UNDERSTANDING THE MATHEMATICAL KNOWLEDGE FOR TEACHING

AMONG PRIMARY MATHEMATICS TEACHERS AT A

LOW-PERFORMING ELEMENTARY SCHOOL

IN OKLAHOMA

A Record of Study

by

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ABSTRACT

      This mixed methods study focused on the mathematical knowledge for teaching among primary mathematics teachers at an Oklahoma elementary school. A need for this study was determined by the lack of student achievement in primary mathematics at this elementary school. The study consisted of quantitative data collection in the form of two instruments. The instruments were designed to measure teachers' mathematical knowledge for teaching. Qualitative data were collected in the form of teacher interviews from four primary mathematics teachers. A mixed methods approach was used to gain a more complete picture of the experience and knowledge of primary teachers in mathematics.

      Findings reflected that teachers had a lower than average level of mathematical knowledge for teaching in the area of Numbers and Operations. They also reflected similar results in Patterns, Functions, and Algebra. Survey results detailed specific training and professional development teachers have received up to this point in mathematics, their teaching experience, and their interest in future mathematics professional development.

      This study was the first step in writing a recommendations report for the stakeholders of this elementary school. Stakeholders requested this information to design a plan for future professional development for its teachers. The goal of this professional development was to build on teachers' discovered weaknesses in primary mathematical knowledge for teaching in order to build their knowledge and affect student achievement in a positive way.

DEDICATION

I wish to dedicate this record of study to my husband whose faith in me brought me to the finish line. Also, I wish to dedicate this to my two little boys: you can do anything you set your mind to.

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Thank you to my mom who was there to provide endless babysitting hours along the road to completing this record of study. The boys enjoyed their special time with their grandmother, and I loved hearing their sweet giggles in the other room as I was writing. Spending the time needed to finish this process would have been impossible without you.

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All work for the record of study was completed independently by the student.

Funding Sources

NOMENCLATURE

CK   Content Knowledge

CAEP   Council for the Accreditation of Educator Preparation

IDEA   Individuals with Disabilities Education Act

LK   Knowledge of the Learner

MKT   Mathematical Knowledge for Teaching

NCTM   National Council for Teachers of Mathematics

OCCT   Oklahoma Core Curriculum Test

PISA   Program for International Student Assessment

PCK   Pedagogical Content Knowledge

PD   Professional Development

PK   Pedagogical Knowledge

ROS   Record of Study

SES   Socioeconomic Status

TIMSS   Trends in International Mathematics and Science Study

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CHAPTER I

INTRODUCTION

Strong mathematics content knowledge and pedagogy in the primary grades (preschool through 2nd grade) are imperative in order to ensure young learners have the prerequisite mathematics skills needed to be successful in future mathematics and in life. The importance of developing a strong mathematics foundation in these young learners creates the critical foundation upon which all future mathematics concepts grow and develop (Harris & Peterson, 2019; Mathematical Association, 2014). Mathematics skills in primary grade children are a stronger predictor of later school success than many other factors, including reading skills (Shellenbarger, 2012). It is important to make mathematics meaningful for students and to help them love mathematics while they are still young, as it is a vital part of their education (Brown, 2014).

Poor academic achievement in mathematics is a significant concern across our nation (Mathematical Association, 2014). The lack of a strong mathematics foundation will compound over time, leaving students ill prepared to meet increasing academic standards for college and workplace success. Several studies have shown the direct correlation between success in primary mathematics and student performance in later mathematics courses (Geary, Hoard, Nugent, & Bailey, 2013; Hill, Rowan, & Ball, 2005). Students need a stronger foundation at the primary mathematics level (Harris & Peterson, 2019; National Council of Teachers of Mathematics [NCTM], 2013).

According to a recent study, one out of five adults in the United States does not have the basic mathematics skills needed to perform simple tasks (Geary et al., 2013). Mathematics

groundwork is vital in the primary school years in order to prepare students for a lifetime of success and a love for mathematics. Geary et al. (2013) stressed the urgency of catching our primary learners as early as possible. They deduced that students who do not have a basic understanding of mathematics before they enter first grade will quickly fall behind their peers and may never catch up. Furthermore, those students who are behind at this point are at a very high risk for struggling with higher order mathematics concepts for the remainder of their academic career. Early remediation has been found to be the key in preventing this from happening (Geary et al., 2013). If students are missing the foundational pieces as early as kindergarten and first grade, they will have huge gaps in their mathematics foundation; and by the time they get to high school or even middle school, they are so far behind, it is impossible to catch up.

Critical Necessity of Mathematical Knowledge for Teaching at the Primary Level

A key component of primary students' mathematical success is being instructed by teachers with a strong mathematical knowledge for teaching (MKT). As Hill et al. (2005) noted, teachers' mathematics content knowledge has been proven by researchers to have a direct effect on students' mathematics achievement as early as first and third grade. Hill et al. (2005) explained that the content knowledge teachers possess plays a very important role in student achievement in early elementary grades. This MKT is important at every level (Cason, Young, & Kuehnert, 2019).

It is imperative to ensure teachers have the knowledge necessary to understand how to instruct students. Primary students are not too young to be taught mathematics content using appropriate vocabulary and in appropriate contexts. Hill et al. (2005) noted in their research that "teachers' mathematical knowledge was significantly related to student achievement gains in

both first and third grades" (p. 371). Hill et al. (2005) illustrated the importance of improving student achievement in mathematics by improving upon teachers' MKT in that area. The NCTM (2013) stated that the number one issue in declining student achievement in mathematics is the classroom teachers' lack of skill in effectively modeling and explaining mandatory concepts.

Mathematical knowledge for teaching is a framework with an aligned assessment that gives a clear picture as to the knowledge and skills teachers possess in mathematics. It assesses the real-world mathematics teachers need to know and understand in order to be successful in the classroom. The assessment can be used as a benchmark to determine teacher's current level of MKT as well as to prescribe professional development for teachers. It is an invaluable tool to gauge the preexisting knowledge teachers have in primary mathematics in order to help their students learn. Chapter II contains an in-depth look at the MKT framework and assessment.

The primary years of mathematics development are critical as they are predictors of student mathematic achievement throughout their school career (Sarama & Clements, 2009). Mathematics is a core component of learning and thinking (NCTM, 2014). When teachers are able to determine the areas that students struggle with early, timely interventions can be applied to close learning gaps and increase understanding. Even though the early years of mathematics development are critical, mathematics performance data for international, national, and state level comparison typically do not begin until third grade. It should be noted that data are not gathered in the primary grades at these levels.

A Look at Mathematics Achievement

Around the Nation and World

Two large-scale studies, Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA), were conducted to

determine how older elementary, middle, and high school students perform in comparison to their peers both nationally and around the world (NCTM, 2014). Unfortunately, there is not an international or national study for assessing primary students' mathematical performance. In looking at the data from the TIMSS and PISA, the United States is performing poorly. As researchers from the University of Missouri have shown, there is a direct link to performance in primary mathematics with performance in subsequent years of mathematics instruction (Hill et al., 2005). The poor performance of our nation's older students in mathematics is displaying the lack of a strong mathematics foundation (Baker, 2013; Cason et al., 2019).

The TIMSS illustrates how students in the United States compare to students in other countries. The TIMSS is completed every 4 years to collect and compare our fourth and eighth grade student mathematics scores with those of other students around the world. The most recent TIMSS data collected in 2011 (with over 500,000 student participants around the world) showed that students in the United States scored lower than students from eight other educational systems, including Ireland, Japan, Korea, China, and Singapore (Buckley, 2012). Scores increased for the United States by 12 points from the 2007 to 2011 administration (Buckley, 2012).

The PISA gauges how our nation's 15-year-old students perform in comparison to students in other nations. According to the 2012 study, the percentage of top-performing students in mathematics ranged from 55% in Shanghai, China, to 0% in Colombia and Argentina. The United States had only 9% of students considered as top performing (Kelly & Xie, 2012). The top-performing average in the United States was lower than the international average score of 13%. In looking at students performing below "proficiency" or level two, Shanghai, China, had only 4%, while the United States had 26% of students. Students from the United States scoring in

the "below proficiency average" on the assessment were higher than the average of 23%. The overall scores for the United States on average were lower than that of 29 other educational systems.

Looking at data at the national and international levels were important to this study of determining the MKT of primary teachers because researchers are showing trends that perhaps could have been corrected in the students' primary years. We are not preparing students early enough for success in mathematics (NCTM, 2012). The long-term effects of these students' poor success are shocking. We need to determine what is happening at the primary level with our students in order to find safety nets for them, so they are successful in later mathematics years.

At the State Level

Two entities currently report students' mathematics achievement at the state level in Oklahoma. The first is the Oklahoma State Snapshot Report and the second is Quality Counts. The Oklahoma State Snapshot report is published by the National Center for Education Statistics. It compares scores dating back to 1990 for the state of Oklahoma in mathematics (Oklahoma State Snapshot Report, 2013). The Quality Counts report has the reputation of being a comprehensive view of the state of American education, grading each state on its overall performance (Chalk, 2015). The Quality Counts report issues summative letter grades for United States schools as well as an overall score for our nation.

According to the Oklahoma State Snapshot Report (2013) in Mathematics, only 68% of middle school students met basic requirements. The number of middle school students meeting these basic requirements has decreased by five points from 2011. The Oklahoma middle school students' average score was lower than the average mathematics score of eighth grade students across the nation. In comparison, the average mathematics score of Oklahoma middle school

students was lower than the average mathematics score for 42 other states/jurisdictions (Oklahoma State Snapshot Report, 2013).

Both the Oklahoma State Snapshot Report and Quality Counts used a grading scale for measuring schools' success called the A-F Grading System. The grading scale was adopted to law in 2011in the state of Oklahoma with the goal of preparing schools to strive for higher standards for their students (Oklahoma State Department of Education, 2013). This scale was used at the elementary, middle, and high school level. Calculating the letter grade for the school took two components into consideration: (a) student performance and (b) student growth. Student performance was measured by the Oklahoma State Testing Program exams and student growth was measured by overall student growth as well as the number of students in the bottom quartile (Oklahoma State Department of Education, 2013). To calculate the school's grade, a performance index was used, ranging from 0-120. Table 1.1 illustrates the grading scale used.

Table 1.1

Oklahoma State Snapshot Report and Quality Counts Index for A-F Scores in Mathematics Grades Kindergarten through 12

Letter Grade	Performance Index Score
A	90-120
B	80-89
C	70-79
D	60-69
F	Below 60

According to data released on January 15, 2015, in the Quality Counts 2015 State Report Card, Oklahoma scored in the D range (67%) for K-12, well below the United States average score of 74. There were only three states that performed more poorly than Oklahoma (Educational Quality and Accountability, 2015). The Quality Counts report for 2015 stated the following:

- At the elementary level (4th grade mathematics), only 36% of students were rated as "proficient," ranking Oklahoma's 4th graders as 42nd in the United States.

- At the middle school level (8th grade mathematics), only 25% of students were rated as "proficient," ranking Oklahoma's 8th graders as 45th in the United States. (Chalk, 2015)

Unfortunately, there are no academic data collected at the primary level, only enrollment data, so there are no indicators as to how primary students are performing statewide. Without these indicators, mathematics educators are often left without solid data to address deficiencies in mathematics concepts before they become advanced learners. These statewide scores are important to understanding mathematics instruction at the state level because it can be a predictor of the specific areas within mathematics that have gaps. These academic gaps are the areas that need to be addressed or remediated before students reach middle school or high school.

At the Local/District Level

The district of Vale (pseudonyms are used for district and school names), a very small rural district, has one high school, one middle school, and 11 elementary schools. Scores are collected throughout the district on a yearly state assessment, the Oklahoma Core Curriculum Test (OCCT). The test is given to public school students in the state of Oklahoma in 3rd through

8th grades and high school. The grading scale was identical to the scale used by Oklahoma State Snapshot Report and Quality Counts.

Understanding mathematics assessment scores from the local high school and middle school are important as they are indicators of the long-term effects of the student mathematics learning that takes place at the primary level. Buffalo High School is the only high school within the district of Vale. At Buffalo High School (i.e., Grades 9-12), mathematics scores are gathered in the areas of Algebra I, Algebra II, and Geometry. The following are the scores for Buffalo High School: In the 2012-2013 school year, 65% were D and in the 2013-2014 school year, 66% were D (Oklahoma State Department of Education, 2014).

At Buffalo Middle School, mathematics scores are gathered in the areas of Algebra I and General Mathematics. The following are the scores for Buffalo Middle School: In the 2012-2013 school year, 60% were D and in the 2013-2014 school year, 62% were D.

This Record of Study (ROS) focused on one of the 11 elementary schools within the district of Vale, Buffalo Elementary School. At Buffalo Elementary School, intermediate mathematics' (i.e., Grades 3 through 5) scores were gathered in General Mathematics. The following were the scores for Buffalo Elementary School: In the 2012-2013 school year, 69% were D and in the 2013-2014 school year, 69% were D.

The "D" rating ranks the district of Vale in the bottom quartile of districts for the state (Oklahoma State Department of Education, 2014). Scores remained consistent with no significant increase in mathematics. If nothing were done to correct primary children's mathematics foundation before they reached upper elementary grades, it would have an increasing effect each year. The continuing trends of poor performance in mathematics were evidence that a change was needed.

Scores were also collected at the intermediate level in Vale via a district benchmark assessment. Buffalo Elementary School fell in the low "C" range for the 2012-2013 school year for their mathematics benchmark scores (Oklahoma State Department of Education, 2013). The following year, 2013-2014, Buffalo Elementary School remained in the "C" grade in mathematics scores as well (Oklahoma State Department of Education, 2014). The bottom quartile of student growth was rated as an "F" at 45% in math. If this trend continued through middle school and high school, students would continue to struggle. These intermediate data points indicate a critical need to prepare young learners before they reached this level.

The Problem of Practice

Context

This ROS focused on Buffalo Elementary School. Buffalo Elementary School opened its doors in 2012 as the 11th elementary school in the district serving over 7,800 students. Since the school was established in 2012, there were no historical data before this point to compare for primary mathematics. The students of Buffalo Elementary School were not doing well in primary mathematics, as the following data show. Data were not collected at the state level for primary learners, so there was no way to compare data at this level.

Vale decided to use assessments from the EnVisions program, the district-adopted curriculum, in order to assess the performance and achievement of the primary mathematics learners (i.e., kindergarten through second grade). EnVisions was used as a curriculum, instructional, and assessment tool. EnVisions was adopted for the primary grades in 2011 throughout the district. The program stressed problem solving and interactive learning among students. Table 1.2 includes the EnVisions Mathematics Assessment scores for the 2012-2014 school years. Mastery of the assessment was considered to be 80% or higher in each grade level.

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As illustrated in Table 1.2, neither the district nor the school had achieved mastery in

mathematics according to this assessment. The school's scores across all three grade levels were

lower in the 2013-2014 school year as well.

Table 1.2

The Percentage of Primary Students Achieving Mastery on EnVisions Mathematics Assessment

School Year	Kindergarten		First Grade		Second Grade	
	Vale	Buffalo	Vale	Buffalo	Vale	Buffalo
2012-2013	60%	58%	67%	61%	61%	61%
2013-2014	65%	55%	67%	60%	61%	58%

This EnVisions data allowed the district of Vale to assess how students were doing at the

primary level. When the data in Table 1.2 were compared, one could track the progress of

students from one school year to the next. Scores for kindergarten students who moved to first

grade had a slight increase over the span of one school year. However, students who moved from

first to second grade showed a decrease from one school year to the next. Students at Buffalo

Elementary School had only used the EnVisions curriculum. Schools throughout the district had

used the Saxon Mathematics curriculum; however, they had been using EnVisions for the past 5

years.

Buffalo Elementary School also had four preschool classes. In the state of Oklahoma,

preschool is not a mandatory grade. Students in preschool attend a full day and have

mathematics, reading, science, social studies, music, and physical education classes. Preschool

teachers are not using a curriculum for any of their subject areas because the district has not purchased one for them. The teachers at Buffalo Elementary School met to create a set of standards for preschool students and adapted elements from the EnVisions program's kindergarten curriculum to use with their preschoolers; thus, it can be stated that they were working to develop their own curriculum. No data were collected at the preschool level from the EnVisions curriculum.

Stakeholder Groups and Values

The primary stakeholders for this ROS were the students of Buffalo Elementary School. There were 250 primary students at Buffalo Elementary School not receiving a quality mathematics education as shown by their test scores, the overall test scores of the schools, and the overall grade of the district. These students deserved a high-quality education in mathematics as a foundation for their future mathematics career. The students were interested in participating in class and making the most of the educational opportunities presented to them.

The second group of important stakeholders at Buffalo Elementary School were the primary mathematics teachers. These primary mathematics teachers (16 total) had all completed their degrees in Elementary Education or Early Childhood Education. These primary teachers understood the importance of providing a strong mathematics foundation for their students. The teachers and administration were doing their best with the current curriculum to provide a quality education to their students.

The final stakeholders were PTO members, parents, and members of the community as a whole. The current primary mathematics students of Buffalo Elementary School were the future work force for the local area. The students needed to have the prerequisite skills necessary for success in college and/or career readiness. If this school system was not producing students who

were ready for the work force or college, all stakeholders would suffer. These stakeholders wanted to see that the students were learning and meeting their educational goals so they could be productive members of their local communities.

Research Questions

This study explored the following overarching question: What is the primary (kindergarten through second grade) teachers' knowledge for teaching mathematics in a low-performing elementary school in Oklahoma? The following guiding questions were investigated:

1. What is the MKT of primary mathematics teachers at Buffalo Elementary School in Numbers and Operations?
2. What is the MKT of primary mathematics teachers at Buffalo Elementary School in Patterns, Functions, and Algebra?

Purpose of the Study

The purpose of the ROS was to explore two specific areas of primary teachers' MKT at Buffalo Elementary School: Numbers and Operations and Patterns, Functions, and Algebra. These areas were chosen because according to NCTM and the Council for the Accreditation of Educator Preparation (CAEP, 2018), they are two areas that are vital for primary mathematics teachers to understand and teach well. They are also the basis for primary mathematics work throughout the school year (NCTM, 2018). In exploring these specific domains, the researcher can determine the amount of MKT primary teachers possess. This is a vital piece in providing future learning opportunities and support for teachers in primary mathematics.

The MKT assessment used in this study has the option to measure three main areas of content knowledge for teachers of mathematics. These include (a) Number and Operations, (b) Patterns, Functions, and Algebra, and (c) Geometry. This assessment used the first two domains

as they are relevant to the K-2 learner. Geometry was omitted from this study because it measures skills needed to teach intermediate mathematics. Chapter II contains a detailed description of the domains of the assessment and the rationale for using this framework and assessment as a basis for this study.

The product of this study was a report generated for the principal of Buffalo Elementary School explaining the MKT the primary mathematics teachers at Buffalo Elementary School had in those areas. At the principal's request, this report was also presented to the faculty of Buffalo Elementary School. The development of a needs report was one way to ensure that teachers' voices were being heard and valued throughout the process of developing a set of recommendations for the primary mathematics program at Buffalo Elementary School.

One objective of this study was to determine the MKT teachers had in two areas of primary mathematics through an MKT aligned assessment instrument discussed in greater detail in Chapter III. The second objective was to generate a report that detailed the MTK of primary mathematics teachers to determine a strategy for professional development. The final objective was to share this report with teachers and administration of Buffalo Elementary School so they can use it as an effective tool to build future professional learning opportunities.

Significance of the Study

The findings of this study were significant for several reasons. First, the findings had practical significance. Data derived from this study highlighted current MKT in two specific areas of mathematics for the primary teachers at Buffalo Elementary School. These were data that had never been identified and were beneficial in tailoring specific learning needs of these teachers. Second, the study had research significance for the district of Vale. The results may not be generalizable outside of Buffalo Elementary School, but they provided specific feedback as to

the perceived needs of the teachers at Buffalo Elementary School at the primary level. This same study can be replicated throughout the other remaining ten elementary schools within the district of Vale to create district-wide professional learning opportunities from which teachers will benefit. The majority of mathematics studies focused on upper elementary, middle, and high school because this was where the majority of the national data were collected. Primary mathematics studies are limited as no state or national data were collected at this level. A report was generated (a) sharing the data collected (the MKT of primary mathematics teachers at Buffalo), (b) providing future recommendations for the primary teachers of Buffalo Elementary School, and (c) sharing conclusions for the school.

A high-quality teacher is defined by Darling-Hammond (2012) as a teacher who is able to provide instruction that will allow a wide range of students to learn effectively in the classroom. A school with high quality teachers was cited on many occasions throughout research as being the main factor that supports positive student achievement in the classroom (Hanushek & Rivkin, 2012; McCaffrey, Lockwood, Koretz, & Hamilton, 2003; Rowan, Correnti, & Miller, 2002). High quality teachers in the primary classroom settings enable these teachers to help build a strong foundation for their students in mathematics that will facilitate success in later grades. The process of determining whether a teacher is of "high quality" or not can be very difficult as there is no single way to measure this, and researchers and policymakers do not always agree on how to measure this effectively (Darling-Hammond, 2012).

Another foundational piece in providing high quality education for students is building the MKT in mathematics teachers. Ball, Thames, and Phelps (2008) noted that when teachers do not have a strong command of the subject matter, they are not likely to be able to teach it with the rigor required for students' understanding and achievement. As a result, students do not learn

the content necessary for more rigorous understanding. The key to developing these high-quality teachers is building and developing their MKT (Ball et al., 2008).

Researchers have also shown a direct link between high-quality mathematics instruction and student achievement (Hill et al., 2005). In a study completed by Hill et al. (2005), they discovered that in first and third grades, the mathematics knowledge possessed by their teachers was a significant factor in increasing student test scores. Mathematics knowledge was measured using a Mathematical Knowledge for Teaching assessment that is discussed in Chapters II and III. This assessment was also used as part of this ROS.

Definition of Terms

The following are terms that were used throughout this study. Although each term may have varying meaning in different contexts, each term was clearly defined as it was used in relationship to this ROS.

Mathematics Knowledge for Teaching (MKT): Specialized knowledge in mathematics needed by teachers that goes beyond simply being able to solve mathematics problems. This includes knowledge of subject matter, content, students, and curriculum (Ball et al., 2008).

Pedagogical Content Knowledge (PCK): The ability of the teacher to include knowledge of the learner, educational context, educational goals, and philosophy, as well as adapting the learning to the abilities and backgrounds of his/her students (Shulman, 1986).

Primary Education: Defined by the National Association for the Education of Young Children (2013) as involving children from birth to age eight. In the education setting, this typically refers to children in grades preschool through second grade.

Professional Development (PD): Professional learning that is ongoing, job-embedded, increases teacher knowledge, and as a result increases student achievement (Loucks-Horsley, 2010).

Trends in International Mathematics and Science Study (TIMSS): An international test of the mathematics and science knowledge in participating countries around the world (Buckley, 2012).

CHAPTER II

LITERATURE REVIEW

Introduction

There was a concerning problem in primary mathematics (grades preschool through second) at Buffalo Elementary School. If we build the teachers' content knowledge in mathematics, their students will benefit (NCTM, 2012). As a result, improving instruction of primary mathematics teachers should be at the forefront as we focus on student achievement at Buffalo Elementary School. This ROS focused upon the following overarching question: What is the primary (kindergarten through second grade) teachers' knowledge for teaching mathematics in a low-performing elementary school in Oklahoma?

Theoretical Framework

The Mathematical Knowledge for Teaching (MKT) framework with an aligned assessment was chosen to answer these overarching questions because it is specific for mathematics teachers (Ball & Bass, 2003; Ball et al., 2008; Copur-Gencturk, Plowman, & Bai, 2019; Marshall & Callahan, 2016). The MKT framework is built on Shulman's (1986) work with PCK, the blending of knowledge of pedagogy and content. The MKT goes on to include other specialized knowledge for teaching beyond PCK, including common content knowledge, specialized content knowledge, and horizon content knowledge (Ball et al., 2008). These other strands of MKT include teachers knowing how to perform computations in mathematics, analyzing mathematical problems and equations, and identifying misconceptions students possess. These subject matter knowledge strands allow the researcher to gain a more complete picture of the knowledge primary mathematics teachers have obtained beyond their PCK. In order to fully unpack the term MKT and its implications for student achievement, the majority of

Chapter II focuses on a review of the specific types of teacher knowledge. This includes current adaptations of the research as it relates to the primary mathematics classroom.

Teacher Knowledge in the Field of Teacher Education

Teacher knowledge in the field of education has changed drastically in the past century. Traditionally, there has been much emphasis on the content teachers need to teach in the classroom (Shulman, 1986). More recently, the pendulum has swung to include another important aspect of teaching, the extent that teachers understand and can effectively communicate the subjects they are teaching to their students in a way that students will understand this information. The field of education has moved its focus to the type of content teachers should be familiar with in order to teach their students effectively.

There are many knowledge systems that are imperative for teachers to understand in order to be effective in the classroom. These knowledge systems form the basis of modern teacher education programs. The first three types of knowledge form the basic foundation of teacher knowledge (Figure 2.1). These include (a) knowledge of the learner (LK), (b) content knowledge (CK), and (c) pedagogical knowledge (PK).
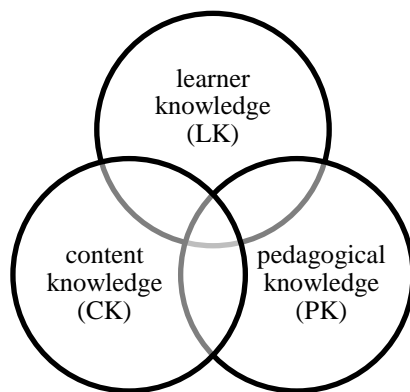
Figure 2.1. Foundations of teacher knowledge. Adapted from Ball et al. (2008).

Content Knowledge

Dewey (1938) explained that a scholarly knowledge of the content being taught was important for teachers to know and understand. Content knowledge refers to the concepts, skills, theories, and principles that teachers teach their students. Shulman (1986) also stated that teachers need to have an in depth understanding of the content being taught themselves, not just a surface-level understanding. Teachers should not only know the content but why the content is true. The depth of a teacher's understanding of the content he or she is teaching affects (a) how teachers structure their lessons, (b) how teachers deliver the content, and (c) how teachers can clarify misunderstandings among students.

Ball et al. (2008) affirmed the importance of teacher content knowledge stating that in the past, more attention has been placed on how much preparation teachers should have rather than what type of content specifically teachers need to be learning to be effective in their specific content areas. Teachers must understand mathematics themselves in order to know how to teach students the content as well as how to dispel misconceptions students many have. Ball et al. (2008) continued their explanation on the importance of CK in teachers by stating that teaching also encompasses the rationales for concepts. They should not only be able to note a correct answer, but to personally know and have the ability to explain to others meanings and rationales. If teachers are unable to understand the different ways of representing a subtraction problem, they will not be able to effectively teach the problem to their students and may aid in students forming misconceptions.

A deep understanding of mathematics knowledge is required in the everyday tasks of teaching, including planning, grading, giving student feedback, and even facilitating mathematical conversations among students (Ball et al., 2008). Primary mathematics teachers

should have a thorough knowledge of the strands of mathematics proficiency for primary students, at the bare minimum according to Ball et al. (2008). This means that primary teachers, according to NCTM (2000), should have a thorough understanding of the following mathematics concepts: (a) counting and cardinality, (b) operations and algebraic thinking, (c) numbers and operations in base 10 and fractions, (d) measurement, and (e) geometry. Teachers who have a firm grasp of the strands of mathematics proficiency incorporate them seamlessly throughout their content teaching. Teachers should also have the following mathematical knowledge: (a) strong conceptual understanding, (b) procedural fluency, and (c) efficiency in problem solving (NCTM, 2000).

The NCTM has joined with the Council for the Accreditation of Educator Preparation (CAEP) to develop a step-by-step guide in the knowledge elementary mathematics teachers should know in order to teach elementary mathematics. (This is not specific to primary mathematics, rather to elementary mathematics in general because teachers in many states are certified to teach kindergarten through fifth grade.) For example, teachers must know the following within the strand of geometry and measurement according to NCTM and CAEP (2018): (a) angle, parallel, perpendicular, and principles of Euclidean geometry in 2 and 3 dimensions; (b) transformations, translations, rotations, reflections, and symmetry; (c) congruence, scaling, and similarity; (d) basic geometric figures in one, two, and three dimensions as well as identification and classification of them; (e) perimeter, area, and volume; (f) coordinate geometry and Pythagorean Theorem; and (g) historical development of geometry and contributing figures.

Two of the foundational domains in primary mathematics include Number and Operations (Domain C.1) and Algebra (Domain C.2). In Number and Operations, teachers

should have a level of expertise content such as ordering numbers, one-to-one correspondence, basic addition and subtraction to 10 and 20, and a basis of number theory (NCTM, 2018). The Algebra domain asks teachers to support the development and fluency with number symbols, relationships in operations, and appropriate tools (NCTM, 2018). The two additional strands included in primary mathematics are Geometry and Measurement (Domain C.3) and Statistics and Probability (Domain C.4). The Geometry and Measurement Domain includes basic shape identification, construction, definition, and manipulations in both two-dimensional and three-dimensional shapes. The Statistics and Probability Domain includes graphical displays of information and basic analysis of these data.

Learner Knowledge

The second area of knowledge teachers should have is a knowledge of their learner. LK is about not only who the learner is but also how the learner learns (Shulman, 1986). Rahman, Scaife, Yahya, and Jalil (2010) defined learner knowledge as having a true understanding of the range of students, as well as how to use differing teaching strategies to reach these students. There are many important scholars who base the foundation of their work on the early learning theories that should be present in the primary mathematics classroom. These primary learners (grades preschool through second) are concrete learners who thrive with hands-on, manipulative based approaches to learning. Some of the theorists whose work support these early learning principles include the following:

1. In Piaget's (1966) work, he expanded on the notion that children do not have the background knowledge to understand a lot of the abstract concepts of mathematics. They instead need a more concrete approach to learning mathematics in order to

make sense of the more abstract mathematics and symbols to come. Using concrete materials or drawing representations are vital.

2. Dienes (1969) concluded through his work that students needed to have many representations of a concept in order to better understand it.

3. Vygotsky (1978) stated that learning should be scaffolded. In this manner, students begin with the concrete or pictorial and move to the more abstract.

4. Cobb (1995) defined the student/mathematics relationship as one needing tools to display complex relationships, even listing tools such as hundreds of charts.

Researchers Carbonneau, Marley, and Selig (2013) completed a meta-analysis of studies using manipulatives to teach mathematics as compared to classrooms that used only abstract concepts and methods to teach mathematics (no manipulatives were used). The researchers concluded that there was a significant difference in favor of using the manipulatives in mathematics instruction. This did not stop, however, at the primary grades. The researchers also determined that there was a positive effect on mathematics learning up to the college level when manipulatives were included.

Learner knowledge in the primary mathematics classroom. According to Krohn (2015), "Creativity, innovation, critical thinking, problem solving, communication, and collaboration are all part of a 21st century math learning experience" (p. 1). There are a wide range of learners in today's classroom requiring an array of teaching strategies, accommodations, and learning styles to be successful. The 21st century learner is also increasingly more diverse with varying cultures, languages, and abilities. Creating a classroom environment that nurtures these learners through hands-on instruction, technology, and best teaching practices should be at the forefront of the 21st century primary mathematics classroom.

Teachers must also be well-versed in the social and interpersonal facets of 21st century learning. This includes teachers scaffolding student learning, and having interactive and collaborative cooperative environments (Zemelman, Daniels, & Hyde, 2012). Teachers must find a way to teach students the skills and concepts mandated by state and national standards while ensuring that students are mastering content that is both developmentally appropriate and challenging (NCTM, 2013). Children in the primary school learn most powerfully from being active participants in their learning. Teachers must allow students to work with manipulatives and construct their own knowledge in order to make it most effective (Zemelman et al., 2012).

Student diversity in the primary classroom. Teachers of 21st century learners must be ready to reach students through culturally responsive teaching methods. Teachers must learn to use the cultural characteristics and experiences of their students in order to increase their academic achievement (Gay, 2002). Teachers are still inadequately prepared to reach the ethnically diverse students in their classrooms. They need to take their knowledge of ethnic diversity and translate that knowledge into teaching an effective curriculum that meets the needs of all their learners in the classroom (Gay, 2002). According to Young, Madsen, and Young (2010), schools are becoming more diverse, but teachers and teaching practices are not necessarily following suit. There still exist in our school system today a great deal of social and school inequity regarding race and ethnicity that teachers need to be cognizant of in the classroom (Ladson-Billings & Tate, 1995).

Successful mathematics teaching among low income and minority students is at a critical level (Ukpokodu, 2016). Students in these schools had teaching practices in place that did not engage them effectively (Ukpokodu, 2016). Her research aligned with the research of Ladson-Billings to describe the method of culturally responsive teaching needed that used students'

cultural knowledge in order to teach lessons. This included studying how different cultures look at mathematics in their daily lives. NCTM (2000) stated the importance of inquiry-based teaching and cooperative learning as strategies for effective and culturally responsive teaching strategies.

Emerging trends in birth rates and immigration showed that soon the United States would not have a singular majority group making up 50% of the population (Crouch, 2012). "Traditionally, schools in the past were more homogenous, but, with changing demographics, schools are increasingly becoming more ethnically diverse and multilingual" (Madsen, Schroeder, & Irby, 2014, p. 25). The typical classroom demographics have changed to include many types of learners with differing needs. These include:

1. English Language Learners (ELL): These students often come from non-English speaking homes and are unable to communicate fluently or learn effectively in English (Ross et al., 2012). As of 2013, in the state of Oklahoma, between 3-5.9% of public-school students were ELL students. In the United States as a whole, there are an estimated 9.2% or 4.4 million students (Ross et al., 2012).

   ▪ In order to teach to this population effectively, researcher Moore-Harris (2005) suggested that the teacher connect learning to previous knowledge the student may have, ensure the student understands the vocabulary, and make the experience as concrete as possible. The teacher needs to understand the culture the student is coming from. For example, the student may come from a culture that reads from right to left instead of left to right. This would cause the student great difficulty in understanding procedural mathematics problems (Morre-Harris, 2005).

2. Students with Disabilities: According to the Individuals with Disabilities Education Act (IDEA), students with disabilities are required to receive a free and appropriate public education that is the least restrictive environment (U.S. Department of Education, 2014). As of 2013, there were about 13% of public-school students receiving special education services in U.S. schools (6.4 million). Of these students, 35% of them have specific learning disabilities. In the state of Oklahoma, 10.7% of students fall into this category (D. Dawson, personal communication, December 1, 2015).

   ▪ In order to teach this population effectively, Hott, Isbell, and Montani (2014) suggested using strategies to aid in memory retrieval and understanding. These strategies include using mnemonics or visuals to help remember what the problem is asking and how to solve it and making the problems very concrete, including the use of manipulatives.

3. Socioeconomic Status (SES): The families' economic position is based on several factors including income, education, and occupation (U.S. Department of Education, 2014). Oklahoma is still considered to be a state in high poverty, with roughly 16% of students living in poverty (D. Dawson, personal communication, December 1, 2015). According to the Annie E. Casey Foundation (2015), Oklahoma ranked 39th of the 50 states in overall child well-being for 2014.

   ▪ Students in high poverty often do not have as extensive of a vocabulary or as many life experiences to aid in mathematics understanding. To help these students be successful, best practices include spending more time explicitly teaching the

vocabulary in a way students can relate, providing many concrete examples for

students, and using graphic organizers and manipulatives to organize information.

Diversity in Oklahoma Schools and Buffalo Elementary School. According to the

World Population Review (Oklahoma Population, 2013), the state of Oklahoma had the

following racial groupings in 2013: Asian 2%, African American 10%, Hispanic 13%, Caucasian

54%, and other 22%. In the Diversity Index, a measure of the chance that two randomly chosen

students come from the same racial group, Oklahoma scored a 66 in a scale of 0-100. The score

of 66 indicated that Oklahoma was a very diverse state (Oklahoma Population, 2013). Buffalo

Elementary School had the following racial groupings in 2013: Asian 17%, African American

5%, Hispanic 33%, Caucasian 43%, and other 2% based on its fall enrollment (Oklahoma State

Department of Education, 2013). Table 2.1 displays more detailed information for the racial and

ethnic classification data for the state of Oklahoma as well as the district of Vale and Buffalo

Elementary School.

Table 2.1

Racial and Ethnic Data in the State of Oklahoma, Vale, and Buffalo Elementary School

Racial/Ethnic Classification	Oklahoma	Vale	Buffalo Elementary School
Asian	2%	8%	17%
African American	10%	5%	5%
Hispanic	13%	20%	33%
Caucasian	54%	64%	43%
Other	22%	3%	2%

Buffalo Elementary School does not have a majority ethnicity group of 50% or higher. There is great diversity of students in each classroom including Native American and Marshallese students. Buffalo Elementary School also has a population of students with disabilities of 7.6% of its population and an ELL population of 12% of its population (Oklahoma State Department of Education, 2013). As a result of this diverse classroom setting, teachers at Buffalo Elementary School must be well versed with classroom differentiation practices to meet the needs of all learners in their classrooms.

Differentiated instruction is one of the core principles in best teaching practices in the primary classroom. Through differentiating instruction, the teacher is able to meet the needs of his/her diverse learners in the ranges of readiness, interests, abilities, talents, and skills (Kronowitz, 2012). Through differentiation, teachers focus on the core mathematical subject knowledge needed by students including concepts and skills that are essential for students to understand. The teacher then modifies his/her instruction to meet the needs of the learners in his/her classroom (Kronowitz, 2012).

Differentiating instruction in the primary mathematics classroom is about knowing who the learners are and knowing which strategies and manipulatives will meet their needs best. Teachers need to determine how these primary learners can learn efficiently and to the depth required by the standards each school uses (Tomlinson, 2014). This may even include using differentiated mathematics learning centers, small group instruction, individual conferences with students, and many different manipulatives (Tomlinson, 2014).

Pedagogical Knowledge

PK is the knowledge of the practice of teaching and the skills that teachers need in order to make effective decisions daily in the classroom (Alexander, 2009). PK includes teaching

strategies for teaching effectively, classroom management, and theory to help the learners understand the content being taught (Shulman, 1986). This knowledge base also includes a knowledge of various teaching methods and when to use them most effectively in the classroom (Voss, Kunter, & Baumert, 2011).

Hudson (2013) proposed a framework of PK for teachers. This knowledge can be specifically applied to teachers of primary students as well as teachers in the field of mathematics. Hudson (2013) stated these include planning, timetables, preparation, teaching strategies, CK, problem solving, classroom management, questioning skills, implementing, and assessing. As lessons are planned, teachers must take into consideration specific student outcome targets, as well as specific activities that align for student learning to take place.

Among the many things primary mathematics teachers need expertise in (classroom management, learning styles, etc.) is the knowledge of how to teach primary students. These strategies are very different than strategies used to teach intermediate learners. One such strategy is a concrete, pictorial, and abstract approach to teaching mathematics (Sousa, 2008). This approach allows students to experience the mathematics concepts beginning with a very hands-on, concrete approach. This includes different manipulatives and many different examples. As student understanding deepens, the student moves to using pictorial representations and then to a more abstract approach. This approach was based on Bruner (1960) in which students experience mathematics in a hands-on approach in order to make the learning more meaningful for them.

Mathematics teachers at Buffalo Elementary School are teaching with the concrete, pictorial, and abstract approach. In this approach, teachers guide students beginning with the concrete or manipulative use. This includes a variety of manipulatives such as base 10 blocks, cubes, or counters. As students begin to understand the concept further, they move to a pictorial

approach for learning. Through this approach, students create the representations of the problems for themselves on paper. The pictures become the concrete representation on paper for the student. Finally, when the student has a clearer understanding, he or she moves to the abstract approach for the problem. This includes using symbols to represent the problem (Gujarati, 2013). In primary mathematics, this would include using numbers, equations, or even basic inequalities.

When watching a lesson in a primary classroom at Buffalo Elementary School, an observer would note the teacher using a variety of technology to model a lesson to students. Teachers use active involvement during lessons with students and have students practice problems together using a variety of strategies such as SmartBoard technology, individual whiteboards, songs, chants, and group activities. During the lesson, the teacher can be seen circulating the whole group helping students who are struggling and challenging students who have mastered the content. The teacher may also pull small groups of students for remediation or re-teaching of concepts. Finally, the teacher closes the lesson by having several students share their work or share strategies they worked on throughout the lesson.

In the primary school of Buffalo Elementary School, teachers are required to spend a minimum of 1.5 hours daily teaching mathematics. This time includes teaching mathematics skills, procedures, and individual or group practice and tasks (D. Dawson, personal communication, November 13, 2014). In primary classrooms, this mathematics block consists of a calendar time in which basic calendar skills are taught, followed by a lesson from the EnVisions mathematics curriculum. Lessons differ by skill and content; however, all lessons have the same general format.

Pedagogical Content Knowledge

Pedagogical content knowledge (PCK) is the intersection of pedagogical knowledge and content knowledge (Figure 2.2). Shulman (1986) was credited with bringing the ideas of PCK to the forefront of educational practitioners, describing PCK as the specific body of knowledge that combines content and pedagogy.
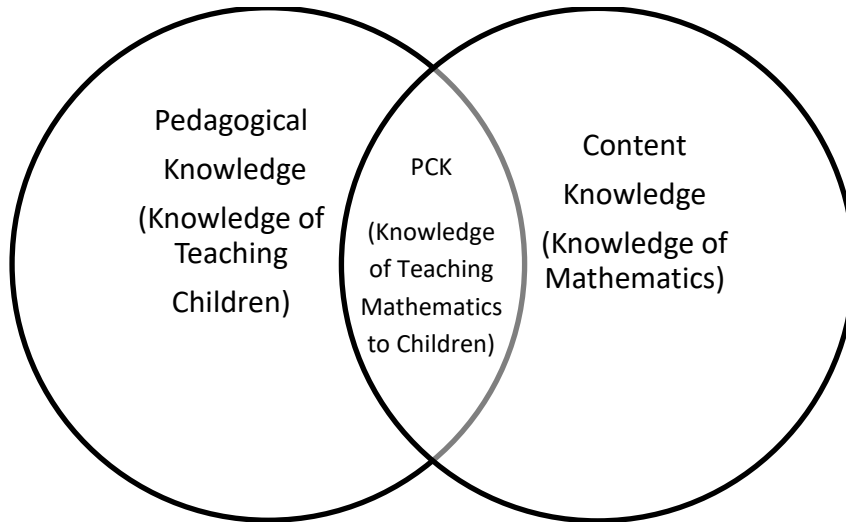
Figure 2.2. Pedagogical content knowledge as the intersection of pedagogical knowledge and content knowledge. Adapted from Ball et al. (2008).

History of PCK

In order to understand the history of PCK, one must look back to the history of pedagogy and content knowledge throughout the teaching profession as well. Pedagogy has its roots in education as early as the 1900s as the material teachers must know to be effective in the classroom. Before this time, pedagogy was not a topic that was of concern in the field of education (Shulman, 1986). Speakers at the 1907 National Education Association's conference began speaking to the ideas of effective teachers having both a specialized knowledge of instruction and a knowledge of the content they were teaching. Parr, President of the National Education Association Department of Normal Schools, as well as Luckey, Professor of

Education at the University of Nebraska both attested that teachers must know the content from the perspective of the learner as well as the teacher (Luckey, 1907). This, however, was not the opinion of all members of the conference.

Teacher education continued to be a debate throughout most of the 1920s through the 1960s with the addition of many new school reforms and ideas of the importance of teacher knowledge. In 1933, the National Survey of Education of Teachers was published sharing that identifying concrete ways of teaching and subject matter content was not successful (Monroe, 1952). The general consensus of this time period was that teachers had the general knowledge they needed to teach the subject areas they were hired for; however, there were still many teachers being hired to teach in subject areas they did not study in school (Douglas, 1935). Up to this point in the history of our education system, it was preferred that a teacher of mathematics was an expert in mathematics content, not in the knowledge and skills of teaching mathematics to children.

In 1986, Shulman identified a new model of teacher knowledge domains. He built his ideas for PCK beginning with past reforms and state board teaching examinations. In studying these tests, he discovered that 95% of the tests assessed the knowledge base assumed necessary for teachers to teach their content, dating back as far as 1875 (Shulman, 1986). In examining teacher tests administered in the 1980s, the pendulum swung to include almost no knowledge base and a complete focus on teaching competencies was present instead.

Shulman (1986) presented the idea that a teachers' cognitive understanding of the subject matter that he or she was teaching had a direct effect on student learning. He believed that in order to be a teacher, one must have not only a knowledge of one's students, but also a knowledge of the subject matter being taught. For example, a teacher must not only understand

the concept of place value for herself, but also understand how to break down this idea to teach it in a way that primary mathematics learners would understand the concept and be able to apply it. Through his work in the Stanford Knowledge Growth and Teaching Project, Shulman and colleagues were able to conduct more research on the importance of PCK noting that PCK is the manner in which teachers combine what they know about teaching to the subject matter they are teaching (Shulman, 1986). He is credited with coining the term PCK and creating its first definitions.

Mathematics Knowledge for Teaching

In the years since Shulman first discussed PCK, several researchers have built upon his ideas, including researchers from the University of Michigan (Ball et al., 2008). In building several measures, these researchers have expanded upon Shulman's notion of subject matter knowledge and PCK. Portions of two of these measures are discussed further in Chapter III as they were used for data collection. Figure 2.3 depicts these new mathematics domains, described as Mathematical Knowledge for Teaching (MKT).
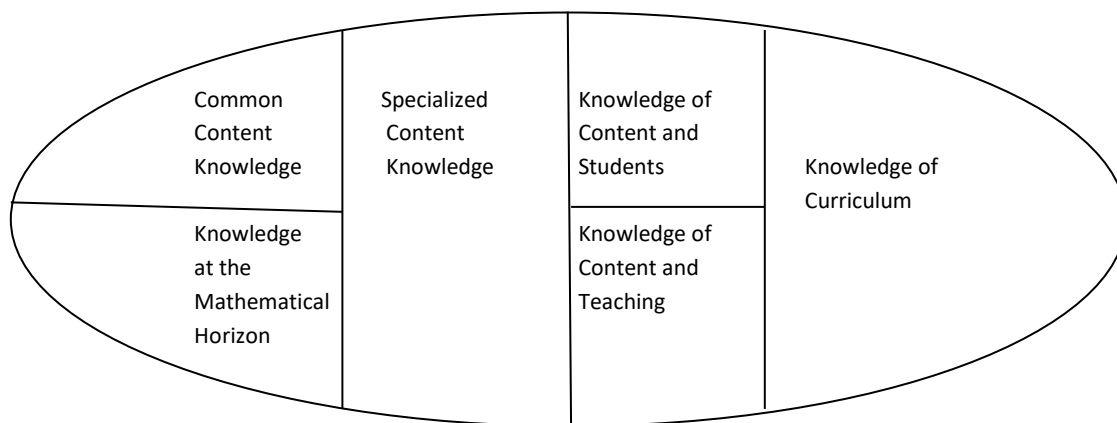
Figure 2.3. The domains of MKT. Adapted from Ball et al. (2008).

Figure 2.3 depicts the expansion of the idea of PCK to include several different areas. These areas are all shown to be vital pieces of the puzzle needed to gain a complete understanding of the concept of teacher knowledge in mathematics. Beginning in the top left of the oval, common content knowledge is the knowledge needed in any mathematics setting. This is the knowledge used to solve a mathematics problem correctly independent of teaching the content. Horizon content knowledge is the ability to look at concepts throughout a curriculum and see how they are interrelated and how they build upon one another. Specialized content knowledge moves into the teaching practice. This is the knowledge needed to see, for example, patterns in student errors. These three areas would fit specifically into the area that Shulman and colleagues referred to as subject matter knowledge (Ball et al., 2008).

The final three domains fit within the PCK framework Shulman suggested (Ball et al., 2008). Knowledge of content and students empowers teachers with the ability to choose examples in teaching with a specific purpose and to anticipate and interpret student thinking in depth. Knowledge of content and teaching and of the content and curriculum are the abilities to be able to look at the curriculum, understand it, and sequence instruction accordingly. The most efficient representations and strategies are used should be chosen to use in examples that will maximize student learning and instruction time (Ball et al., 2008).

Defining MKT in the Primary Mathematics Classroom

This specialized knowledge is important in order for teachers to build the strong mathematics foundation in the primary grades that is so vital for student success (Van de Walle Lovin, Karp, & Bay-Williams, 2013). Mathematical knowledge for teaching exists within a continuum resulting in every teacher having some degree of MKT to act as a foundation to be strengthened (Ball et al., 2008). A teacher possessing this specific knowledge is vital for student

success; therefore, strengthening a teacher's MKT should have a positive effect on the student achievement (Carlson, Gess-Newsome, Gardner, & Taylor, 2013). If teachers do not possess this knowledge to impart on their students, the student knowledge will not have a strong foundation.

In one study of teacher MKT and its relationship to professional development, a sample of 542 in-service mathematics teachers were used from across the United States. These teachers were part of 21 Mathematics and Science Partnership programs. Participants were required to complete a pre-assessment in MKT, professional development, and a post-assessment in MKT. One specific area researchers studied was participants' knowledge of content and teaching (Copur-Gencturk et al., 2019). Researchers determined that a focus on this knowledge in professional development is specifically related to teacher learning. Statistically significant gains (Cohen's $d = 0.33$). Researchers also concluded that an average of 15 hours of professional development in MKT areas would align with an increase in standard deviation of 0.15 in their MKT (Copur-Gencturk et al., 2019).

In a second, longitudinal study, teachers' mathematical knowledge was studied in relationship to their instruction. A total of 21 teachers, in grades kindergarten through eight were studied for 3 years to determine if their MKT changed over time. These teachers were also all participants in a master's degree program. Data were collected through a pencil/paper assessment and classroom observations. The researchers concluded that as teachers' MKT increased, their lesson quality and mathematical goals for their lessons increased as well (Copur-Gencturk, 2016).

Content Knowledge Theories

There were several theories considered in answering this overarching question. The first theory examined was Discourse Knowledge Theory, which builds on PCK. Hauk, Toney,

Jackson, Nair, and Tasy (2013) described the theory as including discourse knowledge and different forms of communication within the mathematics classroom. Table 2.2 provides a brief summary of these theories.

This also includes cultural contexts and ways in which the teacher and students are aware of these cultural responses. This theory is mathematics specific and takes components of teacher mathematical knowledge into consideration; however, the authors stated that it is best aligned with secondary mathematics because secondary mathematics teachers tend to have greater mathematics preparation and experience (Hauk et al., 2013).

The second theory that was explored in relationship to this study was Knowledge in Pieces Theory. The goal of this theory is to understand knowledge and learning of more difficult subjects, beginning with physics and later expanding to include other areas of science, mathematics, and computer science (DiSessa, 2018). This framework aimed to build a two-way bridge between theory and learning and emphases contextuality, a rich variety of strategies, and a complex approach to relationships. Although this framework has been used in mathematics, its strengths, according to DiSessa (2018), lie in the science field, not in primary mathematics.

A third theory that was considered was the Actions, Processes, Objects, Schemas Theory. This theory is specific to mathematics and was originally designed around student learning but has grown to include postsecondary and adult mathematics learning (Dubinsky, 2014). In this theory, the learner's schema for mathematics is built through reflection and discussion. When the learner tries to explain his or her viewpoint using different mathematical communication skills, the learner gains a better understanding of the mathematics (Dubinsky, 2014). This framework is specific to gaining content knowledge in mathematics; however, it is not specific to primary mathematics.

Table 2.2

Summary of Theories on Content Knowledge

Theory	Description	Strengths in Relationship to this Study	Weaknesses in Relationship to this Study
Discourse Knowledge Theory	Discourse knowledge builds on Shulman's PCK foundation. It deals specifically with inquiry and forms of communication in mathematics (Hauk et al., 2013).	This theory is mathematics specific and builds on teachers' mathematics content knowledge.	This theory is noted as best aligning with secondary mathematics teachers because they tend to have greater mathematics preparation and experiences in mathematics than do primary mathematics teachers.
Knowledge in Pieces Theory	The goal of this theory is to build a two-way bridge between theory and learning. One of the main goals is to combine both long-term and short-term perspectives on learning (DiSessa, 2018).	Gaining knowledge is viewed as a complex system. There is a big focus on deeper meaning from prior conceptions (DiSessa, 2018).	This theory lists its strengths in science and is used far less frequently in mathematics. Also, it is not specific to primary mathematics.
Actions, Processes, Objects, Schemas (APOS) Theory	A theory of mathematical understanding originally designed around student learning but has grown to include postsecondary and adult mathematics learning (Dubinsky, 2014). Understanding of mathematics topic develops through reflecting on solutions through social platforms.	A mathematical schema is built by reflecting on actions of learning mathematics (Bansilal, Brijlall, & Mkhwanazi, 2014).	This theory is specific to learning mathematics; however, it is not specific to primary mathematics teachers.
Mathematical Knowledge for Teaching	The MKT framework is built on Shulman's (1986) work with PCK, the blending of knowledge of pedagogy and content. MKT goes on to include other specialized knowledge for teaching beyond PCK, including common content knowledge, specialized content knowledge, and horizon content knowledge (Ball et al., 2008).	This theory is specific to the subject matter knowledge and pedagogical knowledge teachers need in the primary mathematics classroom.	The aligned assessment only measures some of the content strands in primary mathematics, not all strands.

The MKT framework was best aligned with this study because it was built around the specific knowledge that mathematics teachers need in the primary mathematics classroom (Ball & Bass, 2003; Ball et al., 2008). Studies were completed by Hill et al. (2005) that specifically explored primary mathematics teachers' knowledge and the aligned assessment has portions specifically designed for elementary teachers. The assessments were created to measure the specific mathematics knowledge teachers need to be effective in the mathematics classroom beyond mathematics content knowledge. This framework, with an aligned assessment, is the best way to determine primary mathematics teachers' mathematical knowledge for teaching in this context.

Rationale for Using Mathematical Knowledge for Teaching

Mathematical Knowledge for Teaching (MKT) is one effective framework with an aligned assessment that can be used to answer these overarching questions because it is specific for mathematics teachers (Ball & Bass, 2003; Ball et al., 2008; Copur-Gencturk et al., 2019; Marshall & Callahan, 2016). The MKT framework is built on Shulman's (1986) work with PCK, the blending of knowledge of pedagogy and content. The MKT goes on to include other specialized knowledge for teaching beyond PCK, including common content knowledge, specialized content knowledge, and horizon content knowledge (Ball et al., 2008). These other strands of MKT include teachers knowing how to perform computations in mathematics, analyzing mathematical problems and equations, and identifying misconceptions students possess. These subject matter knowledge strands allow the researcher to gain a more complete picture of the knowledge primary mathematics teachers have obtained beyond their PCK.

Using the aligned MKT assessment allows the researcher to determine the mathematical reasoning, understanding, and skills primary mathematics teachers possess (Ball & Bass, 2003; Ball et al., 2008; Copur-Gencturk et al., 2019). The MKT assessment does not purely measure the content knowledge teachers have in mathematics, but also other aspects such as looking for patterns in student errors and determining if a student's approach to solving a problem is valid or generalizable to similar problems (Ball et al., 2008). The main benefit of this assessment is to provide an overview of the specific mathematical knowledge that teachers possess. Information from the open-ended prompts can inform professional development providers concerning strengths and weakness so they can support future professional learning for those teachers (Copur-Gencturk et al., 2019).

The MKT is the best choice for this study because it allows the researcher to gain a clear snapshot of the mathematical knowledge teachers at Buffalo Elementary School possess in both Numbers and Operations and in Patterns, Functions, and Algebra. (The Geometry portion of the assessment was omitted as it is specifically for Grades 3-8.) The aligned assessment assesses teacher knowledge in both areas and is scored by the research author team in Michigan to remove any possibilities for errors in scoring or interpretation. Table 2.3 gives an overview of the available domains for the MKT assessment content areas. The assessment was built specifically with mathematics in mind, and the assessment has been tested with primary mathematics teachers. This framework with aligned assessment allowed the researcher to determine teachers' proficiency as measured by the MKT in order to inform stakeholders of Buffalo Elementary School to effectively plan and develop professional learning opportunities that align with next steps for teacher learning in these areas.

Table 2.3

Summary of Domains of the MKT Assessment

Domain	Target Grade Level	Description
Number and Operations	K-6	Teachers must solve problems that would be assigned to students, evaluate solutions to student work, and represent mathematical content to students in a K-6 setting.
		These include counting and cardinality, arithmetic operations, and the fundamentals of the number theory.
Patterns, Functions, and Algebra	K-6	Teachers must solve problems that would be assigned to students, evaluate solutions to student work, and represent mathematical content to students in a K-6 setting.
		These include algebraic notations, relationships among numbers, and modeling relationships.
Geometry	3-8	Teachers must solve problems that would be assigned to students, evaluate solutions to student work, and represent mathematical content to students in a Grade 3-8 setting.
		This includes geometric constructs, principles of Euclidean geometry, and classifications.

CHAPTER III

METHODOLOGY

Statement Regarding Human Subjects and the Institutional Review Board

A preliminary review of the methods for collecting information from human subjects determined that the methods proposed for this study did not meet the federal definition of "human subjects research with generalizable results." As the information-gathering methods were within the general scope of activities and responsibilities associated with my current position, I was not required to seek human subjects' approval. Please see Appendix A, which is a copy of the email communication regarding the IRB's decision about the study.

Quantitative and Qualitative Paradigms

The purpose of data collection in the quantitative research paradigm was to explain and predict data in numerical forms. This paradigm includes data that are measurable and could produce statistical results (Given, 2008). Quantitative data collection was typically used to generalize results from a sample to a population and recommend a final course of action (Creswell, 2006). There are many benefits to collecting data in this manner, including the speed with which large amounts of data can be collected, including the ability for statistical analysis and generalizable research findings, and providing data that are descriptive in creating a snapshot of the sample of participants being studied (Given, 2008). However, there are several pitfalls to using only quantitative data. In this ROS, the knowledge produced may be too general to apply it directly to the mathematics recommendations report; thus, qualitative data collection was important to gain a complete picture of the participants.

The purpose of data collection in the qualitative research paradigm was to gain a deeper understanding of the qualities and characteristics of participants studied (Charmaz, 2006). Qualitative data collection provides great detail and information about participants' lives and experiences (Creswell, 2006). Researchers can then look for trends in the data in order to inform their decisions. Using only a qualitative approach to collecting data for this ROS has several pitfalls as well. A primarily qualitative approach would miss viewing the overall data set from a statistical perspective, gaining insight on preference and experience trends as well as using descriptive statistics to learn more about the data (Creswell, 2006).

In order to gain a clear picture of the needs of the teachers at Buffalo Elementary School, a mixed methods approach was used to employ the benefits of both paradigms. This method was selected because it combined both quantitative and qualitative approaches, providing a better understanding of the problem than would be gained if either approach were used singularly (Creswell, 2006). This study sought to answer the following overarching question: What is the primary (kindergarten through second grade) teachers' knowledge for teaching mathematics in a low-performing elementary school in Oklahoma? The specific design best supported by this paradigm was the embedded design (Creswell, 2006). According to Creswell (2006), this design was used when qualitative methods were embedded into quantitative methods such that the qualitative data played a secondary role to the quantitative.

Mixed Methods Design

Instructional needs of primary mathematics teachers are multifaceted. Past coursework, professional learning, experience, and curriculum needs are all taken into consideration when viewing the needs of the teachers. In this study, data were collected through a mixed methods survey design. Most of the data were quantitative in nature with several qualitative interview

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questions to help provide clarity. Data collection was used to help further develop the product, a

mathematics recommendations report, containing starting point recommendations for

mathematics professional learning for the faculty of Buffalo Elementary School. The report

outlined the MKT of teachers in Numbers and Operations and Patterns, Functions, and Algebra

using two instruments and several interview questions. The need for a mixed methods form of

data collection in the embedded design was critical because the researcher collected both

quantitative and qualitative data at the same time, results were analyzed independently, and then

in the final phase of the study, the results were analyzed and interpreted (Creswell, 2006). The

qualitative data represented the voices of the participants and aided in validating the quantitative

outcomes (Creswell & Clark, 2011). According to Creswell and Clark (2011), in a mixed

methods study, once the individual analyses are complete in each phase of collection, a mixed

methods interpretation should take place. This final interpretation looked across both quantitative

and qualitative data in order to determine how this information addressed the research question.

Figure 3.1 displays an overview of the phases of data collection.

Figure 3.1. Summary of phases of data collection and analyses.

The primary strength of this design was that even though data were being collected concurrently, data management was a simpler process because the researcher could focus on one data set at a time for initial analysis (Creswell, 2006). The researcher used the qualitative data collected through interviews to expand upon the specific needs of the teachers. The challenges for this design were that it could be difficult to integrate the results from both methods when they were used to answer different research questions. In this study, however, both forms of data collection were used to answer the same research questions. Secondly, Creswell (2006) noted that it can be very difficult to embed quantitative data into a qualitative design. This study embedded the qualitative into the quantitative design, thus this did not have an effect on the study.

This study utilized two data collection methods:

1. Survey of the Study of Instructional Improvement (SII). This survey measured teacher knowledge and background in mathematics. This included follow-up interview questions for four to five participants.

2. The Mathematical Knowledge for Teaching (MKT) assessment. This assessment measured the mathematics knowledge teachers have for teaching.

Figure 3.2 depicts an overview of the data collection methods that were used as part of this ROS.

Setting

Buffalo Elementary School is located in a partially rural, partially suburban town in Oklahoma. The total population of the town is 53,873, a 5% increase in population over the past 5 years. The median household income for this town is $55,000. This elementary school represents the average elementary school in this town. It is surrounded to the east by farmland

and to the south and west by middle-income neighborhoods. Most schools within Oklahoma are similar geographically.

Study of Instructional Improvemet Survey

Measured teacher knowledge and background in mathematics. There were 12 primary mathematics teachers invited to participate with 34 questions total. Additionally, a total of 4 teachers participated in follow-up interviews.

Mathematical Knowledge for Teaching Assessment

Measured teacher MKT. There were 12 primary mathematics teachers who participated with roughly 20 questions total.

Figure 3.2. Data collection overview.

The district is one of the fastest-growing districts in the area due to recent increases in the oil field business. The district serves over 7,800 students, an increase in enrollment of 1,400 students in 5 years. As a result, $99 million in renovations have been made in the past 5 years including the addition of two new elementary schools (Fitzgerald, 2015). The school being used in this study, Buffalo Elementary School, was one of the new schools built. It has only been established for 3 years. The district is currently home to 1 high school, 1 middle school, 11 elementary schools, 1 alternative school, 1 adult education center, and 1 early childhood center (Fitzgerald, 2015). Buffalo Elementary School is home to 426 students. This is an average school size for the area. The school is at 42% free and reduced lunch, which is average for the district (Fitzgerald, 2015).

The district has a very simplistic history of training and professional development offerings for its teachers. At the start of each academic year, all teachers Pre-K through 12

participate in a session that includes a greeting from the superintendent, a motivational speaker, and afternoon "break out" sessions in which teachers meet in grade level groups to go over the curriculum scope and sequence for the school year. This format of the training remains the same each year with only the theme of the motivational speaker changing (A. Smith, personal communication, November 3, 2014). Oklahoma state teaching certificates must be renewed every 5 years. Teachers have two options for renewal. Option A requires teachers to have taught at least 3 years in the state of Oklahoma. If this is the case, no professional learning is needed. In option 2 if teachers have not taught in the state of Oklahoma for at least 3 years, they may use a combination of other teaching experience or 75 professional points from attending workshops, conferences, or PD.

Stakeholders

The target audiences for this ROS were the teachers and administration of Buffalo Elementary School. The school has 25 certified teachers on staff teaching grades preschool through fifth. The school also employs seven certified specialists in roles such as media specialist, music, PE, etc. Administratively, there is one principal, two secretaries, and one counselor. Experience in this current school year for teachers ranges from 26 years of experience to 1 year of teaching experience. There are four alternatively certified teachers on staff and two National Board-Certified teachers. All faculty members of Buffalo Elementary School are female with the exception of the principal.

The target participants are the primary teachers of Buffalo Elementary School. There are a total of 16 female primary teachers in grades preschool through second, 37% of which are African American or Latino. Experience of these teachers range from 1 year to 15 years. All teachers in the primary school have completed their degree in either Elementary Education or

Early Childhood Education and are certified to teach their assigned grade level. A more detailed

representation of primary teachers at Buffalo Elementary School can be found in Table 3.1.

Preschool teachers did not participate in the study because they did not use the EnVisions

curriculum or assessments, only a modified version of the curriculum they had created. There

were a total 12 teachers invited to participate in this study in grades kindergarten through second.

Table 3.1

Sixteen Primary Mathematics Teachers at Buffalo Elementary School

	Pre-K	Kindergarten	First	Second
Gender	4 female	4 female	4 female	4 female
	0 male	0 male	0 male	0 male
Ethnicity	4 Caucasian	2 Caucasian	3 Caucasian	1 Caucasian
	0 African Amer.	2 African Amer.	0 African Amer.	1African Amer.
	0 Latino	0 Latino	1 Latino	2 Latino
Age Range	25-30 years	28-40 years	30-65 years	26-50 years
Experience Range	1 year-5 years	3 years-15 years	5 years-15 years	2 years-10 years

Data Collection Methods

Data were collected in this ROS using two different data collection methods. The first

method was the SII survey. The purpose of this survey was to measure teacher knowledge and

background in mathematics. The second method was the MKT assessment. The purpose of this

assessment was to measure the mathematical knowledge teachers have for teaching.

The specific instruments used in this ROS, the SII survey and the MKT assessment, were purposefully chosen because they both aligned with the overarching and guiding questions. There are several instruments that measure different aspects of mathematics content and experience; however, these two were the best fit. The SII survey was specifically chosen because it allowed the researcher to understand how the teachers of Buffalo Elementary School felt about the current mathematics curriculum they taught and gave a thorough picture of the background that teachers had in mathematics. The MKT assessment was specifically chosen because it asked mathematics questions that were not only content specific, but directly related to teaching different concepts in the classroom. Two other instruments that were explored were the TIMSS 2015 Teacher Questionnaire and the 2000 National Survey of Science and Mathematics Education. Neither of these were chosen because they did not measure any form of which was a very important piece in this ROS. Table 3.2 introduces the measures that were considered in planning this ROS.

The two specific strands to be measured on the MKT, Numbers and Operations and Patterns, Functions, and Algebra were chosen purposefully because they align with two of the most prominent Content Domains in primary mathematics, Number and Operations and Algebra. (The Geometry domain was not used for this study as it measures Grades 3-8.) The MKT assessment gave the researcher a clear picture as to the MKT knowledge teachers possess in these specific areas which make up a large part of the foundation of mathematics in these early grades (NCTM, 2018). Exact samples from the assessment cannot be shared as not to compromise the validity of the assessment. An example of content may include participants looking at student work samples for addition and subtraction problems and determining student

errors, determining if explanations by students are generalizable to like problems, or determining if misconceptions are forming in addition and subtraction problems.

Table 3.2

Measures Comparing Surveys Regarding Teachers' Mathematics Knowledge

	TIMSS 2015 Teacher Questionnaire	2000 National Survey of Science & Mathematics Education	SII Teacher Questionnaire	MKT Assessment
Teacher Background in Mathematics	X	X	X	
Teacher Collaboration In Mathematics	X	X	X	
Mathematics Instructional Practices	X	X	X	X
Mathematics Resources And Curriculum	X		X	
Previous Mathematics PD	X	X	X	
Teachers' Mathematics Knowledge in Practice			X	X
School Improvement in Mathematics			X	

Note. TIMSS (National Center for Educational Statistics, 2015).
2000 National Survey (Horizon Research, 2000).
SII Teacher Questionnaire (University of Michigan, 2001).
MKT Assessment (Ball et al., 2005).

Study of Instructional Improvement Survey

A Likert-style survey was used to begin data collection. The purpose of using this survey first was to measure teachers' attitudes to different statements and the extent that teachers agree or disagree with that statement (Likert, 1932). The item types in this survey measured the agreement, frequency, importance, and likelihood of a variety of statements pertaining to mathematics. A survey was chosen because it is an efficient method for gathering information

before planning and developing any recommendations for further professional learning (Fink, 2013).

The specific survey used was a modified version of the Study of Instructional Improvement's (SII) Teacher Questionnaire (University of Michigan, 2001). The original SII's Teacher Questionnaire consisted of 67 questions grouped in the following categories: Perspective on the School, Reading/Language Arts Instruction, Mathematics Instruction, Instructional Improvement, and Teacher Background. The modified survey used for this ROS only used the following portions: Mathematics Instruction, Instructional Improvement, and Teacher Background and consisted of roughly 34 questions. The purpose of using only portions of the SII was to gain a clear picture of the history of mathematics training, professional learning opportunities, and demographics of the primary teachers at Buffalo Elementary School. All 12 primary school teachers in grades kindergarten through second were invited to participate in this portion of data collection.

The SII survey was developed out of the University of Michigan as an effort to address the issue of comprehensive school reform by improving instruction and student achievement (Rowan & Miller, 2009). Researchers conducted a large-scale, mixed methods study to determine the effect various school reforms had on student achievement. One element of this study was the Teacher Questionnaire used to determine what generates higher levels of student achievement (Other elements of the SII included instructional logs and interviews). The Teacher Questionnaire was developed in 2000 using research and theory to generate questions that would show the strengths and weakness of teachers' MKT in mathematics and reading (Ball, Hill, & Bass, 2005). Each survey item had been piloted with over 600 teachers to provide an overall picture of their MKT (Rowan & Miller, 2009). In total, over 5,000 teachers participated in the

SII. The reliability of this instrument was .7 (moderate effects) and .8 with 60 or more participants (Rowan & Miller, 2009).

The survey was administered electronically via Survey Monkey. Teachers were given a code to enter for the researcher to correlate the data from this survey with data from the MKT assessment. Fitzpatrick, Sanders, and Worthen (2011) explained that giving a survey in this manner allowed teachers to feel more anonymous. All teachers had access to the internet at Buffalo Elementary School, as well as a district-issued laptop and iPad. Teachers were emailed the survey as well as an explicit set of instructions for completion. In order to increase the response rate of the survey, teachers had two weeks to complete it. The timetable occurred during the last week of April and the first week of May. Teachers at Buffalo Elementary School were asked to check their email once per day by the principal in case there was important communication, so teachers were aware of the instruments. All the primary teachers were also members of a private FaceBook group in which the survey information was posted.

Once this survey was completed, four teachers were interviewed using follow-up open ended questions in order gain a clearer picture of the perspective the teachers currently had on the EnVisions curriculum and how they thought about mathematics instruction. Teachers choosing to participate in phone interviews indicated this in the final question of the survey by leaving their email address. The researcher then contacted them regarding the questions. Questions allowed the researcher to determine the perceived usefulness of the curriculum and teacher notes found throughout the curriculum. The following questions were used:

1. When planning a typical mathematics lesson, how often do you consult the teacher notes in the curricula available for each lesson? Do you find that the teaching notes

most often contain information you already know or is there new information presented? Please elaborate.

2. When planning a typical mathematics lesson, do you consult with other sources outside of the curricula for ideas or support? (Other sources might include websites, conversations with other teachers, using elements of previous lessons you have taught from other curricula, etc.) Please elaborate.

3. To what extent do you feel the current curricula used at your school aligns with your ideas and views of teaching mathematics? Please elaborate.

4. How many years have you taught using the EnVisions curricula? What do you view as the main strengths and weaknesses of the program from a teaching perspective?

The primary purpose of these questions was to gather more detailed data from teachers as to their experiences and views of using the EnVisions program to teach primary mathematics. The intervention (a report sharing the data and outlining conclusions and recommendations) was further developed and refined as a result of this data collection. Questions used throughout the process were open-ended and followed up with probes that allowed teachers to elaborate on their responses, if needed (Creswell, 2013). This allowed teachers to share their thoughts in greater depth. Questions were not embedded throughout the survey in order to gain more in-depth responses from participants.

These research interviews were based on the daily use of the mathematics curriculum and teaching resources. In interviewing participants, rather than including these questions throughout the interview, the researcher had the opportunity to encourage participants to expand more upon their thoughts to gain a deeper understanding from participants (Kvale & Brickmann, 2009). The interviews were focused around the questions previously listed;

however, it was not strictly structured to only answering these questions. The researcher had the freedom to ask questions for clarity or further explanation (Kvale & Brickmann, 2009).

In one mathematics study completed by Tobias, Roy, and Safi (2015), the researchers explored the concepts of whole numbers and fractions in teacher knowledge through student work samples and teacher follow-up interviews. The researchers noted that they could clearly see the understanding the teachers had of the concepts through their discussions and observations that allowed them to determine next steps for the teachers. In a second study, 252 teachers were interviewed to explore the knowledge they possessed from mathematics courses they had previously taken. These interviews were conducted as a follow up to obtaining teaching jobs to determine if their training in mathematics was sufficient. Ball (1990) found through her interviews that the teachers possessed most of the basic knowledge base needed to be successful in mathematics teaching.

Interpretation of the quantitative data from SII survey. Data analysis for the quantitative and qualitative pieces was completed independently of one another at this point. To analyze the quantitative data, descriptive statistics were used utilizing the program Excel. The data set was relatively small (a maximum of 12 participants); thus, the program Excel was sufficient in using descriptive statistics to analyze. Data were analyzed by the end of May. Creswell (2013) defined descriptive statistics as describing trends in the data to a single variable. This Likert data were ordinal in nature, meaning that the responses had order or rank (Creswell, 2013).

The purpose of using descriptive statistics was to construct descriptions of the data in order to better summarize it. Many advanced data analysis techniques were not used because the sample size ($n = 12$) was small for this data collection. Measures of central tendencies, measures

of dispersion, and correlation were all measured using the data from the survey. See Table 3.3

for detailed analysis type and rationale for use. Displaying and organizing this data in charts and

tables made it easier to make comparisons.

Table 3.3

Quantitative Data Analysis of the SII Survey and Rationale

Data Analysis Type	Rationale
Measures of central tendencies: median, mode, and mean on questions where applicable (Not all questions were analyzed finding the mean).	These measures used to determine the most frequent responses and the average number where applicable. The mean was not used on questions in which the response required was ordinal or nominal in nature (Howell, 2015). For example, the mean was used to determine the average number of minutes per day mathematics was taught at each grade level.
Measures of dispersion: range of scores, variance, standard deviation, frequencies	The span of the scores as well as the variance of scores on questions where applicable. The variance told the researcher how far away scores were from the mean score (Howell, 2015).
	For example, range of scores were useful in comparing the number of professional development hours each teacher had completed in mathematics this school year.
Correlation: Spearman's Correlation Coefficient	Correlation measures the strength of the relationship between two variables (Howell, 2015). Spearman's Correlation Coefficient was used to measure the degree of association between two variables. It was used to tell if there was a statistically significant relationship between two variables (Howell, 2015).
	For example, determine the extent of the correlation between the number of minutes mathematics is taught per day and the extent to which teachers are comfortable with the EnVisions curriculum.

Interpretation of the qualitative data from SII survey. In order to analyze the

qualitative data from the interviews, themes were identified in the data, coded, and interpreted

(Guest, Namey, & Mitchell, 2013). This type of analysis was more than simply counting words,

but moves into describing ideas and themes within the data (Creswell, 2013). In coding this

data, the researcher had the major theme of MKT in mind that guided the coding. According to

Saldana (2009), themes may be preselected before coding begins or can emerge from the data

during coding. It was also recommended that data be coded manually, not using a special

program when the researcher was new to qualitative work or using a small data set in order to

become familiar with the process (Saldana, 2009).

In coding the information, open coding was used first to create the major categories of

data (Creswell, 2013). Through this process, the category or categories to focus on were

identified (Strauss & Corbin, 1990). The focus in this stage was on the text to define the

categories (Creswell, 2013). An outline was generated to organize the information using

Microsoft Word. As information branched out and was coded with intervening conditions, the

categories all related back to the core category of focus using a model called axial coding

(Strauss & Corbin, 1990). In axial coding, the researcher is rereading the responses to explore

how these concepts and categories are related to one another and to check for further

relationships (Creswell, 2013).

In interpreting these data, themes and trends were emerging throughout the work as they

related to one another. Specifically, statements or information that was similar or identical was

used to drive the recommendations moving forward (Denzin & Lincoln, 2011). As data were

analyzed, a table was generated of major categories (created from open coding) and the

associated concepts (from axial coding) in Microsoft Word (Creswell, 2013).

Mathematical Knowledge for Teaching Assessment

The Mathematical Knowledge for Teaching (MKT) assessment was used as the second instrument for data collection. This measure was developed from the SII survey beginning in 1999 to assess mathematics content knowledge from large groups of teachers at one time (Ball et al., 2005). The team that wrote the assessment as well as the online program consisted of about 45 researchers. Original funding for the creation of this assessment came from the National Science Foundation. This project is no longer underwritten and there is currently a charge for use of the materials. The researcher received a waiver of all fees for using the study as well as a waiver of all fees for training modules.

The questions were written and tested in such a manner that a score of 50% was considered average. The goal of this assessment was not to make a perfect score. Some questions were simple and others were more difficult. This assessment was not written to any specific curriculum or set of standards, rather it was written to the general knowledge deemed important that teachers possess (Ball et al., 2005). Reliability on this assessment was .71-.84 in the Patterns, Functions, and Algebra portions and .81 in the Concepts and Operations portions of the assessment (Ball et al., 2005).

The MKT portion of the instrument was hosted through the School of Education at the University of Michigan. Participants in this study were given a unique code to access the assessment online that aligned with their code for the first SII taken in Survey Monkey. Participants were then given the MKT assessment, a multiple-choice assessment lasting an average of 20 minutes. The assessment tested teachers' mathematics knowledge for teaching. There was no time limit for completion of the assessment. The test items were graded by the

program in order to eliminate error on the part of the researcher. The test items were not shared outside of the testing environment and thus, were not included in the appendix.

An assessment of this design was chosen because it specifically helped the researcher answer the overarching question of this study: What is the primary (kindergarten through second grade) teachers' knowledge for teaching mathematics in a low-performing elementary school in Oklahoma? It also aided in answering the guiding questions:

1. What is the MKT of primary mathematics teachers at Buffalo Elementary School in Numbers and Operations?

2. What is the MKT of primary mathematics teachers at Buffalo Elementary School in Patterns, Functions, and Algebra?

Participants were chosen to complete this instrument using a purposeful sampling technique. All 12 primary mathematics teachers at Buffalo Elementary School were invited to complete the assessment because they could aid in the continued understanding of the problem (Creswell, 2013). The primary faculty of Buffalo Elementary School was very small, with only 16 teachers in this category, 12 of whom were invited to participate in this assessment. As a result, all teachers that meet the criterion of teaching primary grades at Buffalo Elementary School who also used the EnVisions curriculum during the 2015-2016 school year were invited to participate.

Hill et al. (2005) noted that the interpretation of the MKT scores aligned with the following assumptions: they showed that teachers' scores reflected the mathematics knowledge they possessed for teaching and that teachers used their MKT to produce better instruction in order to teach their students. These statements were true if teachers answered questions on the

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assessment accurately and without guessing and if higher scores on student assessments denoted more learning had taken place.

Interpretation of Data for MKT Assessment

To analyze this quantitative data, descriptive statistics were also used in Microsoft Excel. The data set was again a relatively small set (a maximum of 12 participants); thus, the program Excel was sufficient in processing descriptive statics to analyze. The actual data from the MKT assessment were graded by the computer program, so only overall percentages were used for analysis. The first step for the researcher was to gather all the raw scores on the assessment and export them into the Excel software. The second step was to use Excel to perform preliminary data analysis.

The researcher began by calculating the mean scores on the MKT for each teacher. Scores on the MKT were broken down by individual teacher as well as grouped by grade level to view the data both by teacher, by grade level groups, and by the primary school as a whole. It was useful for the researcher to determine the range of scores for primary mathematics teachers to determine if all teachers have similar levels of MKT or if some teachers had substantially more/less MKT as compared to their peers. Frequencies of scores were also useful to group teachers according to their MKT knowledge.

<center>**Convergent Analyses: Data Interpretation of Both Methods**</center>

In the convergent design, quantitative and qualitative data collection are completed and their analyses are made independently of one another (Creswell & Clark, 2011). The results from each method of data collection are then viewed for comparison. This design is used when "different but complimentary data on the same topic is collected to best understand the research question" (Creswell & Clark, 2011, p. 77). In this portion of the study, the data were analyzed

<center>57</center>

together and mixed methods interpretations and conclusions were made. In a mixed methods study, the researcher must look at both sets of data (quantitative and qualitative) to determine if they answer the research question (Creswell & Clark, 2011). The converging analysis of data from all three methods is depicted in Figure 3.3.

Conclusions and Recommendations
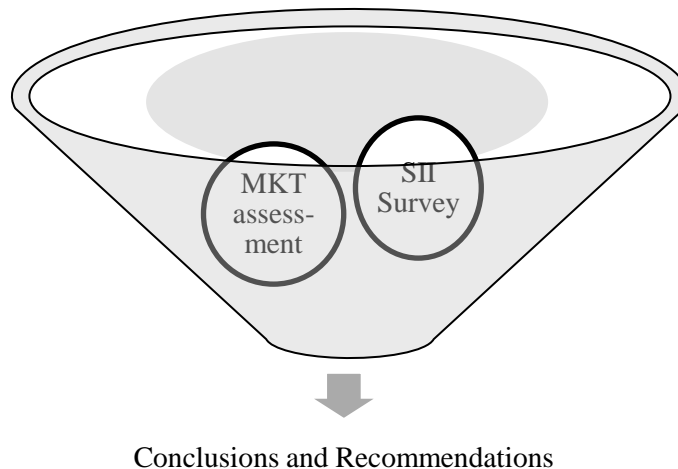
Figure 3.3. Convergence/triangulations of the data from two sources.

This design had several strengths and challenges. Some of the strengths included being able to collect both sets of data concurrently and design procedures that were simpler to follow for new researchers than some other designs (Creswell & Clark, 2011). Some of the challenges included making sure both sets of data addressed the same concepts and ensured that the sample sizes for each set of data were similar. In this study, all measures had been aligned to the overarching question and guiding questions, so this challenge was not applicable (Figure 3.4 depicts this alignment). Secondly, the sample size was small for the SII and MKT, so this was not a relevant challenge in this case.
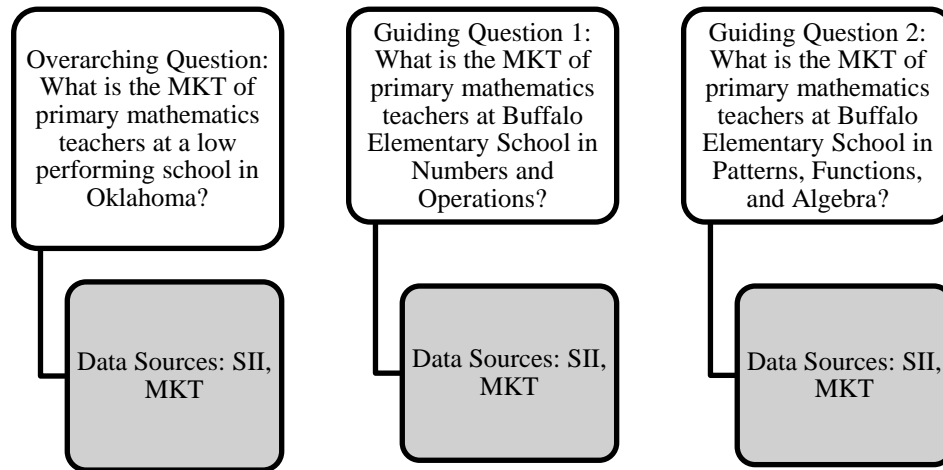
Figure 3.4. Overarching and guiding questions aligned with data collection methods.

Utilizing several data sources in this study aided in achieving triangulation, thus allowing

for greater accuracy (Creswell & Clark, 2011). According to Bryman (2006), "Triangulation

refers to the traditional view that quantitative and qualitative research might be combined to

triangulate things in order that they may be mutually corroborated" (p. 62). A Survey,

assessment, and interviews permitted stronger data validation because the researcher saw the

trends in responses across several or all sources. This allowed the researcher to observe repetitive

themes and viewpoints to help confirm results. This creates a more rounded data set, thus less

bias (Creswell & Clark, 2011).

At this point in the ROS, individual analyses have been made of both the quantitative and

qualitative data sets and a convergence of data sets took place. According to Creswell and Clark

(2011), data should be arranged in a manner that is easy to compare results thus placed in a table.

The researcher then developed a set of procedures to transform the qualitative data themes into

counts to make it easily comparable to the quantitative data. Finally, the data were explored

using descriptive statistics and summarized in order to explain the extent to which the data

answered the research questions (Creswell & Clark, 2011).

Descriptive statistics were used in several ways to perform these analyses using the program Excel in order to answer the research questions. Examples of descriptive statistics included mean, range, and standard deviation of MKT scores. This form of analyses aided in answering the overarching question: What is the primary (kindergarten through second grade) teachers' knowledge for teaching mathematics in a low-performing elementary school in Oklahoma?

Issues of Reliability, Validity, Confidentiality, and Other Ethical Concerns

Issues of reliability and validity are defined as the degree to which the measure produces stable results as well as the measure assessing what it is supposed to evaluate (Creswell, 2013). Both instruments used, the SII and the MKT, were created by experts in the mathematics field at the University of Michigan and all questions were tested in focus groups before using the questions in their study. In this ROS, issues of validity and reliability may have occurred as primary mathematics teachers may not have answered in an honest manner in order to make themselves appear to have more background knowledge than they currently had in mathematics. In order to mitigate this, all participants were coded and not identified by name as to add a level of anonymity to the results. The researcher also used triangulation (multiple viewpoints from different data sets) to allow for greater accuracy and to verify conclusions from the data (Bryman, 2006; Jick, 1979). To address confidentiality issues that may arise during this study, all teachers were coded and only the researcher had the key to the coding.

There were other ethical concerns to consider as well. To reduce errors on the part of the researcher, the MKT program graded the assessment and provided the raw data to the researcher. This meant that all bias in grading was removed. The researcher was also required to complete an online training course before being given access to the MKT assessment. The online course

consisted of three mandatory modules covering the purpose of the assessment, developing assessment plans, and using the online testing environment. The online course also consisted of other modules that assisted in data analysis. All qualitative data were input into Survey Monkey and eliminated errors in transcription on the part of the researcher.

There were several biases that the researcher needed to account for in the analysis of the survey as well. These included a central tendency bias. In this case, teachers may avoid using the extreme positive or extreme negative response to a question (Fink, 2013). A second type of bias is acquiescence bias. Teachers may try to make themselves appear more favorable than they are in reality (Fink, 2013). Fortunately, because the questionnaires were anonymous, there was less chance for this form of bias to be present (Creswell, 2013). Also, ensuring that a scale was used with an equal number of positive and negative statements, balance was provided for responses so as to not lead teachers toward one response over another (Fink, 2013). The data assisted in generating conclusions for the mathematics recommendations report.

Any ethical concerns that arose during this study were dealt with immediately by the researcher. All participation in this study was voluntary by participants. Participants could decide to stop participation in the study at any time. Participants were notified of this before they began participation in this study.

Timeline of ROS

In response to the overarching question, "What is the primary (kindergarten through second grade) teachers' knowledge for teaching mathematics in a low-performing elementary school in Oklahoma?" several instruments were used over one period to collect and interpret data. In the first phase of data collection (the modified SII survey), the 12 primary school teachers spent between 20 and 30 minutes completing their online survey. In the second phase,

(MKT assessment), these 12 teachers spent roughly 30-45 minutes completing the survey. It was noted, however, that there was no time limit to completing either survey.

Data collection and individual analysis were completed by the researcher for Phase 1: Concurrent Data Collection, Embedded Design (SII survey and MKT assessment) in the months of April and May 2016. All data collection of Student EnVisions Data was completed by the end of May as well. The researcher was waiting for data to be reported before analysis could be completed. In Phase 2, the researcher analyzed all data independently. This was completed in May after data were collected. Phase 3: Concurrent Interpretation using Convergent Design began once Phase 1 and Phase 2 had been completed individually. The timeframe for this began in June 2016. A summary of the timeline of methods can be found in Figure 3.5.

Phase 1: Concurrent Data Collection, Embedded Design, (SII survey, Interviews MKT assessment)

Online survey and data analysis roughly 1-2 hours from participants.

April-May 2016

This survey will be distributed to teachers online via Survey Monkey and the MKT website with a 2-week window for teacher participation.

Phase 2: Analyzing the Data Sets Independently

All data will be analyzed separately using Excel program and Microsoft Word

July 2016

Phase 3: Concurrent Interpretation using Convergent Design

Data analysis, coding, and synthesis by researcher.

January 2017- 2019

A mathematics recommendations report will be designed and analyzed based upon the findings from the data collection. Begin to finalize all materials for presentation to the committee in the Fall semester.
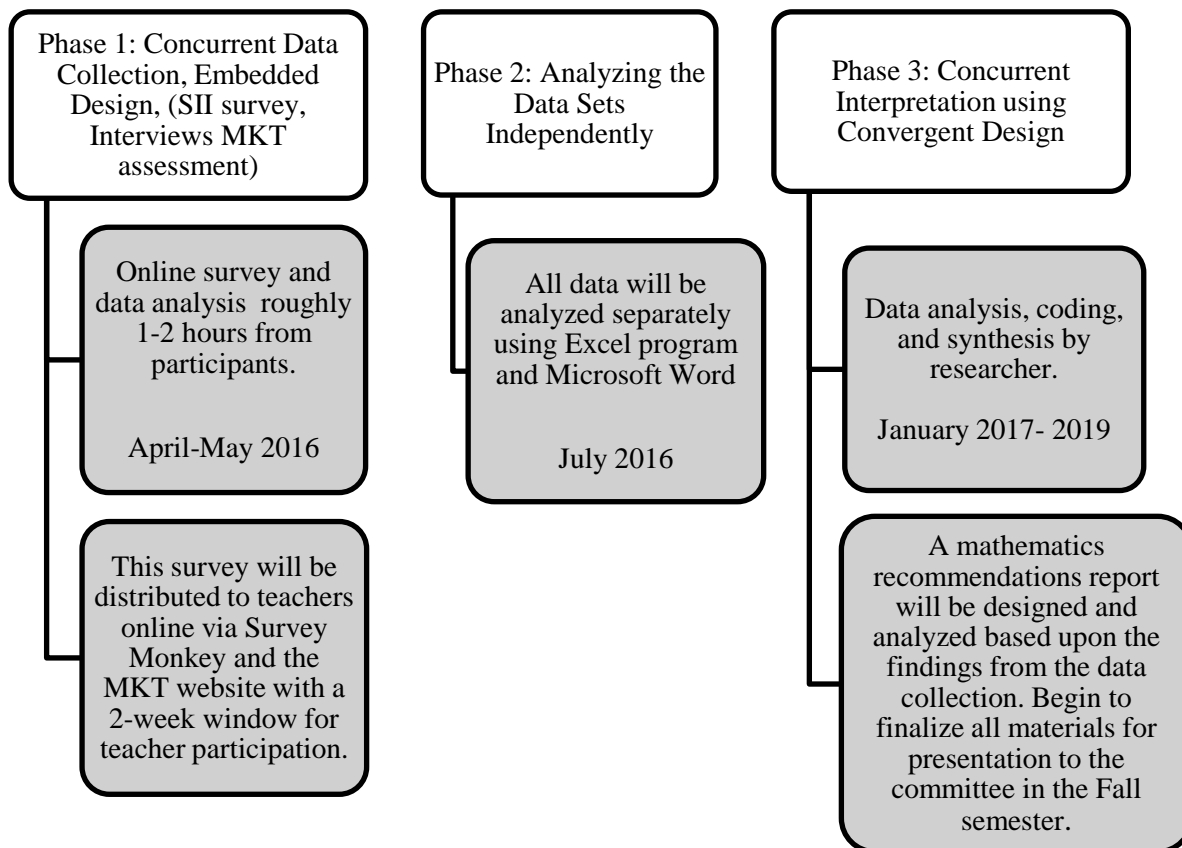
Figure 3.5. Timeline of the study methods.

Limitations

There were four main limitations to this study: (a) the researcher, (b) materials, (c) participation, and (d) time. The first limitation to this study was the researcher. She had moved out of the state and was not present at Buffalo Elementary School at the time of data collection. To account for this limitation, she had taken modes of online data collection into consideration while planning this ROS. This included using a reputable online survey distributer for both portions of the survey. The principal of Buffalo Elementary School was aware of this limiting factor and agreed to meet via Skype to discuss any issues that arose throughout this process.

The second limitation in this design was some of the materials the researcher was using. This study was based upon teacher and student use of the EnVisions curriculum. Therefore, results from this ROS may not be transferrable to other situations in which this exact curriculum is not in use. Also, this survey data cannot be used to make broad, sweeping claims to all primary mathematics teachers outside of Buffalo Elementary School. The researcher explored the data to determine relationships, not to make claims of correlation within primary mathematics at other schools.

The third pitfall in this design was participation. First, the sample sizes that were used throughout this study were very small. The total primary population of Buffalo Elementary School was only 16 teachers, 12 of whom were invited to participate in this study. To help mitigate this pitfall, the researcher clearly explained her study to participants ahead of time. The researcher also explained some of the main benefits of the study, including being able to tailor recommendations for future learning based on the results of this study.

The final limitation was time. Primary teachers had very little time during the school day in which to complete tasks that were not directly related to their classroom teaching. This may be a factor that also limited participation throughout the study. To help alleviate this limitation, administration, who was in full support of this ROS, had agreed not to hold any extra activities for teachers during the survey window in order to help encourage maximum participation by teachers.

<div align="center">**Qualifications of Researcher**</div>

Background

The researcher has been an elementary teacher for 9 years, three of which had been at Buffalo Elementary School teaching first grade. She was hired at Buffalo Elementary School its first year and played a primary role in establishing the school as part of its Foundations Team. She taught all subject areas, including primary mathematics and used the EnVision curriculum for 3 years at Buffalo Elementary School as well as 2 years prior when teaching second grade in the state of Florida. She was very familiar with the successes and challenges of the primary curriculum and had an insider's perspective of the struggles of the primary teachers at Buffalo Elementary School. She had also completed the training modules required by the MKT assessment team in order to effectively use their tools to gather data.

The researcher has a master's degree in Educational Leadership and currently holds a National Board Teaching Certificate. This year, she has taken time off from teaching at Buffalo Elementary School to focus on the ROS work. This gives her the unique advantage of viewing the problem space from a stakeholder's perspective, as well as an outsider looking in on the problem. She has been actively involved in the problem and in looking for a solution as a teacher and as a researcher. All coursework and internships have been completed in order to fully frame

this problem and assist in conducting research. To minimize researcher influence, all quantitative data were coded so teachers were not identified by name throughout the report. The researcher did not share any thoughts or opinions throughout the process with teachers.

Journey to the Problem Space

The principal of Buffalo Elementary School began his teaching career as a band director. He taught in that high school classroom for 5 years while obtaining his principal license at the same time. Once his license was completed, he spent 1 year as a vice principal, then principal of an elementary school within the district, Clover Elementary, for 13 years. He then was asked to be the principal of Buffalo Elementary School, a brand-new school where he has been the principal now for the past 3 years. He plans to retire from education within the next 5 years.

The principal sees value in having PD for teachers but sees more value in having his weekly staff meetings to disseminate information to the teachers. He has thought about changing the schedule around to have time to meet with teachers during the day but does not think that this is something the teachers would want. He is not familiar with the mathematics curriculum nor the importance of building MKT with any of his primary mathematics teachers. He allows the teachers to teach the curriculum in the classroom as they see fit.

Test scores have been steadily decreasing throughout the district and at his school. The principal has had many questions about the reason for the decline of test scores but does not see the need for MKT in general as a solution to these decreasing scores. He questions the value of adding PD when other things will have to be changed throughout the school in order to make this possible. In speaking with the teachers, the researcher has heard on many occasions the teachers asking for more resources and materials to help their students in mathematics. The principal is in

full support of this ROS and will use the recommendations of this study to help his teachers grow professionally in primary mathematics.

Field-based Mentor

The mentor for Internship II was Kelli Smith, counselor and testing coordinator at Buffalo Elementary School. She was a classroom teacher for 9 years and a counselor for 3 years. She has the role of providing professional development as well as coordinating testing and compiling data for the school and reporting it to the district. She was a great mentor because all aspects of her current job focused around the elements the researcher explored in this ROS.

CHAPTER IV

PRESENTATION OF THE DATA AND FINDINGS

Background

This chapter explores the results of the mixed methods study examining the MKT of primary mathematics teachers at Buffalo Elementary School. The goal was to answer the overarching question: What is the primary (kindergarten through second grade) teachers' knowledge for teaching mathematics in a low-performing elementary school in Oklahoma? The following guiding questions were used to aid in answering this overarching question:

1. What is the MKT of primary mathematics teachers at Buffalo Elementary School in Numbers and Operations?

2. What is the MKT of primary mathematics teachers at Buffalo Elementary School in Patterns, Functions, and Algebra?

Quantitative and qualitative data were collected concurrently with the analysis of data performed separately on each data set. Results from each analysis were then merged using the convergent design to yield a final interpretation and explanation of results.

The importance of teachers' MKT in the area of mathematics was a recurring theme in the data. This was supported in the literature review. Ball et al. (2008) affirmed the importance of teachers understanding the mathematics they were teaching themselves in order to understand how to teach students the content and to be able to dispel any misconceptions students may have. Teachers must understand the concept in depth so that they may explain their thinking (National Governors Association Center for Best Practices & Council of Chief State School Officers [NGAC & CCSSO], 2010) and bring about a deeper level of questioning to promote student

thinking (Lee & Francis, 2018; Pennant, 2013). Teachers should also be able to provide a rationale and prove to students why concepts are true (Caldwell, Karp, & Bay-Williams, 2014).

MKT in mathematics can be represented on a continuum; thus, all teachers have some degree of knowledge for teaching mathematics (Carlson et al., 2013). However, the amount of experience an educator has teaching mathematics does not necessarily mean that he or she has a strong knowledge base (Baker & Chick, 2006). Teachers who were found to have a strong MKT foundation were those who participated in research-based mathematics training as evidenced by the increase in their students' achievement (Bailey, 2010; Ball et al., 2005, 2008; Gningue, Peach, & Schroder, 2013).

Presentation of Data

The main purpose of this study was to examine teachers' MKT in two specific areas of mathematics. A recommendations report was provided to the principal of Buffalo Elementary School detailing this information. This recommendations report can be found in Appendix B. The first method of data collection was the Study of Instructional Improvement (SII), a survey used to gain teacher demographic and background information, as well as, follow-up qualitative questions conducted with four participants. The second was the Mathematics Knowledge for Teaching (MKT) assessment, which measured teachers' MKT for teaching mathematics.

Using a mixed methods study allows the researcher to understand where teachers fall on the continuum of their MKT knowledge. In opposition to using one data collection method, utilizing a mixed methods approach enabled the researcher to use the benefits of both paradigms gaining a clearer picture of the teachers' mathematical knowledge base at Buffalo Elementary School (Creswell, 2015). The quantitative data collection allowed the researcher to determine the number of courses taken, and the specific knowledge gained by both teachers and students. The

qualitative data collection allowed educators to expand on quantitative responses, thus providing a more complete snapshot. Figure 3.4 depicts both the guiding and overarching questions for this study, and the methods of data collection used to answer them.

The first guiding question sought to determine the MKT of primary mathematics teachers in the area of Numbers and Operations. The data were collected through the SII survey and MKT assessment end of April through beginning of May 2016. Data utilized included teacher quantitative mathematical knowledge and qualitative teacher responses concerning support of the curriculum and the professional learning provided. Emphasis on answering this question was placed on the data from the MKT assessment results as this instrument directly measured teachers' MKT. The second guiding question was answered from this same data collection, using the scores from the Patterns, Functions, and Algebra portion of the MKT assessment. The quantitative data for these surveys were collected online using Survey Monkey. Teachers who then wished to participate in a phone interview provided their email address in a separate link to be contacted by the researcher. Four participants provided their email addresses; thus, phone interviews were conducted in May 2016. One kindergarten teacher, two first grade teachers, and one second grade teacher participated in interviews lasting between 30-45 minutes each. Quantitative data from the MKT assessment were collected simultaneously via a second link to the MKT website.

These data provided the stakeholders of Buffalo Elementary School a mathematics recommendations report that gave the strengths and weaknesses of the faculty of Buffalo Elementary School. This report was presented in order to provide research-based recommendations for further professional learning in the area of MKT. This information was a powerful tool in designing professional learning opportunities for primary mathematics teachers

with the goal of increasing student learning. It allowed stakeholders to see the amount of MKT teachers already possessed in order to determine any gaps that might exist in their professional learning.

Findings

General characteristics of the quantitative sample are described first to obtain a clear picture of teachers surveyed. On average, the 12 teachers had almost 15 years of teaching experience ($SD = 10.67$), but this average holds a wide range. One teacher had just 1 year of experience with the highest number of years' experience accrued being 33 (Table 4.1). Half of the teachers majored in Elementary Education, and the remaining half majored in Early Childhood studies. The sample was relatively evenly split in terms of those who had achieved a degree higher than a Bachelors (41.7%) and those who had not achieved this. However, only 2 of the 12 teachers were National Board Certified. The average number of years spent at Buffalo Elementary School was 2.67. Class sizes ranged between 19 and 25 students with the average class size comprising 22 students ($SD = 1.98$). The lowest amount of time spent teaching math was 45 minutes per day, with the highest 90 minutes per day.

These data were all important to note before unpacking each guiding question to depict how Buffalo Elementary School compared to state mandates held in place for areas such as class size and amount of time spent teaching mathematics. According to the emergency amendment of House Bill 1017, elementary class size in the state of Oklahoma was capped at 20 students per classroom in primary classes (HB 1017, 2018). The state of Oklahoma was unable to address this legislation and filed an emergency amendment in order to waive paying fines for noncompliance with this bill (Palmer, 2019). According to the Oklahoma Education Commission (2018), the state of Oklahoma only requires students to complete a minimum of 1,080 academic hours per

school year (about 6 hours per day). They do not have requirements for daily instruction times in mathematics.

Table 4.1

Sample Characteristics, Means, Ranges, and Standard Deviations of Primary Teachers at Buffalo Elementary School

	Minimum	Maximum	*M*	*SD*
Number of Years at Buffalo Elementary School	1	3	2.67	.651
Number of Years Teaching	1	33	14.92	10.664
Number of Students in Class	19	25	21.50	1.977
Minutes per day Teaching Math	45	90	74.58	16.984

Note. n = 12.

Guiding Question 1

MKT of primary mathematics teachers in Number Concepts and Operations. This guiding question investigated the MKT of teachers in the area of Numbers and Operations. The two specific areas of mathematics measured were Number Concepts and Operations and Patterns, Functions, and Algebra. As previously noted, both the SII and MKT instruments were used to answer this question, with most emphasis placed on the data collected from the MKT assessment.

The MKT assessment allowed the researcher to compare scores of teachers at Buffalo Elementary School in the area of Number Concepts and Operations. This is a foundational area in primary mathematics. A score of 50% was considered average on this assessment. Teachers at Buffalo Elementary School had mean scores that were below the score considered average on

this assessment (i.e., 50%) in Number Concepts and Operations. The data in Table 4.2 show the mean scores at each grade level in the areas assessed. In both kindergarten and first grade, teachers scored an average of 24% and in second grade 45%.

Table 4.2

Average Scores in Grades K-2 in Number Concepts and Operations by Grade Level

Grade Level	Number Concepts and Operations
Kindergarten	24%
First Grade	24%
Second Grade	45%

Note. $n = 12$. Average score considered 50%.

Table 4.3 depicts the score earned on the MKT assessment in Number Concepts and Operations. In dissecting scores even further, of the four second grade teachers assessed, 75% scored "average" on the Number Concepts and Operations portion of the assessment. No teacher in kindergarten or first grade was able to score in the average range (50%). Scores spanned from 7% to 57%, giving a range of 50 points.

Table 4.3

Score in Grades K-2 by Teacher in Number Concepts and Operations

Grade	Teacher	Number Concepts and Operations
K	Teacher 1	46%
K	Teacher 2	11%
K	Teacher 3	32%
K	Teacher 4	7%
1	Teacher 5	25%
1	Teacher 6	18%
1	Teacher 7	25%
1	Teacher 8	29%
2	Teacher 9	50%
2	Teacher 10	22%
2	Teacher 11	57%
2	Teacher 12	50%

Note. n = 12. Average score considered 50%.

Discussion. According to the MKT data in Number Concepts and Operations, teachers have great room for growth and improvement in future learning. Knowing this information about the teachers at Buffalo Elementary School was vital because this early childhood foundation in mathematics lays the groundwork for the success of students throughout their mathematics careers (Anders & Rossbach, 2015). Studies have shown that teachers' MKT has a very high correlation with their ability to teach mathematics in order to maximize student understanding (Empson & Junk, 2004; Hill et al., 2005). If teachers struggle in thinking mathematically, they

are less able to teach their students to think mathematically in their daily lives and activities (Lee, 2017).

Guiding Question 2

   MKT of primary mathematics teachers in Patterns, Functions, and Algebra. This guiding question investigated the MKT of teachers in the area of Patterns, Functions, and Algebra. As previously noted, both the SII and MKT instruments were used to answer this question, with most emphasis placed on the data collected from the MKT assessment. Scores were analyzed independently of scores in Number Concepts and Operations first, then compared across areas of assessment. Teachers at Buffalo Elementary School performed lower as a whole in Patterns, Functions, and Algebra. Most teachers consistently scored below the average benchmark (i.e., 50%) on this assessment, showing their lack of MKT in these areas. Table 4.4 depicts the average scores by grade level on this portion of the assessment. The scores are between 13% and 33% below the average benchmark score on this assessment. Teachers in kindergarten and first grade also scored well below second grade teachers in this portion of the assessment.

  Table 4.5 depicts scores further broken down. Of the four second grade teachers assessed, only one teacher scored "average" on the Patterns, Functions, and Algebra portion of the assessment. No teacher in kindergarten or first grade was able to score in the average range on this portion of the assessment. Scores in Patterns, Functions and Algebra ranged from 7% to 54%, with a range of 47 points.

Table 4.4

Average Scores in Grades K-2 in Patterns, Functions, and Algebra by Grade Level

Grade Level	Patterns, Functions, and Algebra
Kindergarten	17%
First Grade	20%
Second Grade	30%

Table 4.5

Score in Grades K-2 by Teacher in Patterns, Functions, and Algebra

Grade	Teacher	Patterns, Functions, and Algebra
K	Teacher 1	36%
K	Teacher 2	7%
K	Teacher 3	18%
K	Teacher 4	7%
1	Teacher 5	21%
1	Teacher 6	11%
1	Teacher 7	14%
1	Teacher 8	32%
2	Teacher 9	54%
2	Teacher 10	14%
2	Teacher 11	43%
2	Teacher 12	36%

Note. n = 12. Average score considered 50%.

Discussion. Unfortunately for the teachers and students at Buffalo Elementary School, the majority of research in student achievement reflects that highly qualified teachers positively impact student achievement (Hanushek & Rivkin, 2012; McCaffrey, Lockwood et al., 2003; Rowan et al., 2002). Additionally, studies have shown that in order to build this high-quality education, teachers need to build their MKT (Ball et al., 2008; Hill et al., 2005). Teachers at Buffalo Elementary School have participated in minimal PD. They are interested in future PD; however, this PD needs to be explicit with the goal of building teacher MKT in order to impact student achievement.

In yet another example highlighting the importance of teacher MKT and student achievement, Thomson, DiFrancesca, Carrier, and Lee (2017) completed a recent study exploring the relationships between teachers' mathematics knowledge and their efficacy and outcome experiences with students. The researchers found through a series of interviews that the teachers' knowledge did not change their teaching efficacy, but it did correlate with their student outcome beliefs. The researchers noted that increasing teachers' knowledge could help teachers implement more successful teaching strategies in mathematics (Henderson Pinter, Merrit, & Berry, 2018; Thomson et al., 2017). The study also noted that primary mathematics teachers are trained as generalists and may not have as strong MKT knowledge base as needed to successfully teach mathematics without further professional development.

A Summary of Findings

In Table 4.6, the raw score and percentages of the 28-item test are displayed. Overall, the data suggested a poor level of MKT among this sample. The mean number of correct items for the Number Concepts and Operations element of the test was 8.67, and for Patterns, Functions

and Algebra, the mean number correct was 6.83. Around 31% of Number Concepts and

Operations and 24% of Patterns, Functions, and Algebra items were answered correctly.

Table 4.6

MKT Scores, Raw Scores, and Percentages

	Minimum	Maximum	*M*	*SD*
Number Concepts and Operations - Number Correct	2.00	16.00	8.67	4.60
Patterns, Functions and Algebra - Number Correct	2.00	15.00	6.83	4.26
Number Concepts and Operations - Percent	7.14	57.14	30.95	16.43
Patterns Functions and Algebra - Percent	7.14	53.57	24.40	15.22

Note. *n* = 12.

Although the large standard deviations for both items (4.60 and 4.26, respectively) does

indicate both high and low achievers across the board, when considering whether teachers'

scores were average (the average score for both elements was 50% items correct), it is clear that

the vast majority of teachers performed at below average levels. Only 1 individual achieved a

score above average for both elements of the test (Table 4.7).

Teachers at Buffalo Elementary School displayed many weaknesses in their MKT as

measured on these instruments. They do not see the need to build their own knowledge and how

it directly correlates to their student achievement, as evidenced by their interview comments. The

teachers are assuming that because they completed coursework in college to prepare them for

instruction, they are fully prepared to teach students and thus students should be performing well

on their assessments. They also assume that because students have performed poorly on their

assessments in the past, this illustrates the student's capabilities.

Table 4.7

MKT Scores, Evaluation of Teachers Scoring in Below Average, Average, and Above Average Categories of Assessment

	Below Average n (%)	Average n (%)	Above Average n (%)
Number Concepts and Operations	9 (75%)	2 (16.7%)	1 (8.3%)
Patterns, Functions and Algebra	11 (91.7%)	0	1 (8.3%)

Note. $n = 12$.

The four teacher interviews allowed the researcher to document several themes. This

group of teachers felt strongly that they did not need further professional development or teacher

notes within the curriculum to extend their MKT. Educators expressed that this was because they

were either experienced teachers or because they lacked the time to explore professional notes to

better their practice. The overarching theme throughout the interviews with all teachers was that

they were not teaching the curriculum with fidelity nor utilizing all the components of the

curriculum including taking the time for professional learning opportunities, which is embedded

throughout the curriculum. Not taking the time for these learning opportunities may have caused

teachers to not understand the curriculum and content as well as they could if they had utilized

the program with more fidelity.

Data on participation in more current professional development opportunities suggest that

teachers are not partaking in professional development experiences to a particularly great extent.

Teachers were asked how many professional development sessions they had specific to the

academic year targeted. The activities considered were: Analyzing or studying the current math

curriculum; Improving teacher knowledge of computational procedures; Improving teacher

knowledge of geometry and measurement; Improving teacher knowledge of number concepts;

and Improving teacher knowledge of patterns, functions and algebra. Table 4.8 provides a

summary of the responses. Across the five dimensions considered, the majority of participants

(at least 75% in each case) indicated that they had never participated in any sessions of these

types. Very small percentages had taken part in one or two sessions, and only one teacher had

participated in three to five sessions of one specific activity (Improving teacher knowledge of

geometry and measurement).

Table 4.8

Participation in a Range of Professional Development Activities This Year

	None	1-2 sessions	3-5 sessions
Analyzing or studying the current math curriculum	9 (75.0)	3 (25.0)	0 (0)
Improving teacher knowledge of computational procedures	11 (91.7)	1 (8.3)	0 (0)
Improving teacher knowledge of geometry and measurement	10 (83.3)	1 (8.3)	1 (8.3)
Improving teacher knowledge of number concepts	9 (75.0)	3 (25.0)	0
Improving teacher knowledge of patterns, functions, and algebra	10 (83.3)	2 (16.7)	0

Note. $n = 12$. Percentages in parentheses.

The qualitative data suggest that time pressures may be one reason why the teachers did

not participate in formal or informal professional development activities. The teachers discussed

how there was little time to prepare for teaching, and this may have implications for engaging in

professional development activities. Another reason for low engagement may be that teachers do not find such activities interesting or valuable. As noted by Ms. Erickson (personal communication, April 28, 2016),

> Sometimes it makes me feel like I am back in college in my methods courses reading that stuff and it is boring, so I don't really spend too much time on the boring ones. But sometimes the stuff is newer and I can learn something new from it. It's hard to tell which it will be though, but I usually don't have time for it.

Spearman's rank tests can be used to indicate if undertaking math courses at university or in the last 5 years are associated with MKT scores. The results (Table 4.9) indicate one significant correlation – there is a medium-strength, positive relationship between the number of math courses taken at university and scores on the Pattern, Function and Algebra dimension of the test. No other relationships were significant.

Table 4.9

Spearman's rho Correlations, Math Courses, and MKT Scores

	Number of Math Courses Taken	PD Math Courses in the Last 5 Years
Number Concepts and Operations	.476	.265
Pattern, Function and Algebra	.501*	.163

Note. $n = 12$. *Correlation is significant at $p < .005$. One-tailed tests.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

Having the prerequisite mathematics skills necessary to lay a strong foundation is imperative as young as primary school with teachers playing a vital role (Brown, 2014; Mathematical Association, 2014). Early grade success in mathematics is crucial to student achievement in future mathematics, as well as, developing problem-solving and critical-thinking skills (Harris & Peterson, 2019). Research suggests students should master early mathematics concepts, have high quality mathematics instruction, and be taught critical-thinking skills in the primary grades (Harris & Peterson, 2019; NCTM, 2013; Shellenbarger, 2012).

The goal of this study was to answer the overarching question: What is the primary (kindergarten through second grade) teachers' knowledge for teaching mathematics in a low-performing elementary school in Oklahoma? The following guiding questions were investigated:

1. What is the MKT of primary mathematics teachers at Buffalo Elementary School in Numbers and Operations?

2. What is the MKT of primary mathematics teachers at Buffalo Elementary School in Patterns, Functions and Algebra?

The two methods of data collection consisted of the Study of Instructional Improvement (SII), a survey used to gain demographic and background information from teachers, as well as follow-up questions conducted with four participants and the Mathematics Knowledge for Teaching (MKT) assessment that measures teachers' MKT for teaching mathematics. Excel was used for data analysis.

Summary of Findings

MKT can be measured on a continuum, as all teachers have some amount of specialized content knowledge (Hill et al., 2005). The following guiding questions allowed the researcher to gain a more comprehensive picture of the MKT of the teachers at Buffalo Elementary School in the areas of Number Concepts and Operations and Patterns, Functions, and Algebra. A brief summary of the data sets is described below. These data include both quantitative and qualitative responses.

Guiding Question 1

This guiding question investigated the MKT of teachers in the area of Numbers and Operations. The two specific areas of mathematics measured were Number Concepts and Operations and Patterns, Functions, and Algebra. Both the SII and MKT instruments were used to answer this question, with emphasis placed on the data collected from the MKT assessment.

MKT assessment in Number Concepts and Operations revealed that primary grade teachers are scoring below average as a whole. It is noted that a score of 50% is considered average. Teachers in kindergarten and first grade scored an average of 24%, and in second grade, 45%. In dissecting scores even further, of the four second grade teachers assessed, 75% scored "average" on the Number Concepts and Operations portion of the assessment. No teacher in kindergarten or first grade scored in the average range.

The results suggested the teachers of Buffalo Elementary have vast room for improvement in Number Concepts and Operations. They also indicate that second grade teachers have overall better MKT in this area than kindergarten and first grade; however, all grade levels would benefit from professional development in the area of mathematics. Having this

information is important to Buffalo Elementary stakeholders because it allows for better design and implementation of professional learning for teachers.

Guiding Question 2

This guiding question investigated the MKT of teachers in the area of Patterns, Functions, and Algebra. As previously noted, both the SII and MKT instruments were used to answer this question, with emphasis placed on the data collected from the MKT assessment. Teachers at Buffalo Elementary School performed lower in Patterns, Functions, and Algebra. Most teachers consistently scored below the average benchmark (50%), showing their lack of MKT in these areas. The scores are between 13% and 33% below the average benchmark score on this assessment. Teachers in kindergarten and first grade also scored well below second grade teachers in this portion of the assessment. Table 4.7 displays a summary of scores by grade level.

Teacher interviews played a significant role in understanding these weaknesses further. The overarching theme of the interviews depicted 100% of the teachers were not teaching the curriculum with fidelity or utilizing all components of the curriculum, including professional learning opportunities embedded within the curriculum. Teachers stated several reasons for omitting teacher notes and professional learning throughout the textbook, including time constraints and not finding the information useful to their teaching practice.

Spearman's rank was used to indicate whether mathematics courses taken in the last 5 years and university mathematics courses were associated with MKT scores. There was a medium-strength, positive relationship between previous mathematics courses and the Patterns, Functions, and Algebra portions of the assessment. There were no other significant relationships found.

Overarching Question

What is the primary (kindergarten through second grade) teachers' knowledge for teaching mathematics in a low-performing elementary school in Oklahoma?

Using both quantitative and qualitative data, teachers' MKT knowledge base in specific areas of mathematics, as well as the importance they placed on mathematics learning for themselves was evident. Teachers had MKT that was below average in the areas of Numbers, Concepts, and Operations, as well as Patterns, Functions, and Change. Teachers also participated in little-to-no professional development in mathematics specific content areas.

Having strong mathematical knowledge is vital for teachers to build strong mathematics foundations among their students (Van de Walle et al., 2013). When teachers have strong MKT, it has more of a positive effect on students' achievement (Carlson et al., 2013). When MKT is not a strength, students do not gain as strong of a foundation in primary mathematics compared to teachers who are strong in this area (Harris & Peterson, 2019). Discovering more about teachers' MKT in primary mathematics at Buffalo Elementary School provided administration insight into educator practice and allowed them to create meaningful learning goals and professional learning opportunities. This in turn will positively affect student achievement. The quality of primary mathematics teachers cannot be compromised (Harris & Peterson, 2019).

Implications

This study had general implications for research and practice in the area of primary mathematics MKT. It aligns with prior research in the field that demonstrates the need for developing teachers' MKT in primary mathematics. This ROS also has specific implications for the district of Vale and Buffalo Elementary School. First, the study highlighted some areas of MKT weakness for 12 of its district teachers, thus targeting specific areas for designing and

implementing future professional learning opportunities. Secondly, it unveiled for the principal

of Buffalo Elementary School the MKT areas teachers struggled with and the barriers educators

perceived that inhibited their participation in professional learning.

Implications for Research

This ROS was built upon two foundational pieces of literature in the field of teacher

content knowledge. The first was the work by Shulman (1986) coining the term PCK and

outlining its importance in the field of education. The second was the work of Hill et al. (2005)

in which the researchers studied teachers' mathematical knowledge for teaching in comparison to

student achievement. The researchers found a significant relationship between student

achievement in first and third grades and teacher MKT.

In recent years, there has been a slow emergence of studies in the United States that have

begun their focus on MKT in primary grades. However, many of these studies utilized pre-

service teachers rather than in-service teachers. This study is one of the few that utilized in-

service primary mathematics teachers within the United States to measure specific areas of

MKT. Understanding the current MKT needs of practicing mathematics teachers is paramount in

providing high-quality mathematics instruction to their students (Hill et al., 2005; NCTM, 2014).

Most notably, this ROS aligned with research projects currently being conducted by

Erickson Institute's Early Math Collaborate (McCray, Chen, & Eisenband-Sorkin, 2019).

Researchers through the Institute have been working to translate mathematics research to the

primary classroom. They have developed a MKT in Early Mathematics assessment to aid in

gathering information about teachers in. In this tool, primary mathematics teachers watch two

teaching videos and answer nine open-ended questions about the videos. Teachers' responses are

then scored and coded by trained researchers on a Likert scale (Early Math Collaborative, 2019).

This ROS demonstrated the need for further primary mathematics MKT research and assessment through projects such as the Erickson Institute's Early Math Collaborative. Findings from this ROS demonstrate the importance of gaining an accurate picture of teachers' MKT in order to help them develop specific knowledge for primary mathematics teaching, thus increasing student achievement. Areas of weakness shown in this study aligned with overall areas of difficulty seen in primary mathematics teachers throughout the United States (McCray et al., 2019).

Implications for Practice

This ROS built upon the case for needing quality professional development for teachers in primary mathematics. The goal of this professional learning should be two-fold according to research on MKT and mathematics PD. This included improving teachers' MKT for teaching and learning to produce higher quality student thinking and mathematical reasoning during lessons (Jacob, Hill, & Corey, 2017; Kutaka et al., 2018; McCray et al., 2019). The researchers noted positive effects on teachers' MKT as measured by the same MKT assessment used in this study after teachers completed several professional development sessions focused on teacher and student learning of mathematics through a commercially available PD program (Jacob et al., 2017).

The small population of teachers who participated in this ROS were not unique in their lack of MKT and its effect on student achievement (Hill et al., 2005; McCray et al., 2019). As noted by Tujudin, Chinnappan, and Saad (2018), quality professional development focusing on the link between MTK and mathematics subject matter was key. The world of professional development may be impacted by this work because it illustrates the specific mathematical professional learning needs teachers have and how these needs impact student achievement. A

focus on building primary mathematics professional development is key in that not many programs exist in this specific area.

Implications for the District of Vale

Based on data collected, there are several implications for the district of Vale. Vale hires teachers who are certified by the state: however, they are not truly ready to teach mathematics to the extent and capacity required for full student understanding. These results imply that the district of Vale should offer more specific mathematics professional development for its teachers. This should also not be limited to primary mathematics teachers. Current research validates that providing quality professional development opportunities to deepen teachers' MKT in mathematics will build their content knowledge, thus having a direct effect on student achievement (Hill et al., 2005; Hourigan & Leavy, 2017).

The results also showed that the district of Vale may need to revisit its curriculum choice. If teachers are not using the curriculum to its fullest potential, the district should consider ways in which they can support teachers in this area. This could include more professional development in curriculum, common planning time for teachers, or more feedback on practices from administration. Research also validates teaching curriculum in fidelity in order to effectively gain the most out of the curriculum (Azano et al., 2011). Teachers not teaching the curriculum with fidelity can have a direct negative impact on student achievement (Harn, Damico, & Stoolmiller, 2017).

Implications for the Teachers of Buffalo Elementary School and Their Students

This specific data set gives a window into the thought process of primary mathematics teachers at Buffalo Elementary School. The specific problems chosen on the MKT assessment allowed stakeholders to see not only how educators teach specific content, but also how that

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understanding of content aids in the instructional and learning process. Primary mathematics teachers at Buffalo Elementary School also need specific professional development in mathematics. They noted in the results of their surveys that they were interested in specific mathematics content and in learning teaching strategies. They also stated time constraints as a main reason for not participating in professional learning opportunities or for further delving into the curriculum.

These results advocate for Buffalo Elementary School to provide time for the teachers to have meaningful professional development. Providing common planning time is one way to accomplish this. Teachers need time to learn and plan in order to effectively grow their practice (Merritt, 2017). Teachers currently have planning days and professional development days set aside throughout the calendar year. These days often consist of managerial tasks rather than true professional development. Taking the time to further develop its teachers in mathematics MKT will have a direct effect on teacher learning, thus an impact on student learning (Merritt, 2017).

Recommendations for Improvement

This study focused teacher knowledge for teaching mathematics in primary grades. The data showed a need for improvement in both areas assessed, as the majority of teachers assessed scored below average on this assessment. Based on the results obtained from this ROS, the following recommendations were made to the principal of Buffalo Elementary School:

1. Quality, ongoing specific professional development should be provided for teachers at Buffalo Elementary School and across the district of Vale (Merrit, 2017). It should take into consideration the amount of time teachers spent teaching mathematics, as well as their certification (Hooper, 2018; Smith, Booker, Hochberg, & Desimone, 2018).

2. Professional development should include teachers being exposed to various teaching strategies and observing other effective mathematics teachers in their classrooms (Alamari, Aldahmash, & Alsharif, 2018). This includes strategies for students with special needs and English as a Second Language.

3. A preassessment like the MKT should be given to all teachers to assess their professional learning needs. Similarly, a post-assessment should also be given to teachers to monitor progress and to continue to assess teachers' needs. Periodic needs assessments of teachers should also be conducted to make sure professional learning is not disconnected from daily practice (Darling-Hammond, Hyler, & Gardner, 2017).

The district of Vale has eight professional development days built into its current 2019-2020 school schedule. The district does not participate in early release or extended hours programs in order to provide teachers with more time for professional learning. A primary reason educators stated for not teaching the mathematics curriculum with fidelity or participating in more professional learning opportunities centered on lack of time. Teachers felt the tasks of the classroom consumed their time with no or little time left to independently pursue professional learning. Creating time within teachers' current school year schedule to have these specific learning opportunities is key to ensuring the needed professional development (Darling-Hammond et al., 2017; Merritt, 2017).

Another key recommendation is using assessment to guide instruction with the teachers at Vale, just as they are expected to do for their students. Giving teachers time to participate in a preassessment to determine their specific needs in order to tailor professional development to meet those needs would be the most effective use of both teachers' and district personnel's time. In assessing teachers, having them participate in a quality mathematics professional development

program and post-assessing teachers, the district of Vale can measure the success of their professional development program and can prescribe more personalized instruction for future opportunities (Merritt, 2017; NCTM, 2014).

Regularly conducting needs assessments are key in determining the current learning needs of teachers and tracking growth (Darling-Hammond et al., 2017). Using this data are a concrete way to determine the current needs of the teachers and to provide professional learning that aligns with these needs. This also allows teachers to express areas they may need more support or training in within mathematics contents and strands (Darling-Hammond et al., 2017).

Suggestions for Future Research

The literature in studying MKT in primary mathematics in the United States is still in its infancy. If laying a strong foundation in primary mathematics is imperative for student success, more time should be spent to determine the most effective ways to do this within each school district (Alamari et al., 2018). Mixed-methods studies are vital in understanding both the MKT teachers possess and the paths they took to define their current understanding. Knowing teachers' thought processes and philosophies are an additional way educator learning can be supported in planning future professional development (Darling-Hammond et al., 2017).

This study is only the first step in evaluating primary mathematics teachers' MKT across the district of Vale. If the district wants to see a change in its student achievement, teachers must be at the center of this change. This study can be replicated at a larger scale throughout the district of Vale in order to understand the overall MKT and needs of its teachers in primary mathematics. There is currently a disconnect between the type of professional development that is offered at the school and district levels and the specific professional development the teachers of Vale and Buffalo Elementary School need.

The second area of future research is expanding the assessment to all areas of primary mathematics, not just the two areas assessed in this study. In expanding the areas assessed, the researcher can gain an even broader picture of the needs of the mathematics teachers at Buffalo Elementary School. This will allow the district to plan more long-term professional development as well as determine where areas of mathematics learning overlaps and can be consolidated for professional planning purposes.

A third area of future research includes exploring the diverse learning population. The diverse population at Buffalo Elementary School includes four subgroups of students: students in poverty, minority students, students in special education, and multilingual students (Lee, 2019; Spycher & Haynes, 2019). A quantitative study is needed in this area to explore these sub-groups of students and their individual learning needs in order to provide teachers with the tools to effectively teach mathematics content to these learners. The school is currently not tracking data for these specific groups of students in order to ensure they are effectively meeting standards in primary mathematics.

Conclusion

This study was initiated in response to low student achievement at a low-performing elementary school, Buffalo Elementary School. The research showed deficits in MKT among primary teachers at Buffalo Elementary School. Positively, the study showed a willingness of the teachers at Buffalo Elementary School to learn and grow professionally in mathematics in order to provide the best education possible for their students.

Study findings are intended to show the district of Vale and Buffalo Elementary School areas in which they can better support their primary mathematics teachers in order to enhance student achievement. This study is only a small portion of the specific content knowledge needs

of the primary mathematics teachers at Buffalo Elementary School; however, it is a vital piece in helping teachers grow their practice and in effect, increase student achievement. There is still an ample amount of planning and development needed in order to begin the process of increasing student achievement. However, laying a strong mathematical cornerstone for its primary mathematics teachers is a strong first step in building a durable learning foundation (Hill et al., 2005).

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APPENDIX A

IRB APPROVAL

Dear Melissa,

The IRB has determined that your proposed ROS plans do not require IRB approval. Once the fall internship begins, you will be able to begin collecting information to frame your problems as soon as we complete preparations to "frame" your ROS problems. I would suggest that you re-read the documents associated with the Cohort III Interim Report and begin reading your text for the internship:

Cuban, L. (2001). How can I fix it? Finding solutions and managing dilemmas: An educator's road map. New York: Teachers College, Columbia University.

With my best regards,

Dr. Carol Stuessy, Director
Online Ed.D. in Curriculum and Instruction
Department of Teaching, Learning & Culture

RECOMMENDATIONS REPORT FOR BUFFALO ELEMENTARY SCHOOL

Subject: Recommendations Report Findings

The following is a brief summary of the data collected from studying primary mathematics teacher's mathematical knowledge for teaching at Buffalo Elementary School. Our main findings support the need for professional development in mathematics for this group of primary mathematics teachers. The coded data set, as well as a complete data analysis is available upon request.

The two specific areas of mathematics measured are Number Concepts and Operations and Patterns, Functions, and Algebra. Both the SII survey and MKT assessment were used to answer this question, with most emphasis placed on the data collected from the MKT assessment. Both quantitative and qualitive data were compiled in answering this question.

The main strength of the teachers at Buffalo Elementary School was that teachers are participating in general professional development, although it is not always mathematics specific. Of the teachers surveyed, 100% stated they were willing to participate in future professional development in mathematics. Teachers listed the precise areas to receive this professional development as specific mathematics content by strand (58% of teachers) and general mathematics teaching strategies (33% of teachers), with the remaining teachers being open to any form of professional development.

The primary and most critical area of weakness of the teachers at Buffalo Elementary School was their overall MKT in the areas measured by the MKT assessment. Teachers score higher as a group in Number Concepts and Operations; however, the mean scores in this area (75% of teachers in grades K-2) scored below average (or below 50%) on this portion of the assessment. In the Patterns, Functions, and Algebra portion of the assessment, 91.7% of

teachers scored below average. Only one teacher scored "above average" in both areas of the assessment.

	Below Average *n* (%)	Average *n* (%)	Above Average *n* (%)
Number Concepts and Operations	9 (75%)	2 (16.7%)	1 (8.3%)
Patterns, Functions, and Algebra	11 (91.7%)	0	1 (8.3%)

Teacher interviews played a significant role in understanding these weaknesses further. The overarching theme of the interviews (100% of teachers interviewed) depicted teachers not teaching the curriculum with fidelity or utilizing all components of the curriculum, including professional learning opportunities embedded within the curriculum. Teachers stated several reasons for omitting teacher notes and professional learning throughout the textbook, including time constraints and not finding the information useful to their teaching practice.

The teachers of Buffalo Elementary School had a diverse background and experience range; however, one thing they all had in common was an Elementary Education or Early Childhood major. This was significant because it denoted that all teachers were trained as generalists, not specific subject matter experts in any particular area. Only one teacher took 5 or more mathematics courses in college, with the majority taking only 1-2 courses.

There was a positive correlation (.96) between years taught and score on MKT assessment that showed teachers were gaining experience and improving their practice as time went on, even though they were not participating in much professional development. Similarly, teachers were also not participating in less formal methods of professional learning, such as watching other teachers' model instruction, being observed, and being offered feedback on their practice. Time constraints were found as one of the main elements hindering formal professional learning.

Spearman's rank was used to indicate whether mathematics courses taken in the last 5 years and university mathematics courses were associated with MKT scores. There was a medium-strength, positive relationship between previous mathematics courses and the Patterns, Functions, and Algebra portions of the assessment. There were no other significant relationships found.

Future recommendations include:

1. Quality, ongoing, specific professional development should be provided for teachers at Buffalo Elementary School and across the district of Vale (Merrit, 2017). It should take into consideration the amount of time teachers have spent teaching mathematics, as well as their certification (Hooper, 2018; Smith, Booker, Hochberg, & Desimone, 2018).

2. Professional development should also include teachers being exposed to various teaching strategies and observing other effective mathematics teachers in their classrooms (Alamari, Aldahmash, & Alsharif, 2018). This includes teaching for students with special needs and English as a Second Language.

3. A preassessment like the MKT should be given to all teachers to assess their professional learning needs. Similarly, a post-assessment should also be given to teachers to monitor progress and to continue to assess teachers' needs. Periodic needs assessments of teachers should also be conducted to make sure professional learning is not disconnected from daily practice (Darling-Hammond, Hyler, & Gardner, 2017).

This study is only a small portion of the specific content knowledge needs of the primary mathematics teachers at Buffalo Elementary School; however, it is a vital piece in helping

teachers grow their practice and in effect, increase student achievement. There is still an ample amount of planning and development needed in order to begin the process of increasing student achievement. However, building a strong foundation in its primary mathematics teachers is a strong first step (Hill et al., 2005).

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