematicians and not just students of mathematics. Therefore, educators must be provided ample opportunity to immerse themselves in professional development that is ongoing (Seeley, 2015). These experiences should include building a core of strategies that are proven to motivate and engage students when solving complex problems (Seeley, 2015).

Teachers instructing mathematics should "recognize that they are engaged in a mathematical profession, and consequently they are lifelong learners and doers of mathematics" (NCTM, 2014, p. 99). Resnick shared in an interview with Brandt (1988) that a major goal for schools should be to encourage student thinking, which is not possible if teachers are not required to first think. Aguire, Kantanyoutant, and Zavala

(2012) found that a lack of understanding, as well as low confidence in the ability to teach mathematics, has led to the false implementation of an intended curriculum. The purpose of this mixed methods study was to determine if pre-service teacher pedagogy was improved through the analysis of culturally responsive mathematics. The participants in this study consisted of university students enrolled in a K-8 mathematics course (Aguire et al., 2012).

Grossman (1990) suggested four elements essential to the teaching of mathematics. These elements include:

- a solid understanding of the mathematical content he or she is responsible for teaching;
- the overarching knowledge of what students will know and be able to do mathematically;
- a thorough understanding of the curriculum and available resources, as well as mathematical concepts both vertically and horizontally; and
- the ability to instruct through a variety of strategies and representations that support students' development.

Teaching can only improve if educators are open to learning (Seeley, 2015). Quality instruction has long been recognized as a major contributor to student mastery of concepts (DuFour & Marzano, 2011). Darling-Hammond et al. (2017) elaborated further that the use of professional development strategies that allowed teachers to become active participants in the learning, promoted collaboration, and allowed for observations of colleagues, have an increased likelihood of positively impacting teacher instructional practices. According to Pain (2015), there is a positive correlation between teacher professional development in mathematics and student achievement. Participants in this quasi-experimental ex-post facto correlational design study consisted of elementary students throughout the Chicago suburban area (Pain, 2015). According to Pain (2015), increased student achievement occurred when professional development was meaningful to participants. Graham (2015) echoed this finding but elaborated further that the use of research-based professional development strategies positively impact teacher instructional practices. Specifically, this study focused on professional development tied to instructional delivery in mathematics. Participants in this qualitative action research study consisted of third, fourth, and fifth-grade teachers and their principal (Graham, 2015). However, Perry and Dockett (2002) stated that "one of the biggest challenges for mathematics education is in the area of learning how to develop a profound understanding of fundamental mathematics in adults who interact with the young children in their schools" (para. 12).

According to DuFour and Marzano (2011), to make improvements in a school, leaders must start by improving those who teach in the school. In fact, "effective teaching is the nonnegotiable core that ensures that all students learn mathematics at high levels" (NCTM, 2014, p. 4). Holloway (2004) shared that minority student achievement in mathematics would be improved through quality teacher-student exchanges. Seeley (2015) has suggested that the achievement gap be narrowed, and possibly eliminated, through improved, quality teacher exchanges. Boaler (2016) stated that highly qualified teachers are essential to leveling the playing field and helping those who had entered school underprepared or behind.

According to Boaler (2016) educators, who do not view race, color, or gender as a crutch to excelling in the field of mathematics are essential to student success. Boaler recognized that to accomplish this task, the current beliefs and practices of educators will first need to be changed or adapted. Teacher professional development will serve as a major contributor to shifting the beliefs and perceptions of teachers, and ultimately replace past practices aimed at tracking and low-level student application.

However, teacher beliefs are extremely difficult to change as teachers themselves are products of outdated pedagogy (Nesmith, 2008). Ball (2003) stated that educators were personally taught as children in a system based on rules and procedures, and Brandy (1999) has suggested these same teachers have for years instructed their own students under the assumption that mathematics is about getting the right answer. Therefore, common instructional methods have been that of the teacher bestowing his or her knowledge on the students, very little practice with strategies associated with problem solving, and a general lack of excitement and enjoyment of the overall subject (Seeley, 2015).

District and school leaders have also recognized that developing the talents of individual teachers does not go far in developing the talents of the team or total organization (DuFour & Marzano, 2011). When educators teach in isolation, inequities in learning are created (National Council of Teachers of Mathematics, 2014). Garmston (1997) indicated that adults would excel through opportunities that allow for collaboration and the support of one another, as well as create systems intended to hold one another accountable. DuFour, DuFour, and Eaker (2008) further stated that to achieve mutual accountability on a team, collaboration to achieve a common goal must first exist. Educators should "hold themselves and their colleagues accountable for the mathematical success of every student and for personal and collective professional growth toward effective teaching and learning of mathematics" (National Council of Teachers of Mathematics, 2014, p. 99).

According to Fullan (2008), learning should become the job of all educators. As a strong proponent of teacher leadership, he is suggesting that leaders be fully immersed in the work of developing more effective practitioners. Althauser (2010) discovered that student achievement in mathematics is positively correlated to teacher participation in job-embedded professional development. According to Althauser (2010), there was a relationship between the general efficacy of teachers and socioeconomic status with increased student mathematics achievement. The participants for this quantitative research study consisted of third-grade teachers in Kentucky and specifically focused on efficacy both generally and personally. The goal of this type of professional development is to create a culture of professionalism that is transparent and focused on the strengths and weaknesses of the system, as well as to encourage members to share ideas, insights, and practices to make the most efficient impact on student learning (NCTM, 2014). Strong cultures have members who are committed to improvement efforts, act with follow through, and have high levels of support for the initiatives (Seeley, 2015).

Senge (1990) shared the five disciplines of learning organizations to help districts navigate difficult transitions: systems thinking, team learning, shared vision, mental models, and personal mastery. The use of all five disciplines leads a district to workplace effectiveness (Senge, 1990). Strong professional development models are found to reduce gaps that exist in learning (Moller, Mickelson, Stearns, Banerjee, & Bottia, 2013) and improve student outcomes (Guskey, 2002). All educators within the organization must "hold themselves, individually and collectively, accountable for all students' learning, not just the learning of their own students" (NCTM, 2014, p. 19) for there to be improvement of the total system. The purpose of professional development should be to establish a direct connection to creating an understanding of mathematics beyond the surface level, the ability to understand how students learn the mathematical concepts, and participation in vertical alignment (NCTM, 2014).

Summary

Chapter 2 included a timeline of mathematics instruction beginning in the 19th Century and continuing into the early 21st Century, which included mathematical theories about learning, textbook content and preparation, and instructional practices. Research was also presented that led to a necessary shift in instructional practices. Frameworks for effective teacher professional development were also of focus in this chapter.

Chapter 3 contains information about the research methods and design for the current study. The selection of participants and measurement tool are defined. Data collection procedures, data analysis, and hypothesis testing are presented to determine the impact of teacher professional development on student achievement. Finally, limitations of the study are examined to understand outside factors that may have impacted the data analysis collection process.

Chapter 3

Methods

The motivation for this research study was stagnant student progress in mathematics for third, fourth, and fifth-grade elementary students. Further motivation for this study was to determine if intentional district professional development created consistency and enhanced common practices and pedagogy among classroom teachers, thus leading to a change in student achievement in mathematics. Outlined in Chapter 3 are the research design and selection of participants. Additionally, presented in this chapter are the measurement, data collection procedures, data analysis, hypothesis testing, and the limitations of the study.

Research Design

This study involved a quantitative method incorporating archival data for students' mathematics scores, as measured by the MAP. Independent variables included the data collection years of 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016 in relation to the professional development, student gender, student socioeconomic status, and students with Individualized Education Plans (IEP). The dependent variable was the percentage of third, fourth, and fifth-grade students who scored in the proficient category on the MAP mathematics assessment.

Selection of Participants

Purposive sampling was used to identify participants. Purposive sampling, according to Lunenburg and Irby (2008), is a method that selects participants based on the researcher's experience or knowledge of those to be sampled. The participants selected for this study were third, fourth, and fifth-grade elementary students who took the MAP in School District A, a suburban school district in western Missouri. A second sample of participants was selected from the State of Missouri. Students were third, fourth, and fifth-grade elementary students who took the MAP assessment during the school years of 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016.

Measurement

The mathematics portion of the MAP assessment was utilized to determine a change in third, fourth, and fifth-grade student achievement scores once teacher professional development was received. During the school years 2011-2012, 2012-2013, and 2013-2014, students were assessed on their ability in Number and Operations, Algebraic Relationships, Geometric and Spatial Relationships, Measurement, and Data and Probability (Missouri Department of Elementary and Secondary Education, 2014a). The strands of mathematics assessed beginning in 2014-2015 and continuing to 2015-2016 were Operations and Algebraic Thinking, Number in Operations in Base Ten, Numbers and Operations-Fractions, Measurement and Data, and Geometry (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010a).). In order for districts to transition to the new state assessment in 2014-2015, the Missouri Department of Elementary and Secondary Education developed and distributed a crosswalk document (Missouri Department of Elementary and Secondary Education, 2012). The crosswalk allowed educators to cross-reference the previous version of the Grade Level Expectations that assessed Number and Operations, Algebraic Relationships, Geometric and Spatial Relationships, Measurement, and Data and Probability with the newer version made available by the state (Missouri Department of Elementary and Secondary Education, 2012). Missouri educators were able to connect portions of the outdated standards to the new standards to update curriculum and prepare students for the new assessment.

The state of Missouri released a guide that supported educators in their interpretation of MAP results during the school years of 2011-2012, 2012-2013, and 2013-2014 (Missouri Department of Elementary and Secondary Education, 2015). Assessment items in mathematics included “selected-response items” and “short text items” (Missouri Department of Elementary and Secondary Education, 2015, p. 1). During the 2014-2015 school year, technology-enhanced items were added to the assessment that required students to perform skills such as manipulate data and access embedded graphics (Missouri Department of Elementary and Secondary Education, 2015). Additionally, fifth-grade students were also required to complete a mathematics performance task (Missouri Department of Elementary and Secondary Education, 2015).

> The performance task may require students to do such things as simulate a study and present and interpret data in a table or graph. Students are required to explain their responses; and often the task allows more than one approach to arrive at a correct response. (Missouri Department of Elementary and Secondary Education, 2015, p. 2)

Number and Operations assessment items included the ability to recognize relationships that exist in numbers, as well as the ability to represent numbers (Missouri Department of Elementary and Secondary Education, 2008). Students were also assessed on their ability to recognize how the four operations are related (Missouri Department of Elementary and Secondary Education, 2008). Furthermore, students were assessed on their ability to fluently compute (Missouri Department of Elementary and Secondary

Education, 2008). Algebraic Relationships assessment items included patterns, symbols, and the use of models to show relationships (Missouri Department of Elementary and Secondary Education, 2008). Geometric and Spatial Relationships assessment items included the ability to analyze two and three-dimensional shapes, coordinate grids, and symmetry (Missouri Department of Elementary and Secondary Education, 2008). Measurement assessment items included the use of mathematical formulas and tools, as well as the study of measurement systems such as area and perimeter (Missouri Department of Elementary and Secondary Education, 2008). Data and Probability assessment items included the ability to create and analyze charts and graphs (Missouri Department of Elementary and Secondary Education, 2008). Probability was first introduced in fifth-grade as being able to "describe the degree of likelihood of events using words such as certain, equally likely, and impossible" (Missouri Department of Elementary and Secondary Education, 2008, p. 24).

To roll out the new state standards and assessment criteria, the state of Missouri released an assessment handbook for school districts (Missouri Department of Elementary and Secondary Education, 2014-b). The handbook indicated there would be 31 items assessed on the spring state mathematics assessment beginning in 2014-2015 and continuing into the 2015-2016 school year (Missouri Department of Elementary and Secondary Education, 2014-b). Number Sense and Operations in Base Ten assessment items focused on an understanding of place value (Missouri Department of Elementary and Secondary Education, 2016). Numbers and Operations-Fractions assessment items included the ability to recognize fractions as a number used in counting, the ability to order and find equivalencies, and connecting fractions to decimal values (Missouri

Department of Elementary and Secondary Education, 2016). Operations and Algebraic thinking assessment items included problems that required students to use the four basic operations to solve problems, including word problems, and understand patterns (Missouri Department of Elementary and Secondary Education, 2016). Students were also assessed on their ability to understand multiplication properties (Missouri Department of Elementary and Secondary Education, 2016). Geometry and Measurement assessment items included the ability to work with both two and three-dimensional shapes, identify attributes, as well as understand volume, time, weight, and angle measurements (Missouri Department of Elementary and Secondary Education, 2016). Students were also assessed on their ability to understand area, perimeter, basic measurement conversions, and coordinate planes (Missouri Department of Elementary and Secondary Education, 2016). Data assessment items required the ability to use and make sense of data (Missouri Department of Elementary and Secondary Education, 2016). Members of the Smarter Balanced Consortium (2014), utilized the Mathematics Summative Assessment Blueprint to make decisions regarding mathematical areas of emphasis. District leaders could use this document to prioritize standards, create pacing guides, and align instruction.

Beginning in the 2014-2015 school year, the Missouri Department of Elementary and Secondary Education (n.d.-c) did not specify time limits for each assessment. However, there were suggested timing guidelines to help school leaders and teachers plan the assessment schedules (Missouri Department of Elementary and Secondary Education, n.d.-c). Students were assessed using a variety of item types:

> Selected-response items (also known as multiple choice) present students with a question followed by three or more response options. Short-text items require students to type an appropriate response. Technology-enhanced items use innovative technology to allow students to demonstrate their knowledge in ways that are not possible using paper/pencil assessments. (Missouri Department of Elementary and Secondary Education, 2015, p. 1)

During all assessment years, student achievement scores were divided into four categories: advanced, proficient, basic, and below basic (Missouri Department of Elementary and Secondary Education, 2015). A scaled score provided district leaders a range of scores within each of the four achievement categories to determine how close a student's achievement was to the next level (Missouri Department of Elementary and Secondary Education, 2015). This information provided opportunities for setting district and building goals, as well as identifying students who needed additional mathematics support. For the current study, the two categories of proficient and not proficient were used to organize student assessment results.

To be a reliable assessment of student achievement, scores must be relatively stable when the assessment is replicated in comparable testing environments (Data Recognition Corporation, 2015). To evaluate the reliability of the MAP assessment, Cronbach's coefficient alpha was used (Data Recognition Corporation, 2015). The coefficient alpha measures the variance between the true test score and the observed score, with a range in coefficient alpha between zero and one (Data Recognition Corporation, 2015). For a test to be considered reliable, the value is expected to be closer to one (Data Recognition Corporation, 2015). It is important to note that a student's true test score was an estimated score (Data Recognition Corporation, 2015).

> It is expected that 68% of the time a student's score obtained from a single test administration would fall within one SEM of the student's true score and that 95% of the time the obtained score would fall within approximately two standard errors of the true score. (Data Recognition Corporation, 2015, p. 177)

According to a technical report, reliability information for the third grade MAP Mathematics Assessment had five assessment forms, included 31 or 35 item numbers, and the number of score points received was either 33 or 36 (Data Recognition Corporation, 2015,). Cronbach's coefficient alpha was between 0.88 and 0.90 (Data Recognition Corporation, 2015). The SEM range was 2.35 to 2.54. Both the coefficient alpha and SEM revealed the assessment was both reliable and an indicator of the student's true score. Although the research for this report was completed in 2015, reliability information is still accurate for current assessment data.

According to a technical report, reliability information for the fourth grade MAP Mathematics Assessment had five assessment forms, included 31 to 35 item numbers, and the number of score points received was either 33 or 36 (Data Recognition Corporation, 2015). Cronbach's coefficient alpha was between 0.86 and 0.90 (Data Recognition Corporation, 2015). The SEM range was 2.29 to 2.54 (Data Recognition Corporation, 2015). Both the coefficient alpha and SEM revealed the assessment was both reliable and an indicator of the student's true score. Although the research for this report was completed in 2015, reliability information is still accurate to current assessment data.

According to a technical report, reliability information for the fifth grade MAP Mathematics Assessment had eight assessment forms, included 37 to 41item numbers, and the number of score points received was either 45 or 47 (Data Recognition Corporation, 2015). Cronbach's coefficient alpha was between 0.83 and 0.90 (Data Recognition Corporation, 2015). The SEM range was 2.76 and 3.00 (Data Recognition Corporation, 2015). Both the coefficient alpha and SEM revealed the assessment was both reliable and an indicator of the student's true score. Although the research for this report was completed in 2015, reliability information is still accurate to current assessment data.

Student scores are categorized into levels of proficiency (Basic, Proficient, and Advanced) using cut scores (Data Recognition Corporation, 2015). Conditional Standard Error of Measurement (CSEM) was used to increase the reliability of the assessment (Data Recognition Corporation, 2015). The cut score for the basic level of proficiency for third grade was 2367 with a CSEM of 25 (Data Recognition Corporation, 2015). The cut score for the proficient level of proficiency for third grade was 2432 with a CSEM of 24 (Data Recognition Corporation, 2015). The cut score for the advanced level of proficiency for third grade was 2490 with a CSEM of 26. Although proficiency cut scores were established in 2015, information is still relevant for current assessment data.

The cut score for the basic level of proficiency for fourth grade was 2416 with a CSEM of 26 (Data Recognition Corporation, 2015). The cut score for the proficient level of proficiency for fourth grade was 2473 with a CSEM of 26 (Data Recognition Corporation, 2015). The cut score for the advanced level of proficiency for fourth grade was 2533 with a CSEM of 27 (Data Recognition Corporation, 2015).

The cut score for the basic level of proficiency for fifth grade was 2442 with a CSEM of 23 (Data Recognition Corporation, 2015). The cut score for the proficient level of proficiency for fifth grade was 2502 with a CSEM of 23 (Data Recognition Corporation, 2015). The cut score for the advanced level of proficiency for fifth grade was 2582 with a CSEM of 26 (Data Recognition Corporation, 2015).

To ensure the validity of the MAP assessment, it was important to consider the relationship between the test items and content or domain (Data Recognition Corporation, 2015). To determine convergent validity, test items should have a prevailing factor tied to the specific content or domain to be considered adequately unidimensional (Data Recognition Corporation, 2015). To establish this, a principal components factor analysis was completed for all content areas and grade levels. Through this analysis, it was determined that "the MAP subject area tests exhibit first principal components accounting for more than… 19% of the test variance for Mathematics…. This substantial difference… indicates that one factor appears to be dominant and that the…tests are essentially unidimensional" (Data Recognition Corporation, 2015, p. 181). To further ensure validity, high correlations between the scale scores should not exist between the content tests within the MAP (Data Recognition Corporation, 2015). The correlation coefficient measuring the relationship between scores on the third grade English Language Arts and Mathematics assessments was 0.74. The correlation coefficient measuring the relationship between scores on the fourth grade English Language Arts and Mathematics assessment was 0.75. The correlation coefficient measuring the relationship between scores on the fifth grade English Language Arts and Mathematics assessment was 0.77. The correlation coefficient measuring the relationship between scores on the fifth grade English Language Arts and Science assessment was 0.79. The correlation coefficient measuring the relationship between scores on the fifth grade Mathematics and Science assessments was 0.77.

> Despite high correlations, the tests are not perfectly related to each other, suggesting that different constructs are being tapped; however, the test scores do appear at [*sic*] highly related to one another, suggesting they may be tapping into a similar knowledge base or general underlying ability. (Data Recognition Corporation, 2015, p. 184)

Data Collection Procedures

A research proposal was submitted to the Director of Assessment in School District A prior to beginning the research study (see Appendix A). Permission was granted to the researcher on January 26, 2018 (see Appendix B). On December 6, 2017, an Institutional Review Board (IRB) form was submitted to Baker University and approved by Baker University on January 12, 2018 (see Appendix C).

The proficient (proficient and advanced) and not proficient (basic and below basic) percentages were collected from the Missouri Comprehensive Data System (MCDS) for the school years of 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016. The MCDS was a secured system that required a log-in prior to data collection. The log-in information was secured through the district with the help of the Executive Director of Data and Accountability.

The Achievement Level Four – Public – Historical report was chosen to collect data from the 2011-2012, 2012-2013, and 2013-2014 school years. The Achievement Level Four Report was chosen to collect data from the 2014-2015 and 2015-2016 school years. The category of "select all" was chosen at the summary level for each School District A and state of Missouri report. Gender, special programs, and total were selected under category and the grade levels selected were third, fourth, and fifth-grades. The 2015 and 2016 school years were selected, and the content area chosen was mathematics. The categories of female, male, IEP student, MAP free and reduced lunch, and total were chosen to disaggregate the data. In each of the reports the state proficient or advanced percentages were listed for the school years 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016 to compare with the district percentages.

After the information was selected from the MCDS website, the district percentages for proficient and not proficient were downloaded into an Excel spreadsheet, which was organized by year and demographics. Percentages were listed for the categories of proficient or not proficient. The statistical package used to analyze the data was a Microsoft Excel (Microsoft Office 365 ProPlus 16.0.9029.2253) add-in, PHStat4 (Levine, Stephan, Krehbiel, & Berenson, 2011).

Data Analysis and Hypothesis Testing

The foundation for completing the data analysis was established through examining research questions focused on student achievement to determine the impact of district-provided professional development. Three research questions were developed. Each research question included four subsets that indicated the school years 2012-2013, 2013-2014, 2014-2015, and 2015-2016. Four hypothesis statements were developed to address RQ1 to compare School District A to the state of Missouri. Each hypothesis compares the year prior to School District A professional development implementation (2011-2012) to the years after professional development implementation (2012-2013, 2013-2014, 2014-2015, 2015-2016). Four hypothesis statements were also developed for RQ2 to address the impact of district professional development on student achievement during the school years of 2012-2013, 2013-2014, 2014-2015, and 2015-2016, when compared to no district, provided professional development during the 2011-2012 school year. To address RQ3, 24 chi-square tests of independence were completed for gender, socioeconomic status, and IEP status to compare the change in student achievement prior to district implementation of professional development to the four consecutive years after the implementation of professional development.

RQ1. To what extent is there a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to

- the year after partial district implementation of mathematics professional development (2012-2013) between School District A and the state of Missouri;
- the year after whole district implementation of the mathematics professional development (2013-2014) between School District A and the state of Missouri;
- the year after mathematics professional development included Number Talks (2014-2015) between School District A and the state of Missouri; or
- the second year after mathematics professional development included Number Talks (2015-2016) between School District A and the state of Missouri?

H1. There is a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013) between School District A and the state of Missouri.

H2. There is a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014) between School District A and the state of Missouri.

H3. There is a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after professional development included Number Talks (2014-2015) between School District A and the state of Missouri.

H4. There is a difference in the change in the number of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after professional development included Number Talks (2015-2016) between School District A and the state of Missouri.

For each of the four hypotheses, two chi-square tests of independence were conducted to examine the change in the percentage of students who scored in the proficient category using the district and state assessment data. For each test, the observed frequencies were compared to the frequencies expected by chance. The level of significance was set at .05. The results of each pair of chi-square tests were compared to test each of the four hypotheses.

RQ2. To what extent is there a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to

- the year after partial district implementation of the mathematics professional development (2012-2013);
- the year after whole district implementation of the mathematics professional development (2013-2014);
- the year after mathematics professional development included Number Talks (2014-2015); or
- the second year after mathematics professional development included Number Talks (2015-2016)?

H5. There is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013).

H6. There is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014).

H7. There is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015).

H8. There is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016).

A chi-square test of independence was conducted to examine the change in the percentage of students who scored in the proficient category using district assessment data for each of the four hypotheses. The observed frequencies were compared to the frequencies expected by chance for each test. The level of significance was set at .05.

RQ3. To what extent is the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to

- the year after partial district implementation of mathematics professional development (2012-2013) different based on gender, socioeconomic status, or Individual Education Plan status;
- the year after whole district implementation of the mathematics professional development (2013-2014) different based on gender, socioeconomic status, and Individual Education Plan status;

- the year after mathematics professional development included Number Talks (2014-2015) different based on gender, socioeconomic status, and Individual Education Plan status; or
- the second year after mathematics professional development included Number Talks (2015-2016) different based on gender, socioeconomic status, and Individual Education Plan status?

H9. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2012-2013) is different based on gender.

H10. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after whole district implementation of the professional development (2013-2014) is different based on gender.

H11. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015) is different based on gender.

H12. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016) is different based on gender.

For each of the four hypotheses, two chi-square tests of independence were conducted to examine the change in the percentage of students who scored in the proficient category using the district assessment data. For each test, the observed frequencies were compared to the frequencies expected by chance. The level of significance was set at 0.5. The results of each pair of chi-square tests were compared to determine if the chi-square results were different based on gender.

H13. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2012-2013) is different based on socioeconomic status.

H14. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after whole district implementation of the professional development (2013-2014) is different based on socioeconomic status.

H15. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015) is different based on socioeconomic status.

H16. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016) is different based on socioeconomic status.

For each of the four hypotheses, two chi-square tests of independence were conducted to examine the change in the percentage of students who scored in the proficient category using the district data. For each test, the observed frequencies were compared to the frequencies expected by chance. The level of significance was set at .05. The results of each pair of chi-square tests were compared to determine if the chi-square results were different based on socioeconomic status.

H17. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2012-2013) is different based on IEP status.

H18. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after whole district implementation of the professional development (2013-2014) is different based on IEP status.

H19. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015) is different based on IEP status.

H20. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016) is different based on IEP status.

For each of the four hypotheses, two chi-square tests of independence were conducted to examine the change in the percentage of students who scored in the proficient category using the district assessment data. For each test, the observed frequencies were compared to the frequencies expected by chance. The level of significance was set at 0.5. The results of each pair of chi-square tests were compared to determine if the chi-square results were different based on IEP status.

Limitations

Limitations of a study are not under the control of the researcher. Limitations are factors that may influence the interpretation of the findings or on the generalizability of the results (Lunenburg & Irby, 2008, p. 133). It was possible that the following limitations may have impacted the results of the research study:

1. Teachers implemented what they learned from district provided professional development, but at varying degrees of comfort and ease despite the professional development having been provided by building administrators in a controlled environment and with consistent delivery and expectations.
2. Multiple building leaders presented professional development modules. While district modules were consistent from building to building, information may have been presented in different ways due to individual presenter style and building culture.
3. Different Math Solutions consultants were assigned to individual buildings for the duration of the professional development.
4. Staff members at three elementary schools within School District A independently worked with a mathematics consultant from a local college to

further teacher pedagogy. These consultations were in addition to district-provided mathematics professional development and individualized by building need.

5. During the years prior to the spring of 2015, students were assessed on Missouri standards referred to as Grade-level Expectations (GLEs). However, beginning in the spring of 2015, students were assessed on the Common Core State Standards, which set forth different expectations and criteria for mathematics mastery.
6. During the years 2012 to 2016, the district continued to hire teachers from outside the district for K-5 positions. Therefore, teachers may have implemented professional development without having the previous year's training modules, leading to varying levels of confidence and comfort with their new learning.

Summary

Chapter 3 included an overview of the methodology utilized in this study to determine if district mathematics professional development changed student achievement levels as measured by the MAP assessment. The research design, selection of participants, measurement tool, data collection procedures, data analysis, hypothesis testing, and limitations were outlined in this chapter. The results of the data analysis are presented in Chapter 4, which includes descriptive statistics and hypothesis testing.

Chapter 4

Results

In Chapter 4, hypothesis testing for the research questions is presented to address the three purposes of this study. The first purpose was to determine to what extent district-provided professional development led to a change in the percentage of third, fourth, and fifth-grade students who achieved at the proficient or not proficient categories on the MAP assessment when compared to student scores after mathematics professional development. A second purpose of this study was to determine to what extent there was a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient or not proficient category on the MAP assessment when compared to student scores after mathematics professional development between School District A and the state of Missouri. The third purpose of this study was to determine the effect that gender, socioeconomic status, or the presence of an IEP had on the change in the percentage of students who achieved at the proficient or not proficient categories when compared to student scores after mathematics professional development.

Hypothesis Testing

This section includes the results of the hypothesis testing used to address RQ1, RQ2, and RQ3. To address RQ1, eight chi-square tests of independence were completed for the district and a second set of chi-square tests of independence were completed for the state to compare the change in student achievement. To address RQ2, four chi-square tests of independence were completed to compare the change in student achievement prior to district implementation of professional development to the four consecutive years after the implementation of professional development. To address RQ3, 24 chi-square tests of independence were completed for gender, socioeconomic status, and IEP status to compare the change in student achievement prior to district implementation of professional development to the four consecutive years after the implementation of professional development.

RQ1. To what extent is there a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to

- the year after partial district implementation of mathematics professional development (2012-2013) between School District A and the state of Missouri;
- the year after whole district implementation of the mathematics professional development (2013-2014) between School District A and the state of Missouri;
- the year after mathematics professional development included Number Talks (2014-2015) between School District A and the state of Missouri; or
- the second year of mathematics professional development included Number Talks (2015-2016) between School District A and the state of Missouri?

H1. There is a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013) between School District A and the state of Missouri.

Chi-square tests of independence were conducted using School District A and the state of Missouri data. The results of the chi-square test of independence using the district data indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013), $\chi^2 = 20.19$, $df = 1$, $p = .000$. The percentage of students who scored in the proficient category in the district decreased between 2011-2012 and 2012-2013 (see Table 1).

Table 1

District Observed and Expected Frequencies for H1

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2260	2155.08
	Not Proficient	2081	2185.92
2012-2013			
	Proficient	2090	2194.79
	Not Proficient	2331	2226.21

The results of the chi-square test using the state data indicated a marginally significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013), $\chi^2 = 3.63$, $df = 1$, $p = .057$. Although the change was marginally significant, the percentage of students who scored in the proficient category in the state decreased between 2011-2012 and 2012-2013 (see Table 2).

Table 2

State Observed and Expected Frequencies for H1

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	105,760	105,458
	Not Proficient	95,688	95,990
2012-2013			
	Proficient	105,023	105,325
	Not Proficient	96,170	95,868

These findings do not support H1. The change in the percentage of students who scored in the proficient category between 2011-2012 and 2012-2013 is not different when district and state results are compared.

H2. There is a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014) between School District A and the state of Missouri.

The results of the chi-square test of independence using the district data did not indicate a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014), $\chi^2 = 0.08$, $df = 1$, $p = .780$.

Although the change was not statistically significant, the percentage of students who scored in the proficient category in the district increased between 2011-2012 and 2013-2014 (see Table 3).

Table 3

District Observed and Expected Frequencies for H2

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2260	2266.78
	Not Proficient	2081	2074.22
2013-2014			
	Proficient	2315	2308.04
	Not Proficient	2105	2111.96

The results of the chi-square test using the state data indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014), $\chi^2 = 552.77$, $df = 1$, $p = .000$. The percentage of students who scored in the proficient category in the state decreased between 2011-2012 and 2013-2014 (See Table 4).

Table 4

State Observed and Expected Frequencies for H2

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	105,760	102,025.88
	Not Proficient	95,688	99,422.12
2013-2014			
	Proficient	98,705	102,439.15
	Not Proficient	103,559	99,824.85

These findings support H2. The change in the percentage of students who scored in the proficient category between 2011-2012 and 2013-2014 is different when district and state results are compared.

H3. There is a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after professional development included Number Talks (2014-2015) between School District A and the state of Missouri.

The results of the chi-square test using the district data indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015), $\chi^2 = 96.47$, $df = 1$, $p = .000$. The percentage of students who scored in the proficient category in the district increased between 2011-2012 and 2014-2015 (see Table 5).

Table 5

District Observed and Expected Frequencies for H3

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2260	2487.19
	Not Proficient	2081	1853.81
2014-2015			
	Proficient	2742	2514.69
	Not Proficient	1647	1874.31

The results of the chi-square test using the state data indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015), $\chi^2 = 1364.29$, $df = 1$, $p = .000$. The percentage of students who scored in the proficient category in the state decreased between 2011-2012 and 2014-2015 (see Table 6).

Table 6

State Observed and Expected Frequencies for H3

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	105,760	99,880.06
	Not Proficient	95,688	101,567.94
2014-2015			
	Proficient	95,313	101,192,97
	Not Proficient	108,783	102,903.03

These findings support H3. The change in the percentage of students who scored in the proficient category between 2011-2012 and 2014-2015 is different when district and state results are compared.

H4. There is a difference in the change in the number of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after professional development included Number Talks (2015-2016) between School District A and the state of Missouri.

The results of the chi-square test of independence using the district data indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016), $\chi^2 = 306.26$, $df = 1$, $p = .000$. The percentage of students who scored in the proficient category in the district increased between 2011-2012 and 2015-2016 (see Table 7).

Table 7

District Observed and Expected Frequencies for H4

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2260	2661.57
	Not Proficient	2081	1679.43
2015-2016			
	Proficient	3181	2779.29
	Not Proficient	1352	1753.71

The results of the chi-square test using the state data indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016), $\chi^2 = 180.19$, $df = 1$, $p = .000$. The percentage of students who scored in the proficient category in the state decreased between 2011-2012 and 2015-2016 (see Table 8).

Table 8

State Observed and Expected Frequencies for H4

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	105,760	103,616.86
	Not Proficient	95,688	97,831.14
2015-2016			
	Proficient	104,267	106,410.35
	Not Proficient	102,612	100,468.65

These findings support H4. The change in the percentage of students who scored in the proficient category between 2011-2012 and 2015-2016 is different when district and state results are compared.

RQ2. To what extent is there a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to

- the year after partial district implementation of the mathematics professional development (2012-2013);
- the year after whole district implementation of the mathematics professional development (2013-2014);
- the year after mathematics professional development included Number Talks (2014-2015); or
- the second year after mathematics professional development included Number Talks (2015-2016)?

H5. There is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013).

The results of the chi-square test of independence indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013), $\chi^2 = 20.19$, $df = 1$, $p = .000$. The percentage of students who scored in the proficient category in the district decreased between 2011-2012 and 2012-2013. This result supports H5 that there is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013). Table 9 contains the observed and expected frequencies of third, fourth, and fifth-grade students in the district prior to teacher provided professional development (2011-2012) when compared to students in the district after partial district implementation of professional development (2012-2013).

Table 9

Observed and Expected Frequencies for H5

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2260	2155.08
	Not Proficient	2081	2185.92
2012-2013			
	Proficient	2090	2194.79
	Not Proficient	2331	2226.21

H6. There is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014).

The results of the chi-square test of independence indicated a non-statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014), $\chi^2 = 0.08$, $df = 1$, $p = .779$. The percentage of students who scored in the proficient category in the district increased between 2011-2012 and 2013-2014. However, the increase was not large enough to be considered significant. This result does not support H6 that there is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014). Table 10 contains the observed and expected frequencies of third, fourth, and fifth-grade students in the district prior to teacher provided professional development (2011-2012) when compared to students in the district after whole district implementation of professional development (2013-2014).

Table 10

District Observed and Expected Frequencies for H6

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2260	2266.78
	Not Proficient	2081	2074.22
2013-2014			
	Proficient	2315	2308.04
	Not Proficient	2105	2111.96

H7. There is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015).

The results of the chi-square test of independence indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development that included Number Talks (2014-2015), $\chi^2 = 96.47$, $df = 1$, $p = .000$. The percentage of students who scored in the proficient category in the district increased between 2011-2012 and 2014-2015. This result supports H7 that there is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development that included Number Talks (2014-2015). Table 11 contains the observed and expected frequencies of third, fourth, and fifth-grade students in the district prior to teacher provided professional development (2011-2012) when compared to students in the district after professional development included Number Talks (2014-2015).

Table 11

District Observed and Expected Frequencies for H7

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2260	2487.19
	Not Proficient	2081	1853.81
2014-2015			
	Proficient	2742	2514.69
	Not Proficient	1647	1874.31

H8. There is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016).

The results of the chi-square test of independence indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development that included

Number Talks (2015-2016), $\chi^2 = 306.26$, $df = 1$, $p = .000$. The percentage of students who scored in the proficient category in the district increased between 2011-2012 and 2015-2016. This result supports H8 that there is a change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development that included Number Talks (2015-2016). Table 12 contains the observed and expected frequencies of third, fourth, and fifth-grade students in the district prior to teacher provided professional development (2011-2012) when compared to students in the district after the second year of Number Talks implementation (2015-2016).

Table 12

District Observed and Expected Frequencies for H8

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2260	2661.57
	Not Proficient	2081	2679.43
2015-2016			
	Proficient	3181	2779.29
	Not Proficient	1352	1753.71

RQ3. To what extent is the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to

- the year after partial district implementation of mathematics professional development (2012-2013) different based on gender, socioeconomic status, or Individual Education Plan status;
- the year after whole district implementation of the mathematics professional development (2013-2014) different based on gender, socioeconomic status, and Individual Education Plan status;
- the year after mathematics professional development included Number Talks (2014-2015) different based on gender, socioeconomic status, and Individual Education Plan status; or
- the second year of mathematics professional development that included Number Talks (2015-2016) different based on gender, socioeconomic status, and Individual Education Plan status?

H9. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2012-2013) is different based on gender.

Chi-square tests of independence were conducted using district data for males and females. The results of the chi-square test of independence using the district data for males did not indicate a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013), $\chi^2 = 2.33$, $df = 1$, $p = .1270$. Although the change was not statistically significant, the percentage of male students who scored in the proficient category in the district decreased between 2011-2012 and 2012-2013 (see Table 13).

Table 13

Male Observed and Expected Frequencies for H9

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	728	707.01
	Not Proficient	719	739.99
2012-2013			
	Proficient	727	748.05
	Not Proficient	804	782.95

The results of the chi-square test of independence using the district data for females indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013), $\chi^2 = 16.37$, $df = 1$, $p = .000$. The percentage of female students who scored in the proficient and advanced category in the district decreased between 2011-2012 and 2012-2013 (see Table 14).

Table 14

Female Observed and Expected Frequencies for H9

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	1120	1054
	Not Proficient	985	1051
2012-2013			
	Proficient	1012	1078
	Not Proficient	1142	1076

These findings do support H9. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2012-2013) was different based on gender.

H10. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after whole district implementation of the professional development (2013-2014) is different based on gender.

The results of the chi-square test of independence using the district data for males did not indicate a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014),

χ^2 = 0.71, *df* = 1, *p* = .398. Although the change was not statistically significant, the percentage of male students who scored in the proficient category in the district increased between 2011-2012 and 2013-2014 (see Table 15).

Table 15

Male Observed and Expected Frequencies for H10

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	728	739.34
	Not Proficient	719	707.66
2013-2014			
	Proficient	790	778.17
	Not Proficient	733	744.83

The results of the chi-square test of independence using the district data for females did not indicate a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014), χ^2 = 1.76, *df* = 1, *p* = .184. Although the change was not statistically significant, the percentage of female students who scored in the proficient category in the district decreased between 2011-2012 and 2013-2014 (see Table 16).

Table 16

Female Observed and Expected Frequencies for H10

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	1120	1098.25
	Not Proficient	985	1006.75
2013-2014			
	Proficient	1099	1120.16
	Not Proficient	1048	1026.84

These findings do not support H10. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after whole district implementation of mathematics professional development (2013-2014) was not different based on gender.

H11. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after mathematics professional development that included Number Talks (2014-2015) is different based on gender.

The results of the chi-square test using the district data for males indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development (2014-2015), $\chi^2 = 17.29$, $df = 1$, $p = .000$. The percentage of male students who scored in the proficient category in the district increased between 2011-2012 and 2014-2015 (see Table 17).

Table 17

Male Observed and Expected Frequencies for H11

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	728	783.59
	Not Proficient	719	663.41
2014-2015			
	Proficient	840	784.67
	Not Proficient	609	664.33

The results of the chi-square test of independence using the district data for females indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015), $\chi^2 = 32.78$, $df = 1$, $p = .000$. The percentage of female students who scored in the proficient and category in the district increased between 2011-2012 and 2014-2015 (see Table 18).

Table 18

Female Observed and Expected Frequencies for H11

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	1120	1212.23
	Not Proficient	985	892.77
2014-2015			
	Proficient	1336	1243.33
	Not Proficient	823	915.67

These findings do not support H11. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015) was not different based on gender.

H12. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the second year after mathematics professional development that included Number Talks (2015-2016) is different based on gender.

The results of the chi-square test of independence using the district data for males indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016), $\chi^2 = 97.84$, $df = 1$, $p = .000$. The percentage of male students who scored in the proficient category in the district increased between 2011-2012 and 2015-2016 (see Table 19).

Table 19

Male Observed and Expected Frequencies for H12

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	728	860.34
	Not Proficient	719	586.66
2015-2016			
	Proficient	1044	911.47
	Not Proficient	489	621.53

The results of the chi-square test of independence using the district data for females indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016), $\chi^2 = 111.92$, $df = 1$, $p = .000$. The percentage of female students who scored in the proficient category in the district increased between 2011-2012 and 2015-2016 (see Table 20).

Table 20

Female Observed and Expected Frequencies for H12

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	1120	1288.40
	Not Proficient	985	816.60
2015-2016			
	Proficient	1498	1329.41
	Not Proficient	674	842.59

These findings do not support H12. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016) was not different based on gender.

H13. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2012-2013) is different based on socioeconomic status.

Chi-square tests of independence were conducted using district data for students qualifying for a free or reduced lunch and full pay lunch. The results of the chi-square test of independence using district data for students qualifying for a free or reduced lunch indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013), χ^2 = 8.18, *df* = 1, *p* = .004. The percentage of students who qualified for free and reduced lunch who scored in the proficient category in the district decreased between 2011-2012 and 2012-2013 (see Table 21).

Table 21

Free or Reduced Observed and Expected Frequencies for H13

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	912	864.79
	Not Proficient	1349	1396.21
2012-2013			
	Proficient	848	895.01
	Not Proficient	1492	1444.99

The results of the chi-square test of independence using district data for students qualifying for full pay lunch indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013), χ^2 = 16.55, *df* = 1, *p* = .000. The percentage of full pay lunch students who scored in the proficient category in the district decreased between 2011-2012 and 2012-2013 (see Table 22).

Table 22

Full Pay Lunch Observed and Expected Frequencies for H13

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	870	818
	Not Proficient	516	568
2012-2013			
	Proficient	766	818
	Not Proficient	621	569

These findings do not support H13. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2012-2013) was not different based on socioeconomic status.

H14. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after whole district implementation of the professional development (2013-2014) is different based on socioeconomic status.

The results of the chi-square test of independence using district data for students qualifying for a free or reduced lunch did not indicate a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014), $\chi^2 = 0.15$, $df = 1$, $p = .696$. Although the change was not statistically significant, the percentage of students who qualified for free and reduced lunch who scored in the proficient category in the district increased between 2011-2012 and 2013-2014 (see Table 23).

Table 23

Free or Reduced Lunch Observed and Expected Frequencies for H14

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	912	918.46
	Not Proficient	1349	1342.54
2013-2014			
	Proficient	958	951.77
	Not Proficient	1385	1391.23

The results of the chi-square test using district data for students qualifying for full pay lunch did not indicate a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014), $\chi^2 = 0.75$, $df = 1$, $p = .387$. Although the change was not statistically significant, the percentage of full pay lunch students who scored in the proficient category in the district decreased between 2011-2012 and 2013-2014 (see Table 24).

Table 24

Full Pay Lunch Observed and Expected Frequencies for H14

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	870	859.40
	Not Proficient	516	526.60
2013-2014			
	Proficient	837	847.62
	Not Proficient	530	519.38

These findings do not support H14. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2013-2014) was not different based on socioeconomic status.

H15. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after mathematics professional development that included Number Talks (2014-2015) is different based on socioeconomic status.

The results of the chi-square test of independence using district data for students qualifying for a free or reduced lunch indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015),

$\chi^2 = 55.85$, $df = 1$, $p = .000$. The percentage of students who qualified for free and reduced lunch who scored in the proficient category in the district increased between 2011-2012 and 2014-2015 (see Table 25).

Table 25

Free or Reduced Lunch Observed and Expected Frequencies for H15

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	912	1038.03
	Not Proficient	1349	1222.97
2014-2015			
	Proficient	1194	1067.41
	Not Proficient	1132	1257.59

The results of the chi-square test of independence using district data for students qualifying for full pay lunch indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development (2014-2015), $\chi^2 = 61.55$, $df = 1$, $p = .000$. The percentage of full pay lunch students who scored in the proficient category in the district increased between 2011-2012 and 2014-2015 (see Table 26).

Table 26

Full Pay Lunch Observed and Expected Frequencies for H15

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	870	965.07
	Not Proficient	516	420.93
2014-2015			
	Proficient	1047	952.54
	Not Proficient	321	415.46

These findings do not support H15. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015) was not different based on socioeconomic status.

H16. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the second year after mathematics professional development that included Number Talks (2015-2016) is different based on socioeconomic status.

The results of the chi-square test of independence using district data for students qualifying for a free or reduced lunch indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016),

$\chi^2 = 163.73$, $df = 1$, $p = .000$. The percentage of students who qualified for free and reduced lunch who scored in the proficient category in the district increased between 2011-2012 and 2015-2016 (see Table 27).

Table 27

Free or Reduced Lunch Observed and Expected Frequencies for H16

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	912	1130.83
	Not Proficient	1349	1130.17
2015-2016			
	Proficient	1433	1213.85
	Not Proficient	994	1213.15

The results of the chi-square test of independence using district data for students qualifying for full pay lunch indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development (2015-2016), $\chi^2 = 138.50$, $df = 1$, $p = .000$. The percentage of full pay lunch students who scored in the proficient category in the district increased between 2011-2012 and 2015-2016 (see Table 28).

Table 28

Full Pay Lunch Observed and Expected Frequencies for H16

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	870	1009.22
	Not Proficient	516	376.78
2015-2016			
	Proficient	1177	1038.35
	Not Proficient	249	387.65

These findings do not support H16. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016) was not different based on socioeconomic status.

H17. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2012-2013) is different based on IEP status.

Chi-square tests of independence were conducted using district data for students with IEPs and for students with no IEP. The results of the chi-square test using the district data for students with IEPs indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-

2013), $\chi^2 = 8.93$, $df = 1$, $p = .003$. The percentage of students with an IEP who scored in the proficient category in the district decreased between 2011-2012 and 2012-2013 (see Table 29).

Table 29

IEP Observed and Expected Frequencies for H17

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	113	95.35
	Not Proficient	400	417.65
2012-2013			
	Proficient	66	84.01
	Not Proficient	386	367.99

The results of the chi-square test using the district data for those without IEPs indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after partial district implementation of the mathematics professional development (2012-2013), $\chi^2 = 22.28$, $df = 1$, $p = .000$. The percentage of students without an IEP who scored in the proficient category in the district decreased between 2011-2012 and 2012-2013 (see Table 30).

Table 30

No IEP Observed and Expected Frequencies for H17

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2149	2045
	Not Proficient	1679	1783
2012-2013			
	Proficient	2016	2120
	Not Proficient	1953	1849

These findings do not support H17. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2012-2013) was not different based on IEP status.

H18. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after whole district implementation of the professional development (2013-2014) is different based on IEP status.

The results of the chi-square test of independence using the district data for students with IEPs did not indicate a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014), χ^2 = 0.2.21, *df* = 1, *p* = .137. Although the change was not statistically significant, the percentage of students with an IEP who scored in the proficient or advanced category in the district decreased between 2011-2012 and 2013-2014 (see Table 31).

Table 31

IEP Observed and Expected Frequencies for H18

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	113	104.05
	Not Proficient	400	408.95
2013-2014			
	Proficient	84	93.71
	Not Proficient	378	368.29

The results of the chi-square test of independence using the district data for those without IEPs did not indicate a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014), $\chi^2 = .0.01$, $df = 1$, $p = .929$. Although the change was not statistically significant, the percentage of students without an IEP who scored in the proficient category in the district increased between 2011-2012 and 2013-2014 (see Table 32).

Table 32

No IEP Observed and Expected Frequencies for H18

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2149	2150.73
	Not Proficient	1679	1677.27
2013-2014			
	Proficient	2226	2223.77
	Not Proficient	1732	1734.23

These findings do not support H18. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after the partial implementation of mathematics professional development (2013-2014) was not different based on IEP status.

H19. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after mathematics professional development that included Number Talks (2014-2015) is different based on IEP status.

The results of the chi-square test using the district data for students with IEPs indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015), $\chi^2 = 4.48$, $df = 1$, $p = .034$. The percentage of students with an IEP who scored in the proficient category in the district decreased between 2011-2012 and 2014-2015 (see Table 33).

Table 33

IEP Observed and Expected Frequencies for H19

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	113	100.09
	Not Proficient	400	412.91
2014-2015			
	Proficient	82	95.60
	Not Proficient	408	394.40

The results of the chi-square test of independence using the district data for those without IEPs indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015), $\chi^2 = 94.63$, $df = 1$, $p = .000$. The percentage of students without IEPs who scored in the proficient category in the district increased between 2011-2012 and 2014-2015 (see Table 34).

Table 34

No IEP Observed and Expected Frequencies for H19

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2149	2356.75
	Not Proficient	1679	1471.25
2014-2015			
	Proficient	2608	2400.46
	Not Proficient	1291	1498.54

These findings support H19. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the year after mathematics professional development included Number Talks (2014-2015) was different based on IEP status.

H20. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the second year after mathematics professional development that included Number Talks (2015-2016) is different based on IEP status.

The results of the chi-square test of independence using district data for students with IEPs did not indicate a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016), $\chi^2 = 2.97$, $df = 1$, $p = .085$. Although the change was not statistically significant, the percentage of students with an IEP who scored in the proficient category in the district increased between 2011-2012 and 2015-2016 (see Table 35).

Table 35

IEP Observed and Expected Frequencies for H20

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	113	125.12
	Not Proficient	400	387.88
2015-2016			
	Proficient	132	120.48
	Not Proficient	362	373.52

The results of the chi-square test using the district data for students without IEPs indicated a statistically significant change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016), $\chi^2 = 286.87$, $df = 1$, $p = .000$. The percentage of students without an IEP who scored in the proficient category in the district increased between 2011-2012 and 2015-2016 (see Table 36).

Table 36

No IEP Observed and Expected Frequencies for H20

Year	Proficiency	Observed	Expected
2011-2012			
	Proficient	2149	2505.82
	Not Proficient	1679	1322.18
2015-2016			
	Proficient	3001	2643.94
	Not Proficient	1038	1395.06

These findings do support H20. The change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the second year after mathematics professional development included Number Talks (2015-2016) was different based on IEP status.

Summary

Chapter 4 presented the hypothesis test results for the three research questions. An analysis of chi-square testing was completed using the independent variable of the data collection year in relation to the professional development, student gender, student socioeconomic status, and student IEP status. An analysis of chi-square testing was also completed using the dependent variable of the percentage of third, fourth, and fifth-grade students who scored in the proficient categories on the MAP mathematics assessment. Chapter 5 includes a study summary, findings related to the literature, recommendations for further research, and concluding remarks.

Chapter 5

Interpretation and Recommendations

This chapter includes a summary of the study, as well as conclusions established from the data analysis conducted in Chapter 4. An overview of the problem and purpose, research questions, review of the methodology, major findings, and findings related to literature are communicated. Finally, conclusions, implications related to action, and recommendations for future research are presented.

Study Summary

NCTM (2014) stated the purpose of professional development should be to develop a connection between understanding mathematics beyond the surface level, the ability to understand how students learn the mathematical concepts, and participation in vertical alignment. School cultures that embody teacher professional development have staff committed to improvement efforts, act upon the learning in which they participate, and support initiatives at a high level (Seeley, 2015). Research studies have indicated student achievement in mathematics is positively correlated to teacher participation in job-embedded professional development (Ajjawi, 2015; Althauser, 2010). School District A's professional development implementation and non-implementation years were studied to understand better the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category.

District A when compared to students throughout the state of Missouri (Assistant Superintendent-PreK-8, personal communication, September 29, 2016). Leaders in School District A relied on Boaler's (2016) research to recognize that teachers who had not necessarily had positive experiences with mathematics as students, lacked the knowledge and ability to meet student mathematical needs and teach mathematics beyond the surface level. Furthermore, Boaler (2016) shared that ineffective mathematics instruction was grounded in instructional strategies that utilized memorization techniques and focused on basic procedures rather than providing an opportunity to explore and be creative with numbers and patterns (Boaler, 2016). Leaders in School District A began to align mathematics professional development to strengthen pedagogy and build teacher confidence to implement learned strategies and curriculum effectively. Seeley's (2014) research further encouraged district leaders to connect the mathematics curriculum to the real world. Her research indicated that students able to move learning in mathematics beyond basic memorization of facts and procedures have the ability to create pictures and make sense of place value.

Purpose statement and research questions. There were three purposes of this study. The first purpose was to determine to what extent professional development, beginning in the 2012-2013 school year, led to a change in the percentage of third, fourth, and fifth-grade students who achieved proficient on the MAP assessment when compared to student scores in 2012-2013, 2013-2014, 2014-2015, and 2015-2016. The second purpose was to determine to what extent there was a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the years following mathematics professional development, 2012-2013, 2013-2014, 2014-2015, 2015-2016, when comparing students in School District A to the other districts in the state of Missouri. The final purpose of this study was to determine the effect that gender, socioeconomic status, or presence of an IEP had on the change in the percentage of students who achieved in the proficient category in 2011-2012 on the MAP assessment when compared to student scores in each of the following school years: 2012-2013, 2013-2014, 2014-2015, 2015-2016. Three research questions were posed to address the change of student achievement during the years of 2011-2012, 2012-2013, 2013-2014, and 2014-2015, and the change of student achievement in the categories of gender, socioeconomic status, and IEP status during the same school years.

Review of the methodology. This study involved a quantitative method incorporating archival data for students' mathematics scores, as measured by the MAP. Purposive sampling was used to identify participants for this study. Participants selected were in the third, fourth, and fifth-grade classrooms of School District A, a suburban school district in Missouri. Teachers received district provided professional development during the school years of 2012-2013, 2013-2014, 2014-2015, and 2015-2016. During the school years 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016, students in the third, fourth, and fifth-grade took the MAP assessment and received a score of proficient or not proficient.

The MAP mathematics assessment was utilized to determine a change in third, fourth, and fifth-grade student achievement once teacher professional development was received. During the assessment years of 2011-2012, 2012-2013, 2013-2014, 2014-2015, and 2015-2016, student achievement scores were divided into four categories: advanced, proficient, basic, and below basic (Missouri Department of Elementary and Secondary Education, 2015). Student scores were organized into two categories for this research study: proficient and not proficient. Prior to publishing the MAP assessment, Data Recognition Corporation (2015) provided evidence for the reliability and validity of the assessments. To address research questions and provide the results of hypothesis testing, multiple chi-square tests of independence were completed. Multiple chi-square tests were conducted to compare changes in district and state proficiency for RQ1, to evaluate changes in district proficiency for RQ2, and to compare differences in the changes in proficiency based on gender, socioeconomic status, and IEP status for RQ3.

Major findings. An answer to RQ1 was determined after analysis of the first four hypotheses. While there was not a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the year after mathematics partial district implementation of professional development (2012-2013) between School District A and the state of Missouri, there was a difference when data from 2011-2012 was compared to each of the following years, 2013-2014, 2014-2015, and 2015-2016. Furthermore, School District A began to see an increase in the percentage of students who scored in the proficient category beginning in 2013-2014, while the state experienced a decrease in the percentage of students who scored proficient.

An answer to RQ2 was determined after analysis of H5-H8. There was a significant decrease in the percentage of district third, fourth, and fifth-grade students who scored in the proficient category from the year prior to mathematics professional development (2011-2012) to the following school year after mathematics professional development had been implemented (2012-2013). There was a non-significant decrease in the percentage of students who scored in the proficient category the year prior to mathematics professional development (2011-2012) to the year after whole district implementation of the mathematics professional development (2013-2014). However, beginning in the school year 2014-2015, an increase in the percentage of third, fourth, and fifth-grade students scoring in the proficient categories was found when compared to the year prior to mathematics professional development (2011-2012). From 2011-2012 to 2014-2015 and from 2011-2012 to 2015-2016, there was an increase in the percentage of students who scored in the proficient category.

Two answers to RQ3 were determined after analysis of H9-H12, which focused on gender's effect on changes in proficiency percentages. The percentage of male students in third, fourth, and fifth grade did not experience a change in the percentage of students who scored in the proficient category from the 2011-2012 school year and the 2012-2013 school year. When the difference in the change in the percentage of students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the school years of 2013-2014, 2014-2015, and 2015-2016 was analyzed, there was not a difference based on gender.

Three answers to RQ3 were determined after analysis of H13-H16, which focused on the effect of SES on changes in the percentage of students scoring proficient. A difference in the change in the percentage of students who scored in the proficient category from the year prior to the mathematics professional development (2011-2012) to the school years of 2012-2013, 2013-2014, 2014-2015, and 2015-2016 based on SES was not supported. Regardless of SES, the percentage of students who scored in the proficient category increased between the year prior to mathematics professional development (2011-2012) and the 2014-2015 school year. A similar increase occurred between the year prior to mathematics professional development (2011-2012) and the 2015-2016 school year.

Four answers to RQ3 were determined after analysis of H17-H20, which focused on IEP status. When considering IEP status, a difference in the change in the percentage of third, fourth, and fifth-grade students who scored in the proficient category was not supported when comparing the school year prior to mathematics professional development (2011-2012) to the year after whole district implementation (2013-2014). The percentage of students with an IEP who scored in the proficient category decreased between the year prior to mathematics professional development (2011-2012) and the 2014-2015 school year. The percentage of students without an IEP who scored in the proficient category increased between the year prior to mathematics professional development (2011-2012) and the 2014-2015 school year. A similar increase for students without an IEP occurred between the year prior to mathematics professional development (2011-2012) and the 2015-2016 school year.

Findings Related to the Literature

The major findings summarized in the previous section are linked to research in mathematics regarding recent shifts and common 21st-century practices, pedagogy, and effective professional development models that support student achievement. In fact, much of the literature established a foundation of professional development as a cornerstone to student achievement (Ajjawi, 2015; Murphy-Latta, 2008). Grossman (1990) shared that professional development established a strong understanding of mathematics for teachers, resulting in increased student abilities in mathematics. Guskey (2002), shared that improved student outcomes can be a direct result of a strong professional development model. Additionally, NCTM (2014) added that for students to apply high levels of mathematics, effective teaching models must first be established.

Researchers Murphy-Latta (2008) and Ajjawi (2015) agreed that students benefit from quality teacher professional development, as there is a direct impact on their personal achievement. The findings in this study supported Althauser (2016), who indicated that student achievement in mathematics was positively correlated to teacher participation in job-embedded professional development.

This study found that long term, more students did better on mathematics state assessments after teachers had been immersed in quality professional development. This connected to the research findings of Carillo et al. (2016). These findings demonstrated that increased student achievement was directly related to the longevity of professional development.

Furthermore, NCTM (2014) shared that when teachers collaborate and move away from isolated instruction, inequities that exist within schools can be resolved. Findings connected to this study were both genders and students without IEPs tended to improve over the long term. Additionally, SES did not affect the results, as students qualifying for free or reduced lunch and students qualifying for full pay both experienced a positive change in achievement. Furthermore, the findings suggest that, as Boaler (2016) stated, educators do not view gender as a crutch. The results of this study indicated that both genders experienced a positive change in student achievement, which could be attributed to the district-wide Number Talk requirement beginning in the 2014-2015 school year. Boaler (2016) suggested that demographics such as socioeconomic status may lead to certain groups of students being underprepared in mathematics and not have the ability to perform in comparison to their peers without experiencing instruction from quality teachers. Again, findings supported this statement as both genders and students qualifying for free or reduced lunch and students qualifying for full pay experienced a positive change in achievement.

Researchers DuFour and Marzano (2011) shared that professional development led to teachers delivering quality instruction, which ultimately led to student mastery of concepts. They further reported that to improve a school, leaders must start with those who teach in the classroom (2011). DuFour and Marzano (2011) believed that for the achievement of all students to occur, the talents of the total organization, rather than a select few, must be developed.

The findings in this study supported content based professional development, mentioned by several researchers. Grossman's (1990) four elements began with a solid understanding of the mathematics content. This was echoed in the research of Aguire, Kantanyoutant, and Zavala (2012), as they shared that a lack of understanding was directly connected to poor implementation of intended curriculum. Yoon et al. (2007) further connected to the findings in this study as they shared that mathematics professional development must first be content focused to improve instruction and ultimately increase student achievement.

Additionally, the findings that supported an increase in students' mathematics achievement aligned to Baroody's (2006) research that connected an increase in student ability to professional development, ultimately engaging students in inquiry-based learning. To promote inquiry, Number Talks and its effect on student achievement has been studied by multiple researchers over the years (Boaler, 2016; Celski, 2009; Humphrey's & Parker, 2015; Parrish, 2010) and has been promoted as an instructional strategy to enhance student mathematical thinking, discourse, number sense, and encourages the use of multiple strategies to mentally solve complex problems. This strategy, aimed at increasing student achievement in mathematics, is the opposite of early research presented in the literature. Much of this early research was focused on rote memorization of facts through drill, the execution of specific algorithms through step by step directions, and a large focus of instruction placed on the end product and not the mathematical process to become a better mathematician (Baggett & Ehrenfeucht, 1997; Brownell, 2007; Nesmith, 2008; Seeley, 2015).

Conclusions

Through analysis of the hypothesis statements, evidence was presented that led the researcher to believe professional development was beneficial to student scores. School District A experienced a significant change in the percentage of students proficient on state assessments when compared to students throughout the state of Missouri. Furthermore, School District A experienced an increase in the proficient category beginning in 2013-2014 when compared to the 2011-2012 school year. The state of Missouri student scores decreased in the proficient category throughout all tested years when compared to the 2011-2012 school year, which suggests that professional development aimed at changing teacher pedagogy in School District A was effective in changing student achievement.

Implications for action. It is important that results from this study be shared with representatives of central office from School District A. Findings do suggest that over time, the current professional development model appeared to be useful. However, a decrease in student achievement was noted during the first two of years. District leaders might spend time researching models that are known to have an immediate impact.

Furthermore, it is imperative that district leaders spend time reflecting on past professional development in mathematics. This reflection should include the identification of both strengths and areas of refinement. Leaders should develop an action plan that will address areas of refinement and capitalize further on strengths that have already been developed.

School District A needs to provide specific training for staff members who work exclusively with students who have IEPs in order for a change in the percentage of third, fourth, and fifth grade students with IEPs to occur. Specifically, professional development opportunities to grow in mathematics instruction must include teachers of special education students. According to NCTM (2014), "…we must move from pockets of excellence to systemic excellence by providing mathematics education that supports the learning of all students at the highest possible level" (p. 3). These training modules and opportunities should not be presented as an option for special education teachers but instead a requirement. Furthermore, district and building leaders should spend time in special education settings to further determine barriers that exist to student achievement when compared to their peers. These observations should include an assessment of current effective practices and use of resources, as well as determining outdated and ineffective pedagogy that may exist for those students needing the most support.

Recommendations for future research. Future research is recommended in School District A. A recommendation would be to disaggregate grade levels to determine if professional development was more effective at an individual grade level rather than examining proficiency across the span of grades 3 through 5. This question was beyond the scope of the current study but would offer additional information to understand better the effectiveness of professional development, as well as areas needing further refinement. This information would also be extremely beneficial in adjusting future mathematics professional development plans.

An additional way to extend the current study would be to look more closely at the delineation of teachers and their years of experience. Another important question to ask is how years of experience impacted the district-wide professional development implementation. This information could provide a better understanding of the effectiveness of mathematics professional development and teacher ability to implement learned strategies with fidelity.

A third way to extend this study would be to include a qualitative component based on teacher perceptions. Teacher perceptions regarding effective professional development and how the instruction of mathematics is impacted should be considered. Teacher perceptions can be transferred to students and create negative ideas about mathematics, ultimately impacting instruction and student achievement. This additional component would serve to provide further clarity as to why changes existed or didn't exist within the data.

A fourth way to extend this study would be to divide schools in the district into two categories, extended-year calendar schools and regular-year calendar schools. It would be beneficial to determine if buildings that operate on an extended calendar have a higher number of students proficient on the MAP assessment when compared to those operating on the regular school calendar. If the elementary schools with an extended calendar do have a higher percentage of students proficient, this would suggest that the additional school days are a contributing factor, as well as the district provided professional development.

A final way to extend this study would be to identify a district of similar size and demographics in the state of Missouri. The current study compares district data to the overall state, which is comprised of many districts. The state may always struggle to rise above the district as there are too many variables that impact the change in achievement. The identification of a similar district might provide a better comparison of student achievement due to professional development opportunities in School District A.

Concluding remarks. The current study concurs with the findings of previous researchers that have immersed themselves in professional development practices and mathematics instruction aimed at improving student proficiency levels. Leaders also hoped to compare student achievement in the district to student achievement across the state to better understand the effectiveness of the professional development in School District A. Increases in district mathematics achievement when compared to the overall state achievement would suggest that teacher professional development was powerful and changed past pedagogy. Furthermore, when analyzing only School District A, increases in mathematics achievement occurred over time and after professional development had been implemented for more than one full year. Finally, this information was important to School District A as resources were allocated to professional development and district leaders were charged with discovering the impact on student achievement.

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Appendices

Appendix A: Application to Conduct Research and Criteria for Approval

[redacted] Process for Application to Conduct Research and Criteria for Approval

Review Process

Research by internal or external applicants may only be conducted after receiving formal approval by the district review team.

The district review team is comprised of an Associate Superintendent and an administrative team within the Department of Academic Services. The team meets monthly to review requests to conduct research. Follow-up questions, additional requests, and/or approval are typically provided within 48 hours of the team's discussion. Submissions are reviewed based upon the following criteria:

- Satisfactory research methodology approved by a human subjects review board
- Minimal intrusiveness/disruption regarding classroom instruction
- Voluntary participation
- Confidentiality of participants
- Appropriate and reasonable time/effort requirements of participants
- Potential benefit of the research to positively impact district, building, or classroom practice
- The extent to which the research addresses and/or aligns with the goals of the school district

Submission Requirements

A completed Request to Conduct Research application form, along with the following documentation must be submitted to the office of Research, Evaluation and Accountability. Documents should be submitted at least six weeks prior to the anticipated onset of the proposed research.

Forms may be found on the Staff Portal or by contacting the Research, Evaluation and Accountability office.

Required documentation includes:

1. A copy of the complete application submitted for formal approval by a human subjects review board. This application should include, at a minimum:
   a. A brief summary of the purpose and scope of the research
   b. A brief summary of the research methods including:
      - Participants
      - Selection process
      - Remuneration procedures (if applicable)
      - Assurance of confidentiality of participant identification
      - Consent and assent procedures and documents
      - Activities related to the research, including proposed survey, interview, and/or assessment questions/instruments

      [redacted]roposed survey or interview instrument or protocol must comply with [redacted] Board Policy JHDA; available online at http://policy.msbanet.org/[redacted]/showpolicy.php?file=JHDA-C.1G)

[redacted] Process for Application to Conduct Research and Criteria for Approval

2. Evidence to demonstrate that the proposed research has been formally approved through a human subjects review process.

3. Assurance from the researcher that building principals, teachers, students and/or their parents may opt out of participation without consequence even with approval by the district team.

   Building principals will have the option to decline participation for their building on behalf of their entire staff and/or student population.

   Approval by the district team is required before the researcher may request a building's participation.

4. Assurance from the researcher that results will be communicated back to the district upon completion with anticipated completion date.

Completed documents may be emailed, faxed, or mailed using the content information found below.

Contact:
[redacted]

Appendix B: Research District Approval

Request to Conduct Research

2017-2018

Name of Applicant: Tarah Palmer

Employee of [redacted]**?** **Yes** X **No** ____

If yes, location and positio[redacted]

Is the research in fulfillment of graduate program requirements and/or in partnership with an external organization (e.g., university, college, business, industry, agency, etc.)? Yes X **No** ___

If yes, name of external organization and lead contact person:
External organization: Baker University

Lead Contact Person and Position: Dr. Sharon Zoellner 913-344-1225

Purpose of research: Completion of dissertation for my Ed.D.

Submission Requirements

1. A copy of the complete application submitted for formal approval by a human subjects review board. This application should include, at a minimum:
   a. A brief summary of the purpose and scope of the research including:
      ✓ The extent to which the research addresses and/or aligns with the goals of the school district
      ✓ Potential benefit of the research to positively impact district, building, or classroom practice
   b. A brief summary of the research methods including:
      ✓ Participants
      ✓ Selection process
      ___ Remuneration procedures (if applicable)
      ✓ Assurance of confidentiality of participant identification
      ✓ Consent and assent procedures and documents
      ✓ Activities related to the research, including proposed survey, interview, and/or assessment questions/instruments
      ✓ Extent of intrusiveness/disruption regarding classroom instruction
      ✓ Time/effort requirements of participants
2. ✓ Evidence to demonstrate that the proposed research has been formally approved through a human subjects review process.
3. NA Assurance from the researcher that building principals, teachers, students and/or their parents may opt out of participation without consequence even with approval by the district team.
4. ✓ Assurance from the researcher that results will be communicated back to the district upon completion of study. **(Anticipated date of completion:** May 2018)

Signature of Executive Director of Data and Accountability: [redacted]

Team Review Date: 1/26/2018 Approved: X Not Approved: ________

Signature of Deputy Superintendent: ____________

[redacted] 1/25/18

Signature of Principal(s) of building(s) impacted by research study Date

A copy of this form must be returned to [redacted] ***Executive Director of Data and Accountability with all necessary signatures <u>before</u> approval can be granted to conduct research.***

Appendix C: Institutional Review Board Approval

Baker University Institutional Review Board

January 12th, 2018

Dear Tarah Palmer and Sharon Zoellner,

The Baker University IRB has reviewed your project application and approved this project under Exempt Status Review. As described, the project complies with all the requirements and policies established by the University for protection of human subjects in research. Unless renewed, approval lapses one year after approval date.

Please be aware of the following:

1. Any significant change in the research protocol as described should be reviewed by this Committee prior to altering the project.
2. Notify the IRB about any new investigators not named in original application.
3. When signed consent documents are required, the primary investigator must retain the signed consent documents of the research activity.
4. If this is a funded project, keep a copy of this approval letter with your proposal/grant file.
5. If the results of the research are used to prepare papers for publication or oral presentation at professional conferences, manuscripts or abstracts are requested for IRB as part of the project record.

Please inform this Committee or myself when this project is terminated or completed. As noted above, you must also provide IRB with an annual status report and receive approval for maintaining your status. If you have any questions, please contact me at npoell@bakeru.edu or 785.594.4582.

Sincerely,

Nathan Poell, MA
Chair, Baker University IRB

Baker University IRB Committee
Scott Crenshaw
Erin Morris, PhD
Jamin Perry, PhD
Susan Rogers, PhD