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PERCIEVED FACTORS OF EFFECTIVE TIER ONE MATHEMATICS INSTRUCTION AT THE ELEMENTARY LEVEL

by

Corinna Ho-Yan Lee Hathuc

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ABSTRACT

The purpose of this phenomenological study was to take a deep look at Tier One instruction mathematics at four elementary schools in a suburban district located in southern California. All four elementary schools showed improvement on the California state test in mathematics from 2017 to 2018. Two of the elementary schools made over a 10% gain. The goal was to understand the work of the administrator and the teachers at these two schools in instructional strategies, the use of the district provided curriculum, teacher belief and comfort in teaching mathematics, and the teachers' work in Professional Learning Communities. The two schools with the 10% increase were compared to two schools in the same district with similar demographics but showed less than 1% increase on the California state test. Both qualitative and quantitative data were collected in the form of teacher surveys, administrator interviews, and statewide assessment data.

Since all four schools showed an increase, the researcher found similarities in the responses from the participants. The responses from the teachers revealed that the number of hours spent beyond the contractual hours had a positive association to job satisfaction. The use of the district adopted mathematics curriculum did not have statistical impact on student achievement. All teachers used a variety of instructional strategies during mathematics instruction and there was not a specific strategy that led to student achievement. The administrators at all four schools attributed the increase in student achievement to the positive work environment and culture at their sites; they felt the teachers were all willing to do what was best for students. The researcher then compared responses from the two schools that demonstrated a 10% gain to the schools that demonstrated less than 1% gain.

The results revealed that the teachers at the two sites with the 10% increase reported feeling more prepared to teach elementary mathematics than the teachers at the other two schools in the study. Specifically, the teachers reported having more confidence to provide challenging tasks for the highest achieving students, adapting their teaching to engage students' interest, and helping their students appreciate the value of mathematics. The teachers at the school sites that demonstrated a 10% increase discussed instructional strategies with their colleagues in Professional Learning Communities more than the teachers at the other two schools. The administrators at the two schools that demonstrated a 10% increase built teacher efficacy through specialized grade level professional development focusing on mathematics. The professional development was specific to the needs of the school site and allowed the teacher teams to collaborate and make decisions and changes to positively impact student learning in mathematics.

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This journey would not have been possible without the love and support from my family. Mom and Dad – you are my heroes. Thank you from the bottom of my heart for all you have done for me and being my number one cheerleader in life. To my husband – I could not have done this without you! Thank you for taking the lead while I embarked on career changes and this doctoral journey. To my son – you were born eight months before this journey was completed and have changed my life forever… anything is possible with grit and grace.

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CHAPTER 1: INTRODUCTION

Education for children in the United States has been a topic of interest and concern amongst politicians and educators for decades. High stakes testing and initiatives such as the No Child Left Behind Act (NCLB) of 2001, an accountability system that stemmed from the Elementary and Secondary Act of 1965 (*Elementary & Secondary Education Act (ESEA)/No Child Left Behind (NCLB)*, and Race to the Top (*Race to the Top Fund*, 2016) were implemented with hopes to close achievement gaps for disadvantaged and advantaged students within the education system and to raise America's education.

Statement of the Problem

Mathematics literacy is a serious problem in the United States (NMAP, 2008; Phillips, 2007). According to Phillips (2007) 75% of adults cannot explain how to calculate simple interest paid on a loan, 71% of adults cannot compute miles per gallon on a trip, and 58% of adults cannot calculate a 10% tip on a lunch bill. There is a broad range of students and adults who have difficulties with mathematics at the elementary level, especially with the concept of fractions. Fractions is a foundational skill for ratio and proportional reasoning which has been linked to a student's success in Algebra II (NMAP, 2008). The probability a student will enroll in a four-year college correlates substantially with the completion of Algebra II (Adelman, 2006).

The United States has remained middle of the pack and has underperformed in mathematics relative to international peers (Ginsburg et al., 2005). "At the same time, the United States ranked relatively high in inequity, with the third largest gap in math and science scores between students from various socioeconomic groups" (Jerald, 2008, p. 5). Despite reform efforts from NCLB and the Every Child Succeeds Act (ESSA), the reauthorization of the

NCLB act, which aimed to address these longstanding issues, relatively little has changed either in assessment results or in mathematics' classroom nationwide since 2000. Although the National Council of Teachers of Mathematics (NCTM) first introduced its Curriculum and Evaluation Standards for School Mathematics in 1989, curriculum development and teaching practices have not changed much over the past 25 years (Dossey et al., 2016).

Standardized Assessments and Comparisons

International assessments have provided the United States a broader context within which to understand student learning and teaching practices, adding to the knowledge base on how to improve curriculum and instruction (Ginsburg et al., 2005). One of the biggest cross-national tests is the Program for International Student Assessment (PISA). PISA emphasizes functional skills that students acquired at age 15 as they near the end of their mandatory education. PISA is used to compare education systems worldwide and focuses specifically on how "well students can extrapolate from what they have learned and can apply that knowledge to unfamiliar settings, both in and outside of school. This approach reflects the fact that modern economies reward individuals not for what they know, but for what they can do with what they know" (Schleicher et al., 2016, p.3).

The most recent 2015 results placed America at 38th out of 71 countries in math. Another international assessment that measures students at a younger age is the Trends in International Mathematics and Science Study (TIMSS). The most recent 2015 results showed 10 countries with statistically higher fourth grade math scores than America. In eighth grade, 37 countries had statistically higher average math scores than America out of 48 total countries tested. The 2015 results for American eighth graders were the highest it since the test was implemented in 1995 ("Trends in International Mathematics and Science Study (TIMSS) - Overview," 2018).

America has conducted nation-wide assessments to measure how students are doing across state lines. The National Assessment of Educational Progress (NAEP) assesses fourth and eighth grade students in math, English, science, and history. In 2015, average math scores fell for the first time since 1990, with the scaled score of "240 (on a scale of 0 to 500), the same level as in 2009 and down from 242 in 2013. The average eighth-grade score was 282 in 2015, compared with 285 in 2013; the 2015 score was the lowest since 2007" (DeSilver, 2017, para. 5).

Teacher Preparation to Teach Mathematics

With the adoption of Common Core State Standards in 2010, teachers in California needed to refocus their instruction in the classroom. The Math Common Core State Standards require students to have conceptual understanding and problem-solving abilities that prepares them for college and career fields (Common Core State Standards for Mathematics, 2017). Schools that prepare teachers to teach typically require prospective individuals to earn a degree and take regular arts and science classes such as English literature, science, social studies, math, fine arts, and physical education, as well as "methods" classes that teaches candidates how to present material and anticipate common errors students make (Ball et al., 2001; Ostashevsky, 2016). Programs must be more attentive and have a way to develop teacher expertise in mathematics (Ball et al., 2001; Hill et al., 2005). Deborah Ball, Dean of University of Michigan's education school, believes teaching programs need a course that is geared specifically to guiding teachers through problem solving from various angles and making connections between number operations (Hill et al., 2005; Ostashevsky, 2016). Teacher education requirements in the United States have not changed much; a bachelor's degree and a teaching certificate along with completion of specific subject-matter tests and general knowledge of teaching and education (Dossey et al., 2016).

The Teacher Education Study in Mathematics examined how math teachers in both elementary and middle school levels are trained in the United States and internationally. The study revealed that the training of elementary teachers was in the middle of the international distribution, along with Russia, Germany, and Norway, but trails behind other developed countries such as Switzerland, Taiwan, and Singapore (Tatto et al., 2008). Teachers in the United States are getting weak training mathematically and are not prepared to teach the curriculum needed for students to compete internationally (Ostashevsky, 2016). TEDS-M found that top achieving countries on average allocated half of teacher preparation related course-taking to the study of formal mathematics (Hill et al., 2005; Tatto et al., 2008). Courses include mathematics teaching that focuses on how students learn mathematics and general pedagogy such as instructional design. American institutions on average spend 10% less than higher ranked countries on mathematics (Ball et al., 2001; Tatto et al., 2008).

Two fundamental math courses, linear algebra and a basic year-long sequence in calculus, form the gateway to the study of formal mathematics. Top-performing countries had on average 90% or more of their future teachers taking both courses. By contrast in the United States, 66% of future middle school mathematics teachers studied linear algebra, with less than 55% taking the basic year-long sequence in calculus (Tatto et al., 2008). Dr. William Schmidt, a professor of Education and Statistics who directed the TEDS-M study, cautioned

> Weak K-12 mathematics curriculum in U.S., taught by teachers with an inadequate mathematics background, produces high school graduates who are at a disadvantage. When some of these students become future teachers and are not given a strong background in mathematics during teacher preparation, the cycle continues ("U.S. Teachers Not Well Prepared to Teach Mathematics, Study Finds," 2010, para. 18).

Some teacher credential programs across the United States have incorporated training teachers in science, technology, engineering, and mathematics (STEM) subjects (Dossey et al., 2016). The University of Texas at Austin developed the UTeach Program in 1997 with the goal to increase the number of qualified STEM teachers in U.S. secondary schools. The program has been replicated at 38 universities and four-year colleges nationwide since 2016 (Dossey et al., 2016).

Purpose of the Study

The unified school district in this study implements a multi-tiered system of supports (MTSS) which refers to structures and procedures that help every student be successful in the classroom. Schools across California and the country are comprised of complex social environments that challenge providing effective instruction for students from diverse backgrounds (Chidsey-Brown & Bickford, 2016; Eagle et al., 2015). California Education Code Section 48204 requires schools to provide instruction for all age-appropriate students who qualify for attendance making the classroom rich in diversity with different backgrounds and needs. Incorporating MTSS allows teachers to intervene and meet the needs of the students in the classroom (Chidsey-Brown & Bickford, 2016; Carta & Young, 2019; Morrison et al., 2014).

Tier 1 refers to the education and teaching that includes all general education curricula and procedures (Chidsey-Brown & Bickford, 2016; California Department of Education, 2019; Fletcher & Vaughn, 2009). All students receive Tier 1 education and support throughout every day of their education. Tier 1 is a form of primary prevention because it is provided universally for all students where materials for core instruction are available to teachers and students. For the elementary classroom, students receive Tier 1 instruction in English Language Arts, mathematics, history, and science. Tier 1 materials and procedures are the first and best opportunity to help all students access learning (Archer & Hughes, 2011; Bender & Crane, 2010; Carta & Young, 2019). When implemented correctly, approximately 80% of students should be successful within the Tier 1 core programs (Archer & Hughes, 2011; Chidsey-Brown & Bickford, 2016; Fletcher & Vaughn, 2009). Students needing additional support to be successful will continue through the tiers in the MTSS structure. Tier 1 is a form of prevention because it optimizes the likelihood that students will be successful in school.

Tier 1 mathematics instruction is the core instruction that all students receive in the general education classroom every day (IRIS Center, 2019). Tier 1 instruction typically involves "high-quality whole-group instruction and classroom assessments, coupled with some small-group instruction, differentiated instruction, and limited individual assistance in mathematics as needed" (Bender & Crane, 2010, pg. 25). Tier 1 mathematics instruction includes standards-based curriculum that follow the state adopted math standards. Ultimately, Tier 1 instruction is the first mathematics intervention students receive.

The purpose of this phenomenological study is to discover what factors attributed to effective Tier 1 instructional strategies at the elementary level that contribute to students' understanding of mathematics.

Research Questions

1. How does a teacher's math background, job satisfaction, use of district adopted curriculum, and instructional practices impact student achievement?
2. What is the relationship between time spent in Professional Learning Communities (PLCs) and student achievement in mathematics?

Theoretical Framework

Malcom Knowles' Andragogical theory, also known as Adult Learning Theory, serves as an important framework for this study. Knowles looks at the unique characteristics of adults in a constructivist approach to learning (Cox, 2015). Knowles contrasts the differences in adult learning and the learning styles of children. Most theories of adult learning examine how teachers vary teaching and learning strategies to reach students based on pedagogy - how children learn (Knowles, 1973). Knowles recognized that adults must have a different level of engagement than what is required when teaching children, and andragogy refers to the specialized design of instruction delivery meant for adults (*The principles of adult learning theory*, 2017). There are three assumptions that are relevant to the discussion of adult learners and the shift of mathematical instruction. The assumptions are:

The role of experience. Mezirow (2000) emphasizes the role of experience in learning impacts the learning needs of the individual adult. As individuals move into adulthood, they accumulate experiences that become their resource for learning; the traditional teaching setting and style is not the best form of learning for adults. The use of lectures, audio-visual presentations, and assigned reading "tend to fade in favor of discussion, laboratory, simulation, field experience, team project, and other action-learning techniques" (Knowles, 1973, p. 46). The unique experiences begin to define the person and becomes part of their identity. Cox (2015) describes how adult learners draw upon their vast pool of experience to apply meaning and create new knowledge. The implications are promising for teachers who learned mathematics differently than the current standards and expectations for students with Common Core.

Readiness to learn. The pedagogical approach to building learning sequences for children relies on physical and mental development. When a child develops one skill, the developmental task produces a readiness to learn (Knowles, 1973). Adult learners also have these stages of readiness that are aligned more with where an adult is in life. Adult learners are ready to learn the things they "need" to fulfill social obligations and roles such as workers, spouses, parents, leaders, and so forth. As individuals become productive members of society, they begin to learn their new roles and responsibilities that society mandates. Readiness to learn is a matter of "adults having more psychic energy around goals that are present-focused to satisfy current needs than goals that are future-focused" (Houde, 2006, p.94). It is important to engage the adult learner to learn and have the content be relevant in their present life. Adult learners are more apt to value learning when it will assist them "to cope effectively with real life situations and problems," thereby affecting their readiness to learn (Ozuah, 2005, p. 84). Teachers, Cox (2015) argues, are more likely to want to learn and be ready to learn when the demands of the profession require them to learn something new or in order to evolve as teachers.

Orientation to learning. Children's perspective toward learning is one of postponed application; what they learn in school is for their adult life and the future whereas adults seek information with a problem-centered mentality (Bastable & Dart, 2017). Adults want to take what is taught and apply it immediately to their life. The perspective is one of immediacy and is different from that of a child. When teaching adults, the approach and environment cannot be structured like traditional schooling; adult learners have high expectations. They want to be "taught about things that will be useful to their work and expect to have immediate results" (Pappas, 2013, para. 8). Adult learners respond to the demands being placed on him or her. Teachers are increasingly being asked to differentiate and use a variety of Tier 1 instructional strategies to teach mathematics to students. With these demands, an increase may occur in teachers' desire to know how to successfully deliver math concepts to students.

Adult Learning Theory and Differentiation for Students

Inherent with the assumptions in Knowles' Adult Learning Theory, there are implications for practice. Knowles suggests that adult educators should develop learning objectives based on the learner's needs, interests, and skill levels and look for the individual's specific needs and interests (Knowles, 1984). This idea can be viewed as differentiation within the classroom for student learning.

Evidence suggests that heterogeneous classrooms with focused attention to students' varying needs in the context of high-quality curriculum and instruction, can benefit a very broad spectrum of learners in areas such as achievement, attendance, discipline, satisfaction with school and college application and attendance rate (Tomlinson, 2015). With Common Core and 21st century learning, all students should consistently experience curriculum and instruction that requires complex content, reasoning, metacognition, creative thinking, and the skills of learning, flexibility, and collaboration (Small, 2012). Students who regularly experience a pedagogy of poverty are not only disproportionately poor during their school years but are also being schooled for a future of poverty; therefore, teachers must meet the needs of all the learners in their classrooms (Akkus, 2016; Tomlinson, 2015). It is important for teachers to respond to students and intervene in meaningful ways when they see students not learning. Differentiation allows multiple opportunities and alternatives for developing learning strategies based on the surface and deep levels of learning which lead students to build conceptual understanding. Teachers should respond to students' needs and create different levels of expectations for task completion within the unit or lesson (Lawrence-Brown, 2004).

Differentiating instruction is not a new idea but is relatively a new practice in mathematics (Bender, 2013; Small, 2012). In other subject areas, teachers allow students to work on alternative projects, but it is less likely that teachers vary the material they ask students to work with in mathematics. Math teachers will more frequently teach all students based on a curriculum goal presented in a textbook (Small, 2012). Differentiated instruction is helpful to any teacher, is critical for teachers in inclusive classrooms, and has great importance for students who struggle in the mastery of grade-level curriculum (Lawrence-Brown, 2004). Differentiation should not result in a "watered down" curriculum for struggling students (Bender & Crane, 2010). Educational systems and parents increasingly expect teachers to be aware of what each individual student – whether a struggling, an average, or gifted student – needs and to plan instruction to take those needs into account. There is general agreement that the following three elements are needed to differentiate math instruction: big ideas, prior assessment, and choice (Gregory & Chapman, 2007; Small, 2012).

The focus of instruction must be on the big ideas and themes being taught in mathematics to ensure that they are addressed at every level. Big ideas form a framework for thinking about important mathematics and supporting standards-driven instruction. Teachers need to know how students in the classroom vary in their mathematical development level (Bender, 2013; DuFour, DuFour, Eaker, Many, & Mattos, 2016). This requires collecting data formally and informally to drive how instruction is differentiated and assessed for progress. By knowing where students are, teachers are able to understand what students need in the way of learning and can present situations that challenge each individual while still encouraging all students to take risks and responsibility for learning (Bender, 2013; Karp & Howell, 2004).

A teacher can differentiate instruction in many ways. Instruction can be differentiated based on a student's readiness, learning style, or interest by varying the content, process, or product (Lawrence-Brown, 2004; Tomlinson, 2015). Some teachers who are less comfortable differentiating instruction with the main lesson may be willing to provide some choice in follow-up activities for students to practice concepts. Some of the strategies that have been suggested include the use of menus from which students choose from an array of tasks, tiered lessons in which teachers teach to the whole group and vary the follow-up for different students, learning stations where different students attempt different tasks, or other approaches that allow for student choice towards the same overall lesson goal (Bender, 2013; Small, 2012; Tomlinson, 2015). The core construct of differentiated instruction is to increase the array of different instruction options presented to students as educators respond to the wide diversity of learning needs within the classroom.

Significance of the Study

America's ability to compete in a global market depends heavily on education (National Academy of Engineering, 2012). Science and math education are vital for success, yet the United States public education system is not adequately developing the readiness needed to sustain the nation's economy or solve the scientific and mathematical challenges of the future (Espinosa et al., 2019). Teaching students math concepts using traditional and whole group procedures may not be enough for their success (National Research Council, 2001).

The research and results of this study can be used by district administrators, elementary school administrators, teacher mentors, coaches and instructional staff to improve math professional development and Tier 1 strategies in the classroom for classroom teachers. Site administrators work to develop their school site plans, which includes professional development and allocating money towards instruction; incorporating specific strategies that best meet the needs of the school site and improve student achievement in mathematics can be obtained from this study.

Additionally, teacher education programs can use the results to bolster their math methods courses for the development of preservice elementary math teachers. This research adds to the base that is currently available regarding mathematics instruction at the elementary level.

Definition of Terms

The following are definitions of terms that are used throughout this study. More thorough explanations follow in the preceding chapters.

Assessment. A process of collecting and deliberating about one or multiple sources of information with the intention of creating an understanding of what students comprehend and how they apply knowledge (Stiggins & Chappuis, 2012).

California Assessment of Student Performance and Progress (CAASPP). The California Assessment of Student Performance and Progress (CAASPP) was established on January 1, 2014 and replaced the former state-wide standardized testing program known as the Standardized Testing and Reporting (STAR) program (*CAASPP Description*, 2018).

Smarter Balanced Computer Adaptive Test. Computer adaptive assessment that includes a range of item types such as selected response, constructed response, table, fill-in, graphing, and so forth.

Smarter Balanced Performance Task. Extended activities that measure a student's ability to integrate knowledge and skills across multiple standards; is a key component of college and career readiness.

Common Core State Standards. The Common Core State Standards are a California collection of standards meant to build student capacity for college and career readiness from Kindergarten to 12th grade. According to the Common Core State Standards Initiative (2010), the standards focus on results rather than means, which allow teachers the freedom to available resources and curriculum to achieve the intended results.

Curriculum. Lessons and academic content taught in a specific course that is followed by the instructor of the course.

Differentiation. Educational strategy where students of different abilities, learning needs, and levels of academic achievement are grouped and/or met by teaching strategies, lessons, and activities.

Instructional strategies. Techniques teachers use to help students learn and understand concepts taught in class.

Multi-Tiered System of Support. The practice of providing high-quality instruction and interventions matched to student need, monitoring progress frequently to make decisions about changes in instruction or goals, and applying child response data to important educational decisions (Eagle et al., 2015)

Tier 1. Instruction and interventions delivered by the classroom teacher to impact all students in the classroom.

Tier 2. Additional time and support given to students, in a small group, in addition to Tier 1 instruction.

Tier 3. More intensive support given to students who are not demonstrating success in Tier 2. The support is more frequent and in smaller groups than in Tier 2 but is still in addition to Tier 1 instruction.

Professional Development. Activities designed to enhance the professional knowledge, skills, and attitudes of educators to improve the learning of students (Guskey, 2003)

Professional Learning Communities. According to DuFour, DuFour, Eaker, and Karhanek (2010) professional learning communities (PLC) have a shared vision, collaborate on student learning, review student data, and act based on student data. This definition was clarified by DuFour & Fullan (2013); PLCs have a relentless focus on learning for all students, a culture that collaborates to support student and adult learning and focuses on continuous improvement.

Universal Screening. Assessment given to all students to identify those who may benefit from additional instructional support and to get information for determining the optimal allocation of resources available at the school site (Raines et al., 2012).

Limitations

The limitations of this research include potential validity threats that are associated with self-reporting measures on the survey by the participants in this study. A combination of methods was used to minimize these threats that include assuring participants of their anonymity and confidentiality of their responses. The content in the survey may 'cue' the participant to select an answer that theoretically sound appropriate but may not accurately reflect their classroom practices.

This study included elementary school teachers in grades K-6. All participants teach mathematics. The study also included elementary administrators that have been at their school sites for more than two years.

Delimitations

This research focused on four schools that are located in a suburban district in California. All participants are from a select group and the researcher utilized convenience sampling and works in the same district as the participants. The study only focused on Tier 1 instructional strategies in mathematics in a K-6 school setting. The study focused on the relationship between the teacher's job satisfaction and knowledge of mathematics, use of district provided curriculum, professional development and time spent in Professional Learning Communities towards student achievement in mathematics. The author of this study was the primary researcher responsible for all data collection and analysis. The researcher is a district administrator and knew the participants professionally throughout district trainings.

Summary

This research paper is presented in five chapters. Chapter 1 contains a statement of the problem, the purpose of the study, research questions, theoretical framework, significance of the study, definitions, limitations, delimitations, and a summary. Chapter 2 includes a review of the relevant literature, such as academic standards for mathematics, teaching and job satisfaction, professional development, teacher preparation to teach mathematics, effective Tier 1 instruction, and Professional Learning Communities. Chapter 3 is comprised of the description of the setting and participants, sampling procedures, instrumentation and measures, plan for data collection and analysis, plan to address ethical issues, and a summary. Chapter 4 depicts the results of the study, with an introduction, quantitative data analysis, findings of qualitative research, and a summary. Chapter 5 reviews the discussion of results and findings, with an introduction, implications for practice, recommendations for further research, conclusions, and summary.

CHAPTER 2: REVIEW OF LITERATURE

Introduction

This chapter informs the reader with the rationale of further study regarding effective Tier 1 mathematics instruction at the elementary level. The researcher reviews the evolving education standards throughout the United States and concepts in mathematics that are challenging for students at the elementary level. To help improve student achievement in mathematics, evidence based instructional practices and teacher preparation to teach mathematics standards is discussed in this chapter along with professional development and Professional Learning Communities.

Academic Standards for K-12 Mathematics

Marzano, a preeminent K-12 educational researcher, believed the primary lesson to be learned from U.S. students' lackluster performance on the Trends in International Mathematics and Science Study (TIMSS) testing was to embrace the downsizing of curriculum that standards-based education would produce (Schmoker & Marzano, 1999). However, the history of the standards-based movement in education provides evidence that what Marzano believed 20 years ago regarding curriculum never materialized, and, in fact, furthered the mile-wide, inch-deep curricular in U.S. mathematics educations. In 2001, Marzano reported that the 2000 National Council of Teachers of Mathematics (NCTM) Principles and Standards for the Teaching of Mathematics had yet to be efficiently and systematically implemented. Marzano's nationwide analysis of state standards documents found that most math standards have become so lengthy that nearly two thirds of the standards would need to be eliminated to be adequately implemented within the instructional time available during an academic school year. Lengthy standards proved counterproductive.

In contrast to the inefficient U.S. standards, the success of international peers' is often attributed to a tighter and more condensed set of academic standards for mathematics. Ginsburg, Cooke, Leinwand, Noell, and Pollock (2005) examined the TIMSS and PISA results and found the highest scoring countries covered less mathematical content per grade-level when compared to other countries that took the TIMSS and PISA. This allows teachers and students increased time for teaching and learning the concepts being taught. The Common Core Standards development team applied this knowledge to internationally benchmark the new learning standards for United States schools. However, the development of new standards was not limited to aligning content to international peers, as vertical and horizontal coherence and best practices for teaching mathematics led to standards for both mathematical content and practices (Student Achievement Partners, 2019).

Creation and Implementation of Common Core State Standards

The Reagan administration released a report about The United States' public education system in 1983. The report included a long list of recommendations to improve public schools, including the adoption of rigorous standards. By the end of the 1990s, all states had adopted standards for student learning, assessments aligned to the standards, and accountability systems that measured school performance based on student attainment of the standards (Rothman, 2012). Every state established its requirements for student proficiency per grade level until graduation. A 2010 study by the American Institutes of Research documented a huge gap in expectations, with some states expecting their students to accomplish far more in school than other states with much lower standards (Conley, 2014). The expectations for student learning varied from state to state, but inequities fall within the state and districts as well.

The curricular inequity for learning mathematics for students who live in the same district, attend similar schools, and are enrolled in the similar grade can have very different experiences in the classroom (Akkus, 2016). The lack of coherence and uniformity across the nation lead to the development of the Common Core State Standards (CCSS) in 2009. The Common Core State Standards provides a common mathematics curriculum for all states that have chosen to adopt the standards. The population across states and regions are increasingly more mobile that having common grade-level expectations is helpful for teachers, parents and students (Dossey et al., 2016). These standards were developed with the guarantee that all students graduate from school with the necessary skills and knowledge to achieve in school, profession, and adulthood regardless of which city or state they reside in (Akkus, 2016; Karge & Moore, 2015). The role of the new common standards is to ensure that all students can be successful in an economy and society that is changing and that will continue to do so throughout their lifetimes (Conley, 2014).

The Common Core State Standards were developed by the National Governors Association Center for Best Practices and the Council of Chief State School Officers in collaboration with teachers, school administrators, and curriculum experts to provide a clear and consistent framework to prepare students for higher education and the workforce (Bender, 2013). States recognized the value of "consistent, real-world learning goals and launched this effort to ensure all students, regardless of where they live, are graduating high school prepared for college, career, and life" (*Development Process*, 2018). The process took three years before states and territories were reviewing and adopting the standards. The initiative was supported by education associations and councils, i.e. The National Education Association (NEA), American Federation of Teachers (AFT), National Council of Teachers of Mathematics (NCTM) and

National Council of Teachers of English (NCTE), the American Council on Education, and the State Higher Education Executive Officers (SHEEO) (Akkus, 2016).

Development of the Common Core State Standards was driven largely by a response to the new realities of the U.S. economy situated in an increasingly complex global economy (Conley, 2014). Postsecondary data had shown that newly enrolled American college students were inadequately prepared, as indicated by only one fourth of American College Test (ACT) test-takers having reached college readiness levels in English, reading, mathematics, and science (Conley, 2014; Rothman, 2012).

Math Common Core State Standards

Research studies of math education in high-performing countries have concluded that the United States needs more focused and coherent standards to improve mathematics achievement in the country (Common Core State Standards for Mathematics, 2017; Schmidt & Houang, 2012). The Common Core Math Standards were developed to address the problem of a curriculum that is "a mile wide and an inch deep" and gives clarity and specificity at each grade level (*Common Core State Standards for Mathematics*, 2017, para. 3). The math standards are designed to emphasize conceptual understanding of key ideas and address how students learn.

The Common Core Math Standards define what students should understand and can do in their study of mathematics. Key shifts called for by the Common Core State Standards for mathematics include (1) a greater focus on fewer topics, (2) establishing coherence by linking topics and thinking across grades, and (3) pursuing three aspects of rigor in the major work of each grade: conceptual understanding, procedural skills and fluency, and application ("United States – TIMSS 2015 Encyclopedia," 2015).

To date, the Common Core State Standards for mathematics have been endorsed by "every major mathematical society president, including the American Mathematical Society and the American Statistical Association," and both considered the standards to be an "auspicious advance in mathematics education" (Friedberg, 2014, p. 1). Leinwand's (2014) reported that the CCSS could potentially shift teaching and learning in mathematics education in the United States:

> The fact that, for the first time, the U.S. has what is essentially a national curriculum, equivalent in quality to what is found in the highest scoring countries in the world, means the focus of leadership can finally shift from arguing about what math to teach, to how to best teach the agreed upon content to all students. (p.4)

The Common Core State Standards have the capability to improve both the quality and equality of mathematics education (Akkus, 2016). Although the adoption of the CCSS-Mathematics is considered a significant step towards a coherent math education for U.S. students, the NCTM (2014) provided K-12 stakeholders with a reminder that "the new standards provide guidance and direction and help focus and clarify common outcomes, educators and policymakers need to understand that standards do not teach; teachers teach" (p. 1). In other words, the standards must be correctly implemented in order to improve student learning of mathematics.

California and 46 other states have adopted a new set of academic standards for math that require teacher instruction to change and be more in depth (Karge & Moore, 2015; Rothman, 2012; Schmidt & Houang, 2012). Students are expected to demonstrate a deeper understanding of math concepts (Ma, 1999; Parrish, 2014). One of the biggest challenge teachers face is helping students shift from computation to problem solving.

Focus on fewer topics. Instead of covering many topics, the Common Core standards ask math teachers to narrow and deepen students' conceptual understanding and focusing deeply on specific mathematical domains (Akkus, 2016; Conley, 2014). The Common Core State Standards focus on a small number of core mathematical ideas so students can gain strong foundations with conceptual understanding, procedural skill and fluency, and the ability to apply the math they know to solve problems inside and outside the math classroom (Conley, 2014; Schmidt & Houang, 2012). With fewer topics, teachers have more time to focus on specific concepts and can ensure that their students understand the material (Akkus, 2016). Students also have time to process, practice, and integrate new ideas into their learning with focused domains (California Department of Education, 2015).

The major focus for students in kindergarten through second grade is concepts, skills and problem solving related to addition and subtraction. Students in third through fifth grade focus on concepts, skills, and problem solving related to multiplication and division of whole numbers and fractions. Sixth grade students shift to ratios and proportion and early algebraic expressions and equations. Seventh grade students continue their understanding of ratios and proportional relationships and arithmetic of rational numbers. In grade eight, students focus on linear algebra and linear functions ("Key Shifts in Mathematics", 2019).

Coherence. Mathematics is comprised of interconnected concepts and has a sequential order. Therefore, the standards are designed around a coherent progression from grade to grade. Coherent standards provide a sequence of topics and performances that are logical and reflect, where appropriate, the sequential and hierarchical nature of the content (Schmidt & Houang, 2012). This allows the standards to reinforce major topics in each grade and support math concepts that students will learn in the following grade. The standards are designed in progressions that link as a student moves from grade to grade. This makes learning connected across grades so students can build new understandings on a foundation built from previous years (Conley, 2014). The main mission of the Common Core initiative is for teachers to collaborate in classrooms and across grades to determine the way they will teach math so that there is a clear and logical progression as a student moves through school (Akkus, 2016). Each standard can be viewed as an extension of previous learning and not an isolated concept.

The National Mathematics Advisory Panel (2008) recommended that "a focused, coherent progression of mathematics learning, with an emphasis on proficiency with key topics, [be] the norm in elementary and middle school mathematics curricula" (p. xvi). This approach is also supported by international comparisons that have shown that the top-performing countries foster the in-depth and logical development of mathematical knowledge by intentionally sequencing topics for students (Ginsburg et al., 2005).

Rigor. The standards embed perseverance and strategic reasoning, so students need to be able to solve problems using multiple methods (Kruger, 2018). Rigor is not intended for teachers and students to feel that math is harder, but rather gain a deeper understanding of mathematics. As mentioned previously, mastery in the standards require students to have conceptual understanding of key concepts in each grade level (Conley, 2014; Polikoff, 2017). Coupled with understanding, students need to demonstrate procedural skills and fluency and accuracy with calculations. Students are given the opportunities to practice core functions, so they can solve more complex concepts and procedures (*Key Shifts in Mathematics*, 2019). Students should be able to use math flexibly for applications in problem-solving contexts (Conley, 2014). Rigor in this context ensure that students can make meaning of mathematics and are able to apply what they know to real-world problems (*Aligning Content and Practice*, 2019).

Standards for Mathematical Practice

Along with the mathematics standards, The National Governors Association published a set of recommended performance skills as a general description of students' mathematics performance expectations to help guide instruction (Bender, 2013). These performance skills are known as the Standards for Mathematical Practices (SMPs). There are eight SMPs that work interdependently with the standards and describe skills and expertise that students should demonstrate along with the math standards. These standards address "habits of mind" that students should develop to foster mathematical understanding and expertise, as well as concepts, skills, and knowledge (California Department of Education, 2015).

The SMPs focus on the process of problem solving, reasoning and proof, communication, representation, connections, strategic competence, conceptual understanding, procedural fluency, and productive disposition (Common Core State Standards for Mathematics, 2017). The Mathematical Practice Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) are shown in Figure 1 and are grouped into four categories. These four pairs of standards can help teachers continually incorporate the core of the SMPs into classroom practices (California Department of Education, 2015).

The SMPs are considered a critical component for teachers and students to meet the content and assessment expectations of the Common Core State Standards; the practices require teachers to "pursue, with equal intensity, three aspects of rigor: (a) conceptual understanding, (b) procedural skill and fluency, and (c) application" (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). These practices describe the varieties of expertise that mathematics educators at all levels should seek to develop in their students (Common Core State Standards Mathematics, 2013). The SMPs carry across all grade levels and describe the attributes of a mathematically proficient student. As students move from elementary school through high school, mathematical tasks as students require more and more advanced understanding of mathematical principles. Sound teaching and learning allow students to become flexible with how they work and solve problems (*Common Core State Standards Mathematics*, 2013). The SMPs will enable students to be successful in later mathematics courses and to apply math to real-world settings (*Aligning Content and Practice*, 2019).

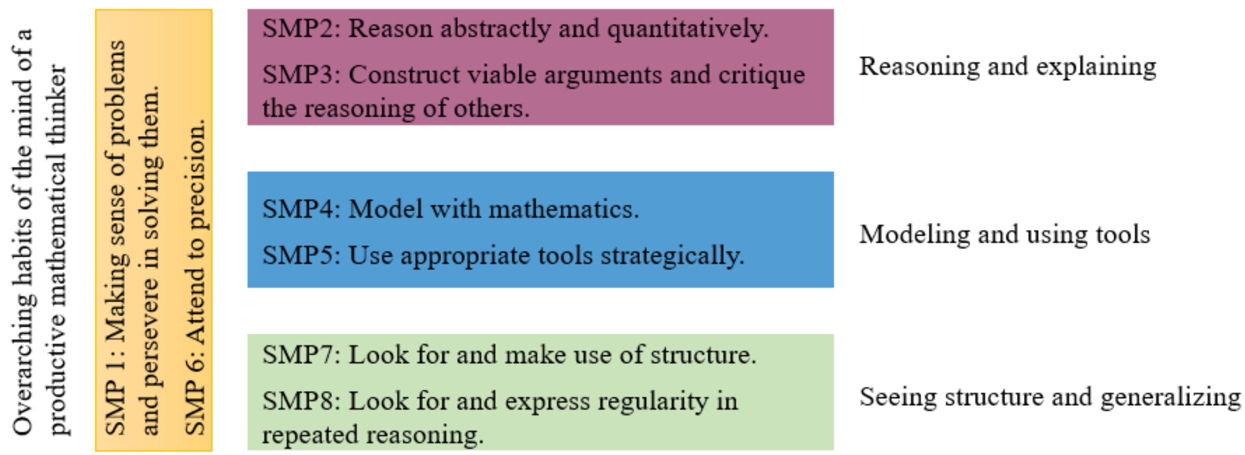


Figure 1. Grouping the Standards of Mathematical Practices (SMPs). This figure shows the eight SMPs grouped into four categories beginning with the rectangle on the far left and then moving from the bottom to the top with the other three rectangles (California Department of Education, 2015).

Mathematical Challenges for Students

Many students have difficulty in mathematics; at the elementary level, it is hard to find evidence conclusively showing specifically which ideas or topics are particularly difficult for students. The National Mathematics Advisory Panel was established to identify areas of concern in mathematical education in the United States and to provide directions to ensure that teacher graduates attain international standards in mathematics (NMAP, 2008). When evaluating the 2008 "National Report Card" – The National Assessment of Educational Progress (NAEP), results revealed seven areas of difficulty for many TK-12 students and are stumbling blocks for students at the elementary level (Graeber, 2005; NMAP, 2008). The seven areas are numeration, rational number ideas, multiplicative thinking, rules and procedures, application of skills to problems, symbols in early mathematics and algebra, and language and logic in geometry.

Numeration

Number is an abstract entity that describes quantity using symbols. Numeration requires the understanding of number concepts and notation in order to name, write, read, interpret, and process numbers to secure knowledge of place value and renaming (Behr & Jungst, 1971; Seah et al., 2005). A child's first encounter with numbers in their school math involves numeration.

Kindergarten math standards have a math domain that is specific to that grade-level only: Counting and Cardinality. These standards make up half of the overall kindergarten math standards and focus on students' understanding of objects to number names. Within the Counting and Cardinality standards, numeration foundations are set and will lend to further mathematical standards with operations: know number names and count sequence, count to tell the number of objects, and compare numbers (Common Core State Standards Mathematics, 2013). However, according to California Education Code Section 48200, the mandatory age for parents to enroll their child in school is six years old, which is first grade for most children (*Law section*, n.d.). Therefore, if a child does not attend kindergarten and did not complete any prior schooling before the mandatory age for school, he/she will miss out on the foundation of numeration.

Number sense can be facilitated by environmental circumstances, both in and out of school. For example, Griffin et al. (1994) found that entering kindergarteners differed in their ability to answer questions such as, "Which number is bigger, 5 or 4?" High SES students answered the question correctly 96% of the time, compared to low SES-children who answered correctly only 18% of the time. Griffin et al. (1994) carefully documented how, on average in well-educated middle-class homes, a good deal of informal instruction about numbers and concepts related to numbers takes place. By contrast, on average, significantly less of this type of instruction occurs in low-income homes. Children who recognize their letters, who are read to at least three times a week, who recognize their basic numbers and shapes, and who demonstrate an understanding of the mathematical concept of relative size as they enter kindergarten are more likely to understand the mathematical concept of ordinality and sequences, successfully solve addition and subtraction problems, and successfully solve multiplication and division problems (Denton et al., 2002).

Research in developmental psychology indicates that infants demonstrate early skills in subitizing, recognizing when the number of objects or sounds changes after being habituated to a first number (Chard et al., 2008; Wynn, 1992). Instruction in mathematics offered to students in pre-K and kindergarten classrooms should be designed to build on these already emerging skills. However, instructional programs are not designed to teach students early number sense and to develop it more formally into early arithmetic skills in the elementary grades (Bryant et al., 2008; Chard et al., 2008).

Another early mathematical topic students encounter within numeration is rote counting. Young students with mathematics problems have difficulty with the conceptual understanding of some counting principles and counting difficulties affect the use of more advanced counting abilities to solve arithmetic combinations (Bryant et al., 2008). Also, mastery of numbers and patterns does not ensure grasp of the base-ten system. The base-ten system utilizes the digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 to assign place value to numerals in our counting and monetary system; each number is 10 times the value to the right of it. The base-ten place value system is fundamental to understanding algorithms with the four basic operations with whole numbers and decimals (Graeber, 2005). However, place value refers to the written form of a number where the value of any digit in the whole number is determined by its position and is an abstract concept for children to understand (Bryant et al., 2008; Seah et al., 2005). Evidence suggests that students do not learn place value concepts sufficiently to understand procedures for multi-digit calculations (Bryant et al., 2008).

Rational Number Ideas

A rational number is a number that can be expressed as a ratio of two integers, a and b, where b is not 0. For example, rational numbers are commonly represented using two different notation systems: fraction and decimal notation. In upper elementary, students in grade 4 and beyond, understanding and working with decimals and fractions is pivotal. However, the concepts learned in the primary years working with whole numbers do not generalize with rational numbers and are more abstract than natural numbers (Kainulainen et al., 2017). Whole numbers have unique order and remain true with their sequence, but between any two fractions or decimals are an infinite number of other numbers. For example, children learn early on the next largest number after 4 is 5. When working with rational numbers, students need to distinguish if 4.5 is greater than 4.51 or 4.505 and cannot rely solely on their whole number understanding.

Also, rational numbers can be represented in infinite ways, for example when working with equivalent fractions, having more digits does not equate to a larger value as is true with whole numbers (Kainulainen et al., 2017; Siegler & Lortie-Forgues, 2017). Historically, fractions have been one of the most difficult mathematical skills to master, for children with and without difficulties (Behr, Wachsmuth, Post, & Lesh, 1984; Hiebert & Wearne, 2011; McLeod &

Armstrong, 1982; Ni, 2001). Common struggles for children are understanding that a fraction represents part-whole relationships and operations with fractions are not intuitive as with whole numbers (NMAP, 2008; Misquitta, 2011). In the early stages of learning fractions, children are taught part-whole relationships with pictorial diagrams, such as slices of pie; however, this becomes difficult for children to conceptualize improper fractions and the understanding that fractions as continuous and infinitely divisible (Misquitta, 2011). Students with learning disabilities tend to overgeneralize whole number strategies to fractions by adding denominators and numerators as separate wholes (Woodward et al., 1999)

Decimal notation is somewhat easier than fraction notation because it shares a base-ten structure like whole numbers. The number is written as a row of digits with each place in the row corresponding to a certain power of ten. However, the meaning of a decimal point is difficult for students to understand (Siegler & Lortie-Forgues, 2017). Similar to fractions, with whole numbers more digits equate to a larger number, but this concept does not generalize with decimals. If two decimals have the same number of digits to the right of the decimal point, addition and subtraction is very similar to addition and subtraction of whole numbers with the decimal point being in the same column. However, when two decimals have unequal numbers of digits to the right of the decimal point, children tend to apply their knowledge of whole numbers and align the numbers from the rightmost digit rather than place value. For example, a common error would be 0.31 + 0.8 = 0.39 (Siegler & Lortie-Forgues, 2017). Hiebert and Wearne (1985) found that 48% of seventh graders correctly answered 0.86 – 0.3, while 84% correctly answered 0.60-0.36. Similarly, another common struggle for students with multiplication and division of decimals is the use of columnar position, as in 1.2*3.4=40.8 (Hiebert & Wearne, 1985).

Many students struggle to relate fractions to decimals, percentages and ratios. Fractions and decimals are less used in everyday language, which limits the connections that can be drawn between the formal mathematical concepts and their use (Kainulainen et al., 2017). The teaching of fractions must include conceptual understanding with visual and hands on experiences that make clear the of which numbers are used for numerator and denominators (Westwood, 2016). When students first learn to count, children often use their hands or physical objects as tools to help the process and build conceptual understanding. However, when learners need to expand their number concept, the safety of the fingers or physical objects often reach an end and other effective strategies become important to learn and use (Kainulainen et al., 2017).

Multiplicative Thinking

Multiplication begins with the need to group together various numbers of objects using repeated addition. However, the process is different from additive thinking (Seah et al., 2005). In upper elementary school grades, students must often give up their additive thinking for multiplicative thinking. Distinguishing between additive and multiplicative comparisons and using proportional reasoning are major conceptual hurdles for many students (Lamon, 1994). Early on, students are taught that multiplication yields larger numbers, however this idea cannot be absolute, especially when working with rational numbers. Multiplicative thinking requires a clear conceptual understanding and full knowledge of mathematical processes and the relationships among them in order to conceptually understand and apply to all numbers (Seah, et al., 2005).

Expectations for mental multiplication and division begin with counting in multiples, progressing from twos, fives, and tens. These counting skills are gradually converted into table-fact knowledge with the expectation that children will know multiplication facts before completing elementary school. As students are working towards mastery for mental multiplication, the math journey builds in the development of multiplying and dividing multi-digit numbers. Through this process, there often is not a smooth transition from the language and reasoning associated with chunking and mental math to the language of the standard algorithm (Thompson, 2004).

Rules and Procedures

Procedural understanding involves knowledge of the steps taken to complete a mathematical task (Lai & Murray, 2015). The number of "rules" or procedures increase dramatically as a student moves through grade and content levels. There are procedures for adding, subtracting, multiplying, and dividing whole numbers, decimals, integers, and fractions. There are procedures for how to rename fractions as decimals and vice versa, and how to rename mixed numerals as improper fractions and vice versa.

Students who do not have the conceptual understanding of these procedures tend to learn math rules by rote (Graeber, 2005; Lai & Murray, 2015). For students whose rote recall is limited, the procedures maybe easily confuse or readily forgotten (Hiebert, 1984). Students abstract or generalize procedures from following the steps in pre-solved examples, but when their knowledge is rote or insufficient, they might overgeneralize or overspecialize the rules and procedures (Yetkin, 2003). Students often memorized poorly understood procedures and therefore not able to apply them to real problems that differed in any significant way from textbook exercises (Lai & Murray, 2015; Schmittau, 2004; Yetkin, 2003).

Students are able to solve simple mathematical problems but were less successful with problems of greater complexity (Lai & Murray, 2015; Schmittau, 2004). Generally, conceptual understanding for rules and procedures can be built into students' knowledge system and application for understanding place value: ordering decimals, translating fractions into decimals, concept of place value, etc. However, students struggle to explain their understanding of algorithms for multiplication and division (Lai & Murray, 2015).

Application of Skill to Problems

Application of mathematics – not learning of basic facts – is an area in which many students are not successful. The foundation of arithmetic relationships learned from memorization does not translate to higher level mathematical courses causing negative experiences in mathematics (Parrish, 2014).

Reasoning is a central skill in problem solving and children need to be given time and opportunities to develop their reasoning skills. Reasoning is also closely bound with communication skills. It is difficult for a teacher to assess a student's reasoning ability if he/she are not able to communicate his/her ideas to others in some capacity. Students need support and experience in order to develop their ability to communicate mathematical ideas and to verbalize their thinking (Darch et al., 1984; Thompson, 2004).

Problem solving in elementary school places is a task where students are asked to decide which operation and method of calculation should be used. Typically, problem solving is in a form of a word problem, which disguises calculations wrapped in words (Darch et al., 1984; Jagals & van der Walt, 2016; Thompson, 2004). The decision-making process seems to be operating within a very limited set of expectations. However, children will be faced with problems in which they need to decide how to tackle the problem, how to gather and organize the data and how to represent and communicate their findings (Thompson, 2004). When presented with a problem in mathematics, children need to exercise their ability to interpret the question, to decide on an approach, to apply their knowledge to the situation and use it to find a solution.

Problem solving can be extremely challenging to incorporate within the lesson for teachers (Nohda, 2000). Problems and questions tend to be open-ended and children may choose different routes and emerge with different findings. Each child is likely to progress at solving the problems at different rates and planning time for these sessions is unlikely to fit neatly into the daily lesson. Teachers should provide students opportunities to explore solutions, investigate, and recognize patterns along with eliciting student thinking where responses require students to explain the process and the product (Rigelman, 2007).

Symbols in Mathematics and Early Algebra

The difference between arithmetic and algebra is in the way questions and problems are expressed (Chick & Vincent, 2005). Students need to be able to recognize alphabet symbols, numerals, and nonalphabetic symbols in mathematics. Standard written symbols play an important role in student learning of mathematics, but students may experience difficulties in constructing mathematical meanings of symbols (Yetkin, 2003). Most of the difficulty in understanding symbols comes from the fact that in the standard form, written symbols might take on different meanings in different settings. In order to understand mathematical symbols, students need to learn multiple meanings of the symbols depending on the given problem context (Monroe & Panchyshyn, 1995; Yetkin, 2003).

Early algebra is algebraic thinking in elementary and middle grades and is not the same for students in higher level algebra courses. Early algebra refers to opportunities given to students to engage in age-appropriate forms of algebraic reasoning (Hohensee, 2017). For example, children can think of functional algebraic relationships early on such as “Mary has 3 more candies than John” where Mary’s candies are dependent on John’s candies. Early algebra can build on background contexts within a problem and are coupled with word problems, operations with whole numbers and rational numbers, and in formulas.

Arithmetic teaches students to compute and produce answers; students think of the equal sign as a function. However, in algebra, the equal sign expresses a relationship of equivalence and is a more sophisticated view of the symbol (Alibali, Knuth, Hattikudur, McNeil, & Stephens, 2007). Behr, Erlwanger, and Nichols (1976) conducted a study with children grades 1 to 6 and investigated students' view of equality sentences. The equal sign is a symbol that expresses equality, its meaning depends on the context of the question and students typically see the equal sign as a function (Molina et al., 2017). Equalities such as $4 + 5 = 3 + 6$ were presented to students. A common student response was "after the equal sign should be the answer and not another problem" (Kieran, 1981, p.3).

Another conventional change for students is working with letters, known as variables, and numbers simultaneously within a problem. Students treat letters in mathematical problems six different ways. The letter could be evaluated, not used, used as an object, a specific unknown, a generalized number, or as a variable (Küchemann, 1978). The range of use for a variable requires students to have a strong understanding and flexibility with their mathematic thinking.

Research has shown that a significant number of students hold misconceptions about variables and that misconception impede learning (Lucariello et al., 2014). The first common misconception is students did not view variables as part of the mathematical statement and ignored the variable and proceeded with the given problem. The second type of misconception is when students treat variables as a label for an object, this is typical in geometry problems. The third type of misconception is when students believe a variable is a specific unknown rather than a set of multiple values (Lucariello et al., 2014). In cases where students have misconceptions, learning is more challenging.

Language and Logic in Geometry

Just as algebra is playing a more important role in early mathematics education, so is geometry. In geometry, everyday language is used in technical ways. Right angles do not imply the existence of left angles, a plane does not carry people to distant planes, and yards is not a space in which to play. English language learners need assistance with these dual-meaning words. Geometry also requires understanding of set and subset relationships. Students need to understand how to classify geometric shapes and properties of figures (Graeber, 2005).

In primary education, children process geometry in a specific learning sequence. Students begin the first level of learning by identifying shapes and figures according to concrete examples. Students then move to the descriptive level where they identify shapes according to geometric properties (Thompson, 2004). For instance, students can identify that a rhombus is a shape with four equal sides. The next level of learning, the abstract level, allows students to identify relationships between classes and figures (Thompson, 2004). For example, students can determine why a square can be classified as a rectangle, but a rectangle cannot be classified as a square using properties of each shape. At the fourth stage, the formal level, students can produce a short sequence of statements to logically justify a conclusion. It should be noted that each level is not in isolation, but rather fluid and cyclical. The first level of learning in geometry can be applied to all levels and contexts (Thompson, 2004).

Research on the teaching and learning of geometry indicates that physical experience and physical manipulation of shapes is important at all ages. Students should experience a wide variety of geometrical experiences to gain a firm understanding of geometrical relationships

(Puchner et al., 2008; Thompson, 2004) Currently, grade K-3 standards for geometry focus on recognizing and naming geometric shapes (Common Core State Standards Mathematics, 2013). Students in grades K-3 should study objects, motions, and relationships in a spatial environment. This will improve spatial thinking and can improve a students' mental calculation and problem-solving skills.

Tiered System of Support for Academic Improvement in Mathematics

The goal of a tiered system of support is to improve academic and behavioral outcomes for all students and provide research-supported early intervention services so that difficulties may be corrected before the student requires special education services (Jimerson et al., 2016; Witzel & Clarke, 2015). The reauthorization of Individuals with Disabilities Education Act (IDEA) in 2004 provided schools with the opportunity to use a student's response to evidence-based instruction as a method for identifying students eligible for and in need of special education services (U.S. Department of Education, n.d.). Schools were required to have distinguishable levels of instruction and intervention. The most widely used term in education for this model is Response to Intervention (RTI) that provides a tiered system of support for all students (Jimerson et al., 2016).

A tiered system of support begins with high-quality instruction and universal screening for all students regardless of proficiency (Bryant et al., 2008; Gersten et al., 2009). High-quality instruction seeks to prevent mathematics difficulties while screening allows for early detection of difficulties if they emerge. A universal screening tool consists of a brief assessment that is administered to all students at the beginning, middle, and end of the school year. Universal screening provides a snapshot of student performance given the current state of how resources are allocated at the school site (Jimerson et al., 2016). Students who fall below the benchmark levels associated with the screening tool are given additional time and support or are progressed monitored for a short time to gather additional information regarding the student's risk for learning difficulties; this can be viewed as the beginnings of interventions within the MTSS model. Screening data can be used in combination with results from the most recent statewide assessment to determine students who are at risk and what potential areas to target in an intervention program (Witzel & Clarke, 2015). In the area of mathematics, one type of measurement that has been widely used in the universal screening process is Curriculum-Based Measurement (CBM) universal screeners for early numeracy, computation and concepts, and application (Lembke, Hampton, & Beyers, 2012; Witzel & Clarke, 2015). Student responses to intervention are measured to determine whether they have made adequate progress and (1) no longer need intervention, (2) continue to need some intervention, or (3) need more intensive intervention (Gersten et al., 2009).

Tiered Intervention Framework

There are different models with a varying number of tiers of support, it is widely accepted that there must be at least three tiers with increasing instructional intensity: core (Tier 1), supplemental (Tier 2), and intensive (Tier 3) (Jimerson et al., 2016; Witzel & Clarke, 201). Students are assigned to various tiers of intervention based on instructional need (Lembke et al., 2012). Students who do not respond to research-based interventions at a tiered level may receive additional and more intensive interventions. The goal is not to move students from one tier to another; instead students are provided with intensive support in addition to core instruction (Gregory et al., 2016). Students who are unable to respond to multiple tiers of intervention may be referred for special education services.

The three tiers are built on effective, grade level core instruction. The foundation of a successful system of intervention and support is effective initial teaching (Gregory et al., 2016). Supplemental and intensive intervention cannot compensate for ineffective initial teaching which requires differentiated instruction to meet the needs of each student. Tiered levels do not mean placing all students with learning difficulties in the same classroom and pulling them out of core instruction or high expectations for their work (Kanold et al., 2018).

Tier 1. The goal of core instruction at Tier 1 is to prevent problems and to effectively meet the majority of student academic needs and is considered the most important tier in a MTSS model (Bryant et al., 2008; Jimerson et al., 2016; Witzel & Clarke, 2015). At Tier 1, all students participate in core instruction that is high-quality, research-based, systematic, and developmentally appropriate (O'Meara, 2011). Primary prevention begins with a research-based core curriculum in mathematics that is accessible to all students. The NMAP (2008) reviewed the literature in mathematics and determined that broad areas of focus for mathematics instruction might include: curricular content, learning processes, teachers and teacher education, instructional practices, instructional materials, assessment, and research policies. It is critical that teachers are implementing the core curriculum with fidelity, with frequent reflection on student progress and teacher instruction (Lembke et al., 2012). Instruction at this tier should include differentiated instruction that incorporates flexible groupings and small group instruction. Universal screening data is used to determine the student's level of performance and to inform flexible instructional groups throughout mathematics instruction.

High-quality Tier 1 instruction should lead to fewer students needing additional support where about 80% of students' needs are met at this level. Students must have access to high-quality core curriculum and program of instruction before moving onto other tiered support

(Jimerson et al., 2016; O'Meara, 2011; Witzel & Clarke, 2015). With this expectation comes the idea that if approximately 80% of students are not successful, it is the system or instruction that needs to change or adjust; this principle clarifies expectations of and for the classroom teacher (O'Meara, 2011). If a lesson was taught through quality curriculum and instruction, and 80% of the students are not successful, reteaching or a different approach to teaching needs to be implemented at the universal level (Witzel & Clarke, 2015).

This also helps teachers with planning and pacing of lessons and when to move forward with a new learning objective. If 80% of students have responded with success to the curriculum and instruction, it is time to move on in the instructional sequence (O'Meara, 2011; Witzel & Clarke, 2015). For example, if students have received instruction on multiplication of two-digit numbers and more than 80% of the class is now successful with the skill, it is time for the teacher to move on to the next skill. The students who have not yet mastered the skill will continue to move on while receiving additional supports to master two-digit multiplication. The concept of 80% success is a way to gauge if students' needs are being met; if 80% are successful the system is working. If less than 80% are successful, the system is not working and needs to change.

The National Council of Teachers of Mathematics (2000) report that assessments in mathematics should be more than a test at the end of instruction. Instead, assessments should become part of instruction that guides teachers to enhance student learning. It is recommended that teachers continually gather information about student performance and make appropriate decisions about instruction, content, pacing, review, and enrichment or remediation for all students (DuFour et al., 2016; Lembke et al., 2012).

Tier 2. Secondary intervention is more appropriate for students who fall below benchmark scores on universal screening or are not making adequate progress with core curriculum (Eagle et al., 2015; Lembke et al., 2012). Students in this tier receive supplemental small group mathematics instruction aimed at building targeted mathematics proficiencies in addition to core instruction at the Tier 1 level (Gersten et al., 2009; Witzel & Clarke, 2015). Tier 2 does not replace Tier 1 grade-level standards instruction, but rather provides additional instruction to fill critical gaps of knowledge (O'Meara, 2011; Witzel & Clarke, 2015).

Tier 2 includes intervention to prevent further mathematics difficulties with ongoing progress monitoring to assess response to treatment for students who are identified with risk status in early mathematics skills and concepts (Bryant et al., 2008). Therefore, Tier 2 intervention need to be frequently monitored and re-evaluated so students can move in and out of the intervention based on progress. Progress monitoring should be used to determine whether a student is responding appropriately to the intervention and whether there is a need to modify the type of support the student is receiving (Jimerson et al., 2016; Lembke et al., 2012). Gersten et al. (2009) noted that all students who receive additional intervention services should have their progress monitored weekly or monthly depending on the severity of their need.

Specifically, for Tier 2 mathematics interventions, instruction during intervention needs to be explicit, systematic, and supplemental to the core curriculum (Bryant et al., 2008; Gersten et al., 2009; O'Meara, 2011). A multi-tiered system of support (MTSS) has become the overarching framework that targets improvement in academic and behavioral outcomes for all students (Freeman et al., 2017). In 2009, the Institute of Educational Sciences (IES) published a practice guide on MTSS in mathematics. The review of mathematics intervention research led to eight recommendations for implementing MTSS. The findings indicated that systematic and explicit instruction is most effective with students who struggle. Students in Tier 2 need to be provided with a model of how to perform a skill or solve a problem, guided practice and corrective feedback throughout the learning the skill, and repeated review of the material. Explicit instruction allows step-by-step modeling of how to solve computation problems, coupled with explaining the reasoning behind the method to the students (Gersten et al., 2009; Witzel & Clarke, 2015).

Tier 3. Students who struggle to respond to secondary intervention or who are identified as the most academically needy following benchmarking, typically move into Tier 3. Tier 3 intervention is the most intensive support provided to students who do not make adequate progress in primary or secondary intervention efforts (Gersten et al., 2009). There are a very small number of students who need this level of intensity of support; typically, about 5% of the population (O'Meara, 2011). Students in Tier 3 should be in a smaller group and longer duration than students in tier 2 for more intensive support. Like Tier 2, instruction for students in Tier 3 should incorporate explicit instruction, opportunities for students to verbalize mathematical reasoning, a variety of visuals, a logical sequence of examples, and frequent feedback. Progress monitoring should occur weekly to ensure there is an appropriate mix of instructional strategies. Progress monitoring becomes a vital component of Tier 3 to help inform teaching and make data-based decisions.

The objective of providing additional supports at this increased level of intensity is to promote student success. Tier 3 directly supports the core instruction through intensive supports and services (Jimerson et al., 2016). The interventions are aligned to the needs in small group instruction of Tier 2 as well as the core instruction in Tier 1. Each tier builds on the one before it, rather than replacing it. A student receiving Tier 3 supports continues to receive core instruction with differentiated supports from Tier 1 (Gersten et al., 2009; O'Meara, 2011). Typically, if a student fails to show improvement after receiving first best instruction and tiered support, a referral for an evaluation for special education services would be recommended by the teacher and school (Gersten, et al., 2009).

Evidence Based Practices in Mathematics

In a study of teaching practices in Germany, Japan, and the United States, Stigler and Hiebert (1999) found that teachers in the United States continued a tradition to present mathematics as a large collection of terms and procedures. This extensive observational research found typical U.S. mathematics lessons consisted of a teacher-led presentation, followed by a quick-paced question-and-answer session, with the teacher demonstrating solution methods and having students work very similar problems, and then closing the class by assigning more similar type problems for homework (Fuson, Kalchman, & Bransford, 2005; Roth McDuffie & Mather, 2006). Such traditional teaching methodology stands in contrast to research-based approach to learning mathematics that can increase students' ability to learn, understand, and apply complex mathematics concepts (National Mathematics Advisory Panel, 2008). Teacher educators must determine why this gap between research and practice continued to exist, what the root causes may be, and what interventions are appropriate and available to address different variables.

Student success depends to large degree on the effectiveness of the instruction they receive. Effective instruction is dependent on numerous factors and values as well as goals. The National Research Council's study, *How Students Learn: Mathematics in the Classroom* (National Research Council, 2005) and *NCTM Principles and Standards for School Mathematics* (NCTM, 2000) list three principals of student learning:

1. Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fill the gap with new concepts

and information, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.

2. To develop competence in an area of inquiry, students must (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.
3. A "metacognitive" approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their process in achieving them.

Given the hierarchical nature of mathematics, a solid foundation at a young age is needed if students are expected to understand more complex concepts. Instruction needs to build on and draw out student thinking. Students are expected to work on conceptual understanding and the procedural knowledge of topics, and students must master specific skills to be proficient in math. Frequent opportunities for students to express their thinking and opportunities for teachers to direct and correct learning is important (Loucks-Horsley & Matsumoto, 1999). Effective teaching and learning depend on a balance of these features in the classroom environment (Donovan & National Research Council, 2005). The challenge for teachers lies in knowing how to plan and structure the curriculum to consider balancing whole-class, group and individual teaching, as well as child-initiated, adult-directed or adult-supported activities (Thompson, 2004).

No matter what age, children start school at different times of the year, with very different prior social, cultural and educational experiences and, inevitably, very different mathematical and numerical understandings (Fuson et al., 2005; Loucks-Horsley & Matsumoto, 1999; O'Meara, 2011; Thompson, 2004). Therefore, teachers will need to consider what children already know, understand, and can do. Instruction that builds on students' prior knowledge and connecting new learning will help students' conceptual understanding with mathematics and "students must learn mathematics with understanding actively building new knowledge from experience and prior knowledge" (NCTM, 2000, p. 20). Instruction that emphasizes the attainment of conceptual understanding and reasoning as well as mastery of basic facts and operations should be the basis at the elementary level (National Research Council, 2005; NCTM, 2000). From there, students learn the logic in mathematics and developing the student's own ability to use this logic to develop strategic competence and a productive disposition.

Another challenge for teachers is to provide learning opportunities and high expectations to meet the needs of diverse groups of children to ensure that most children meet the grade-level standards (O'Meara, 2011). At the same time, the teacher should provide extension activities for children demonstrating mastery at a quicker level and systematic intervention for those needing additional support (Gregory & Chapman, 2007; Lawrence-Brown, 2004). To ensure that all children make the best possible progress, a wide range of teaching strategies will be required to motivate, support and extend the lesson for the diverse classroom (Fuson et al., 2005; Thompson, 2004). There are eight evidence based instructional strategies that assist with students' understanding of mathematics:

Explicit, Systematic Instruction Method

A focal point of explicit instruction is frequent and purposefully planned instructional interactions among teachers and students around critical academic content. These instructional interactions must be of high-quality. High-quality instructional interactions are those appropriately and sufficiently distributed throughout the stages of learning. Characterizing high quality, explicit instructional interactions are three key components: (a) clear and concise teacher demonstrations, (b) frequent opportunities for students to practice what teachers demonstrate, and (c) timely academic feedback from teachers to students related to students' attempts to solve academic problems (Archer & Hughes, 2011; Bryant et al., 2008; Doabler et al., 2015). During a planned and sequenced lesson, the teacher presents lessons that build on one another and move from simple skills to more complex ones. As each lesson builds, the teacher chunks information into manageable chunks for the students and prioritizes each learning intention from easy to more difficult (Gersten et al., 2009; IRIS Center, 2018).

Explicit instruction involves teaching a specific concept or procedure in a highly structured and carefully sequenced manner (Archer & Hughes, 2011). Explicit instruction is characterized by a series of supports or scaffolds where students are guided through the learning process with clear statements about the purpose and rationale for learning the new skill, clear explanations and demonstrations of the instructional target, and supported practice with feedback until independent mastery has been achieved (Archer & Hughes, 2011; Gersten et al., 2009). Teaching mathematics in this manner can be highly effective and can significantly improve a student's ability to perform mathematical operations as well as solve word problems (Archer & Hughes, 2011; IRIS Center, 2018). During the explicit instruction, the teacher connects to prior knowledge, gives precise instructions, models concepts and provides opportunities for students to practice with scaffolded instruction. Explicit instruction reduces ambiguous processing for students (Bruce & Grimsley, 1987; Gersten et al., 2009). The teacher uses clear and consistent wording with unambiguous explanations and demonstrations to explain and teach math concepts to students before students are released to work without teacher support (Doabler & Fien, 2013).

During explicit mathematics instruction, teachers prompt groups of students and individuals to communicate and demonstrate their mathematical knowledge. This can be done through the teacher modeling and conducting think-alouds. Group responses serve as a mechanism for maintaining student engagement during an entire lesson (Bruce & Grimsley, 1987; Doabler et al., 2015). Teachers can also informally assess students' understanding of the lesson and mathematical understanding for that day.

With gradual release, teachers work strategically from explicit instruction to guided instruction before students are to work independently. Teachers use prompts, cues, and questions to guide students towards mastery (Fisher & Frey, 2008). Guided practice in the classroom supports students during the early stages of math learning. This support is systematically withdrawn as students become more proficient with a particular math concept or skill (Doabler & Fien, 2013). Over the years, researchers have identified aspects of effective guided math practice (Archer & Hughes, 2010; Carnine, 1997; Chard & Jungjohann, 2006; Doabler et al., 2012; Kame'enui & Simmons, 1999). These aspects can be summarized as the following: (a) identify and pre-teach prerequisite skills, (b) select and sequence instructional examples, (c) use verbal prompts, (d) use multiple representation of math ideas, (e) provide cumulative review (Archer & Hughes, 2011; Doabler & Fien, 2013). During the gradual release of students' ability to work independently, timely and systematic feedback (Bruce & Grimsley, 1987). Feedback provided by the teacher should be specific that clarifies what students did correctly and what they need to improve (Gersten et al., 2009). Students should be provided with opportunities to correct their errors with corrective feedback from the teacher.

There is a consensus among researchers about the value of explicit instruction for students with or at risk for mathematics disabilities (MD). Mathematics intervention studies consistently demonstrate that students with or at risk for mathematics disabilities demonstrate greater gains in classrooms that provide explicit instruction compared to other instructional approaches (Doabler et al., 2015; Baker, Gersten, & Lee, 2002; Gersten et al., 2009; National Mathematics Advisory Panel, 2008). Students with MD have trouble acquiring a deep understanding of mathematics, both conceptually and procedurally. Evidence suggests these difficulties may stem from poor instruction and/or a variety of cognitive correlates, including processing speed, working memory, and attention (Doabler & Fien, 2013). Gersten et al. (2009), analyzed 11 studies targeting interventions for teaching students with MD. Findings indicated a large and meaningful effect ($d = 1.22$) for explicit instruction on student math achievement. Darch, Carnine, and Gersten (1984) conducted a study on explicit instruction for problem solving with fourth graders that were currently failing, and the results indicated that students who received explicit instruction performed significantly better than students who received basal instruction. Student attitudes in the explicit group liked the lesson more and felt they learned more when compared to students in the basal group. The researchers found that students that received explicit instruction were more engaged and applied what was taught on assessments when compared to students that did not receive explicit instruction (Darch et al., 1984).

The Institute of Education Sciences (IES) recommended that math interventions should provide explicit and systematic instruction when teaching struggling learners (Doabler et al., 2012). Explicit and systematic instruction incorporates (a) unambiguous teacher models; (b) carefully sequenced instructional examples; (c) instructional scaffolding; (d) timely academic feedback; (e) cumulative review (Doabler et al., 2012; Darch, Gerten, & Gersten, 1984). Although students needing additional math support benefit from explicit, systematic instruction, students during whole group instruction may benefit from this as well. Recent studies have begun to show that explicit instruction can play a critical role in whole-class instruction (Doabler & Fien, 2013).

Visual Representations

Visual imagery plays a vital role in information processing (Bishop, 1989; Del Grande, 1990; Dreyfus, 1991). Visual representations are flexible and can be used across grade levels and different types of math problems. Visual representation can include, but are not limited to number lines, strip diagrams, pictures, graphs and charts, manipulatives, and graphic organizers. Before students can solve problems, they should be able to create the task in a visual form. Some students can visually represent problems automatically, while others will need to be explicitly taught.

In lower elementary, the use of concrete objects for initial stages of learning to reinforce the understanding of basic concepts and operations are effective (Gersten et al., 2009). The use of manipulatives can help give concreate examples of visual representation. It is important that teachers make explicit connection between the manipulative and the abstract concept that is being taught (IRIS Center, 2018). When using manipulatives in the classroom, students may raise questions that would lead to a deeper understanding of math (Ma, 1999). Visual representations and manipulatives can be used to introduce, practice, or remediate a math concept. Effective use of manipulatives bridges the gap between informal math and formal math. It is important that the manipulative fit the developmental level of the child (Boggan et al., 2010).

Manipulatives can be helpful for young children, but they must be used correctly. The use of manipulatives in mathematics helps students form internal representations (Puchner et al., 2008). Children must understand the mathematical concept being taught rather than simply moving the manipulatives around (Boggan et al., 2010; Ma, 1999). Students use more problem-solving skills when given processing time before manipulatives than students who were given manipulatives right away (Puchner et al., 2008). It is important to teach students to construct a model to represent the situation in the text followed by solution planning based on the model (Jitendra et al., 2007). Manipulatives should be appropriate for the students and chosen to meet the specific goals and objectives of the mathematical program. It is important that teachers plan the kind of student thinking that will occur when using manipulatives and identify how this thinking is directly connected to lesson content goals.

Having a conversation as a whole class after the use of manipulatives is important. In these discussions, students may report, display, explain, and argue for their own solutions. Through the discussions, “the explicit construction of links between understood actions on the objects and related symbol procedures” would be established (Heibert, 1985, p. 509). Leading a discussion after using manipulatives, however, demands more breadth and depth in a teacher’s subject matter (Ma, 1999). With manipulatives, various issues and questions may be raised by students. If a teacher does not know multiple ways to represent and solve the problem, the discussion can be challenging to lead students through (Ma, 1999).

As a student progresses through in math, visual representation of math concepts such as solving equations, fraction equivalence, and the commutative property of addition and multiplication need to be strengthened (Gersten et al., 2009). Incorporating number lines, graphs, or simple drawings of concrete objects can be used as visual representations. The ability to express mathematical ideas using visual representations and then converting the visual to symbols is critical for success in mathematics. It is important that the teacher links visual representations with standard symbolic representation used in mathematics (Gersten et al., 2009).

Schema Instruction

Students who have difficulties with mathematics typically experience severe difficulties in solving word problems related to mathematics concepts and operations they are learning (Gersten et al., 2009). Schema instruction has been suggested as a possible evidence-based practice for improving problem solving performance of students (Noltemeyer, Marie, Mcloughlin, & Vanderwood, 2015). Problem solving is an important life skill which involves finding an appropriate response to a situation which is unique and novel to every problem solver (Esan, 2015; Karatas & Baki, 2013). Teachers can assist with the process by chunking information in ways that are consistent with working memory and long-term transfer. One of the ways to do this is through work with schemas, or mental structures that represent content (Fisher & Frey, 2010). Schema instruction involves teaching students the structure of various problem types, how to categorize problems based on structure, and how to determine appropriate solutions for each problem type (Gersten et al., 2009; Peltier & Vannest, 2017). Tools such as concept maps, word webs, and graphic organizers provide students with schemas that they can use to organize information. These scaffolds, or temporary supports, provide students with organizational systems for learning content (Fisher & Frey, 2010). When students are taught the underlying structure of a word problem, they not only have greater success in problem solving but can also gain insight into the deeper mathematical ideas in word problems (Gersten et al., 2009).

Schema instruction helps students be successful with word problems (Peltier & Vannest, 2017); Powell, 2011). This could be a difficult task for students, since word problems involve a variety of skills to be successful. Word problems require students to be able to read and understand text, including mathematics vocabulary. Students also must identify the appropriate strategy and operation to solve the word problem. To help students with word problems, teachers can help students recognize problem scheme (IRIS Center, 2018). Schema refers to the underlying structure of the problem or problem type. There are two types of schemas: additive schemas and multiplicative schemas. Schema instruction approaches have been classified into two types: schema broadening and schema based (Powell, 2011). Schema based instruction involves the following steps: (a) identify the schema, (b) complete the corresponding schematic diagram, (c) identify a solution plan, (d) carry out the plan and check for reasonableness. Schema broadening instruction involves the following steps: (a) identify the schema, (b) write the corresponding algebraic equation, (c) identify the solution plan, and (d) carry out the plan and check for reasonableness (Peltier & Vannest, 2017). The two approaches are similar; however, a major difference is schema broadening includes instruction on how transfer features in order for students to generalize to novel story problems (Lowrie & Kay, 2001; Powell, 2011).

Additive schemas can be used for addition and subtraction problems and are commonly used for early elementary school through middle school. Word problems include asking students to find the total, difference and change. Multiplicative schema can be used to solve multiplication and division word problems. There are three types of multiplicative schemas: equal, comparison, and ratios and proportions. As students advance in school, they will encounter multi-step mathematical problems and need to develop new structures or schema (Fuson et al., 2005).

Metacognitive Strategies

Students who struggle with mathematics tend to be poor problem solvers. They approach mathematics problems using a small number of strategies that cannot be applied to every problem. Teaching students who struggle with mathematics how to think on their own is essential for them to solve mathematics problems. Typically, these students do not have an idea of what they should do when they confront a mathematical problem and are unable to explain the strategy they used to reach a solution (Cardelle-Elawar, 1992). By contrast, students who perform well on complex cognitive tasks are those who possess well-developed metacognitive skills (Sternberg, 1986, Cardelle-Elawar, 1992). Teachers can assist students by helping with cognitive strategies and help students focus attention of relevant information to solve the problem. However, teaching cognitive strategies is not enough.

Teachers should pair instruction on cognitive strategies with metacognitive strategies – strategies that enable students to become aware of how they think when solving mathematics problems. When paired with cognitive strategies, metacognitive strategies have been shown to increase the understanding and ability of students with mathematics learning difficulties and disabilities to solve mathematics problems (Pfannenstiel, Bryant, Bryant, & Porterfield, 2015). Cognitive and metacognitive strategies should enable students to become aware of how they think when solving problems. Young students pay attention to how quickly they solve a problem, not necessarily accuracy, when reflecting on their competence in mathematics (Efklides & Vlachopoulos, 2012). Teaching students' metacognitive strategies can help students learn how to plan a problem, monitor whether their approach is working, and modify their approach if it is not working or if their answer is incorrect (Cardelle-Elawar, 1992).

In one study conducted by Tobias (1978), students who were directed to engage in self-explanation as they solved mathematics problems developed deeper conceptual understanding than did students who solved those same problems but did not engage in self-explanation. This was true even though the common time limitation on both groups meant that the self-explaining students solved fewer problems in total. Helping students become more metacognitive about their own thinking and learning will serve them well in all learning endeavors (National Research Council, 2005).

Metacognitive processing allows people to select and invent strategies explicitly by thinking about their understanding of the task demands, their available cognitive resources, and their own experience in solving similar problem (Pennequin et al., 2010). Developing this at the elementary level and progressing through secondary school will deepen an individual's metacognitive abilities (Jagals & van der Walt, 2016).

Math Talks

Whole-class question and answer sessions are not enough to develop mathematical understanding (Thompson, 2004). Encouraging math talks and allowing students to talk about their mathematical thinking can be beneficial (Donovan & National Research Council, 2005). Students and teachers actively discuss various approaches to solving math problems. This communication about mathematical thinking can help students and the teacher understand concepts or methods. Conducting math talks helps teachers understand their students' methods and can provide information for lesson planning and design. This kind of formative assessment is a powerful approach to raising standards (Black & Wiliam, 1998; Thompson, 2004).

Math talk is recognized as essential for developing understanding and making connections between mathematical ideas and mathematical skills and procedures (Thompson, 2004). Students gain confidence in expressing themselves when speaking mathematically to explain their calculations. Recording math talks allows teachers and other professionals to focus on students' responses. This gives teachers an opportunity to extend the use of different strategies shared by students in subsequent lessons. It is important that teachers plan mathematical goals with math talks. These goals will help teachers focus on specific vocabulary and conversations. Sometimes the aim is for students to share many different ideas and possibilities, while at other times the focus might be on vocabulary or error analysis (Kazemi & Hintz, 2014).

A study conducted by Professor Neil Mercer at the Open University showed that a focus on math talk can improve mathematical learning (Mercer, Wegerif, Dawes, & Higgins, 2002). In this study, children were taught to follow agreed ground rules for discussions as they completed collaborative tasks prior to finding the solutions. The mathematical tasks given to students were open-ended questions or questions with multiple solutions. The results showed that students participated in these math talks scored significantly higher than those in the control classes. The findings from the study indicate that the interaction and use of language improved students' reasoning skills (Mercer, Wegerif, Dawes, & Higgins, 2002).

Extending academic math talk opportunities will allow students to apply their conceptual knowledge to deepen understanding (Frey & Fisher, 2011). Moving from whole-class group discussions to productive group work can further student engagement. This is best accomplished through student roles within small groups and opportunities to work on tasks together. The task complexity should be considered for productive group work. The task should be complex enough that the first attempt may not be successful, so group members need to engage in discussion about strategy and next attempts because students attend to error analysis more closely (Frey & Fisher, 2011; Kapur, 2008). When students talk, they think. Talking provides students with practice and an opportunity to clarify their understanding in the presence of their peers. As students talk, teachers gain a greater understanding of students' mastery of the subject matter.

Students should have the opportunity to share their mathematical ideas while working in groups or with others. Students who work in groups during mathematical investigation and actively learn content display increased achievement (Freeman et al., 2014; Ing, et.al,. 2015). Collaborative engagement appeals to the nature of most children. Most individuals have peer-oriented social goals and are pursued along with academic goals simultaneously in the classroom. Students who belong to groups and value the academic goals of group work are likely to adopt motivational strategies (Summers, 2006). The students' environmental changes and psychological needs must be considered when selecting collaboration opportunities and groups.

Multiple Methods to Solve Problems

Discussing multiple problem-solving methods in the classroom and understanding why different methods work can help provide a conceptual understanding and help students with different approaches (Donovan & National Research Council, 2005). Students are expected to provide reasons for their approaches and compare alternative methods for solving problems. The task and the discussion of the task should connect to relevant real-world applications or other important concepts in mathematics. Students should work in a variety of settings: whole class, small group work, and independent work (Greeno, 2003). When teachers presented multiple solution strategies for solving the same problem, students demonstrated significant increases in procedural flexibility, conceptual knowledge, and procedural knowledge (Durkin, Star, & Rittle-Johnson, 2017; Jitendra et al., 2011).

Students are engaged and fascinated by different methods that emerge from the various strategies to solve the same math problem (Boaler, 2016). Students believe that for each kind of math situation or problem there can be several correct methods and their engagement in strategy development is continued. This does not mean all strategies are equally good. However, students can learn to evaluate different strategies for their advantages and disadvantages (National Research Council, 2005).

If students are taught that for each kind of math situation or problem, there is one correct method, there can be a disconnection between their reasoning and strategy development when trying to apply mathematics to real life situations and problem-solving skills (Fuson et al., 2005). Students learn that an answer to math problems is either wrong or right, and one does not need to look at wrong answers more deeply. Instead, students learn to only look at how to get the right answer. When the nature of the math problem changes slightly, or students have not used the taught method for a while, they may feel completely lost when confronted with a novel problem because they cannot solve the problem (National Research Council, 2005).

Teachers can include open-ended questions during math instruction to allow students to expand their procedural flexibility, conceptual knowledge, and procedural knowledge. Open-ended problems refer to the problem that is formulated to have multiple correct answers (Nohda, 2000). Students can elaborate their process and communicate to others their solutions. This also allows the teacher to understand the students' ideas and help sophisticate their solutions and math practices (Nohda, 2000).

Support Productive Student Struggle

Effective instruction to assist with conceptual understanding and reasonableness in mathematics occurs when a teacher presents challenging, rich tasks that are selected to draw on students' current knowledge but require some invention or application that is not directly stated by the teacher. The teacher maintains the challenge of the task by giving students information or hints that guide their discovery. The teacher evokes students' prior knowledge, scaffolds students' thinking, and questions students' reasoning (Graeber, 2005).

Recent neurological research on the brain shows that when people make mistakes, the brain sparks and grows (Boaler, 2016). Psychologist Jason Moser studied the neural mechanisms that operate in people's brains when they make mistakes. The brain has two responses: one that occurs when the individual does not know an error has been made, known as ERN response, and another response that reflects a consciousness to the mistake. The power of mistakes is critical information, as children and adults everywhere often feel terrible when they make a mistake in math. Students think making mistakes means they are not a math person, because society has been focused on a performance culture in which mistakes are not valued – or worse, mistakes are punished. Countries that top the world in math achievement, such as China, deal with mistakes in mathematics very differently. Teachers and students in China are accustomed to openly discussing mistakes made in mathematics because it is valued in the classroom and opens dialogue amongst peers (Boaler, 2016; Ma, 1999). Teachers in China tend to have a deeper conceptual understanding and are able to lead their students to find and discuss mistakes made while solving problems. In the United States, teachers intend to do the same with students, but have only procedural understanding and typically provide feedback on the procedure rather than using illustrations and demonstrations of the rationale (Ma, 1999).

Students that struggle to solve problems learn to listen to each other as different students offer ideas. Students make mistakes and take wrong turns, but eventually students begin to solve the problem with many different students contributing. Students combine their own thoughts and ideas with methods that can later be used to face in the world.

Academic Vocabulary and Writing

Students encounter general vocabulary words in everyday language and in their usual reading experiences. Most elementary mathematic textbooks use general vocabulary and content specific vocabulary (Monroe & Panchyshyn, 1995). Students should use the language of mathematics to share their thinking explicitly. This explicit thinking will help deepen mathematical understanding and metacognitive ability (Beasley et al., 2017). Mathematics language is connected to students' conceptual understanding of content knowledge and skills (Powell & Driver, 2015). Students need to understand that math vocabulary terms are connected to symbolic representations to solve problems (Powell & Driver, 2015). Teachers should explicitly introduce unfamiliar vocabulary, discuss confusing terms, and encourage students to use mathematics vocabulary in their questions and conversations to ensure understanding (Dustin & Tyminski, 2013; Powell & Driver, 2015).

Monroe and Panchyshyn (1995) broke academic language related to mathematics into four categories: (a) technical words which have one meaning (e.g., "trapezoid"), (b) sub-technical words which have multiple meanings (e.g., "degrees"), (c) general words common in everyday language that have some type of meaning in mathematics (e.g., "simplify"), and (d) symbolic words in which amounts are represented by abstract numerals or symbols (e.g., "plus" as "+"). Students should have extended opportunities to encounter words and engage in meaningful processing of such words. Bay-Williams and Livers (2009), as well as Monroe and Orme (2002), suggested providing explicit instruction of mathematics vocabulary and opportunities for students to encounter mathematics vocabulary in everyday and context-related situations (Powell & Driver, 2015). Mathematics material is difficult to read with more concepts per word, per sentence, and per paragraph than any other area that it is particularly crucial to emphasize vocabulary instruction in the content area (Monroe & Panchyshyn, 1995). Panchyshn and Monroe (1992) found that more than half of the words included in elementary mathematics textbooks were not among those most frequently used in children's reading materials.

Teachers need to show students that math problems are more than just a solution and that each problem has a process. Teachers must model the writing process with students and demonstrate how to explain the thought process in solving the problem. Once students are used to the writing process in mathematics, they will need assistance with expanding and elaborating on the solution path (Beasley et al., 2017).

Teacher Preparation to Teach New Math Standards

California adopted the Common Core standards in 2010, and schools and districts began rolling out the standards in varying degrees in subsequent years. Districts were responsible in preparing teachers and districts on the implementation of the new standards. Challenges with the implementation of the new standards, as with any new curriculum districts faced "lie in interpreting the standards, identifying appropriate materials for use in the classroom, including materials for students with special needs, and providing resources to support teachers in the transition" (Dossey et al., 2016, p. 88).

By spring 2015, students in California began the new standardized assessment known as Smarter Balanced Assessments in English and Mathematics under the CAASPP. The inconsistencies across the state of California has been a concern for the State Board of Education (Harrington, 2017; Loucks-Horsley & Matsumoto, 1999). In 2017, California Department of Education officials outlined the work that needs to be done to prepare teachers to successfully integrate the standards into the classroom and the amount of professional development that is needed for all teachers (Harrington, 2017). Many teachers and administrators in California "have not received high-quality training to successfully teach the rigorous Common Core math standards" (Harrington, 2017, para. 15). Due to differences of opinion about high-quality teaching and professional development, there have been inconsistencies with training teachers throughout California (Harrington, 2017; Loucks-Horsley & Matsumoto, 1999).

According to Greatness by Design (2012) a blue-ribbon task force report, teacher preparation programs in the state vary widely in quality. Once teachers are hired, professional development opportunities to improve their skills vary widely across the state, as well. Furthermore, many teachers face the challenge of teaching in a way they have not been taught before (Ball et al., 2001; Hill et al., 2005; Loucks-Horsley & Matsumoto, 1999). Most teachers have been trained to instruct students to solve problems using a discrete set of rules and procedures with speed and accuracy but without necessarily understanding mathematical logic (Ball et al., 2001; Harrington, 2017; Parrish, 2014). Under the new standards, teachers need to think about math as a set of concepts that students can discover instead of rote recall. Understanding mathematical concepts is essential for the development of mathematical competence, but many teachers do not have the professional learning or training to teach students conceptual understanding (Harrington, 2017; NCTM, 2000). Ma (1999) argued that teachers need "a profound understanding of fundamental mathematics" in order to teacher mathematics well (p. x). Most elementary school teachers in the United States do not possess the knowledge and professional development centered around a deep understanding of mathematics to provide quality educational experiences for their students (Ball et al., 2001; Ma, 1999)

Elementary school teachers generally are not prepared to teach mathematics (Angus, Olney, & Ainley, 2007) and these teachers report a lack of suitable activities for responding to learner diversity (Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006). Teaching mathematics in elementary schools has always been perceived as difficult (Schuck, 1996), and requiring teachers to learn new teaching strategies only exacerbates the struggle. While most elementary school teachers appreciate the importance of mathematics in the education curriculum, many feel completely unprepared to teach it (Angus et al., 2007). This perception of the primacy of mathematics, together with a lack of confidence in the ability to teach it, often leads to methods of teaching that emphasize procedure over conceptual understanding (Ma, 1999, p. 107).

In the last two decades, studies on teacher change have presented the competent teacher as a decision maker, problem solver, and person of values and beliefs that strongly influence the teaching practice. Recent initiatives in math education have placed a great responsibility for reform on the teacher (Ginsburg et al., 2005; Hill et al., 2005). These responsibilities include an emphasis on mathematical process such as problem solving and reasoning, communication and discourse around mathematical topics, connections within and across content areas (NCTM, 2000). Many of these responsibilities are new to the typical classroom teacher and require change at some level. Teachers are asked to build mathematical knowledge and processes and help foster students' beliefs that they can learn and do mathematics that is reasonable, useful, and worthwhile. These broadened goals and higher expectations present challenges (Graeber, 2005).

Wright, Horn, and Sanders (1997) analyzed the achievement scores of more than 100,000 students across hundreds of schools and concluded:

> The most important factor affecting student learning is the teacher. In addition, the results show wide variation in effectiveness among teachers. The immediate and clear implication of this finding is that seemingly more can be done to improve education by improving the effectiveness of teachers than by any single factor. Effective teachers appear to be effective with students of all achievement levels, regardless of the level of

> heterogeneity in their classrooms. If the teacher is ineffective, students under the teacher's tutelage will show inadequate progress academically regardless of how similar or different they are regarding their academic achievement. (p. 63)

Teaching and Job Satisfaction

Since 1984, studies on the American teaching force have shown that recruitment and retention of quality teachers impacts the education system (Darling-Hammond, 1984; Liu & Ramsey, 2008). As older teachers retire, many younger teachers leave for other occupations (Tye & O'Brien, 2002). Evidence suggests that new recruits are less academically qualified than those who are leaving, and the number of new entrants is insufficient to meet the coming demands of teachers (Darling-Hammond, 1984; Ingersoll & Smith, 2003). The most academically able teaching recruits leave the profession within a very short amount of time (Ingersoll & Smith, 2003; Liu & Ramsey, 2008). In the United States, about half of new teachers leave the teaching profession within the first five years (Darling-Hammond, 1984; Ingersoll & Smith, 2003; Liu & Ramsey, 2008). The teacher attrition rate follows a U-shaped curve: high for young teachers early in career, low for mid-career teachers, and high again for older teachers near retirement (Grissmer & Kirby, 1992; Tye & O'Brien, 2002). Harris and Adams (2007) found that teacher turnover is relatively high for older teachers reflecting that they retire considerably earlier than other professionals. They hypothesized that the teacher pension is a more significant factor in labor market decisions (Harris & Adams, 2007).

Shortages of qualified teachers in subject areas such as mathematics and science are expected to grow as the supply for prospective teachers shrink (Ebadi, 2000; Ingersoll & Perda, 2009; Liu, Rosenstein, Swan, & Khalil, 2008; Shymansky & Aldridge, 1982). Teachers in science and mathematics are more likely to leave teaching than others because their skills are rewarded relatively more in the private sector, and schools do not usually differentiate pay based on domain of expertise (Liu & Ramsey, 2008; Murane et al., 1991). Teaching jobs traditionally have a single salary scale that rewards teachers based on educational level and years of teaching experience; the pay does not reflect the supply and demand of teachers in various subjects (Liu et al., 2008).

Several factors contribute to the shortage of teachers in K-12 education. Demographic trends are expected to increase the problem of teacher shortage (Darling-Hammond, 1984; Ebadi, 2000; Liu & Ramsey, 2008). Female teachers are more likely than male teachers to remain in teaching because teaching offers them a flexible schedule that allows more time to spend with their families (Ingersoll & Smith, 2003; Liu & Ramsey, 2008). However, academically talented women and minorities, who were once restricted to teaching as a professional option, are now choosing other occupations that promise greater financial rewards, more opportunities for advancement, and better working conditions (Darling-Hammond, 1984; Ingersoll & Smith, 2003; Ingersoll & Perda, 2009; Tye & O'Brien, 2002).

Teachers' salaries fall well below those of most other occupations that require a college degree. Compensation in public education has long trailed behind the private industry; employees in private industry typically earn more than teachers with comparable educational credentials (Ebadi, 2000; Liu & Ramsey, 2008; Murane et al., 1991; Tye & O'Brien, 2002). In the 2015 National Teacher and Principal Survey (NTPS), overall "45% of teachers agreed that they were satisfied with their salary, and 55% disagreed" (U.S. Department of Education, 2018, para. 2) Higher salaries for teachers are only part of the solution to this problem as in other occupations. Working conditions and school environment affect teachers' abilities to perform their jobs effectively (Tye & O'Brien, 2002).

Some researchers find that teachers are increasingly viewed as bureaucratic functionaries rather than as practicing professionals (Lieberman, 1990; Ozga, 2017). Professionalizing teaching will require a new career structure in which improved preparation and professionally enforced standards of practice are combined with increased responsibility and compensation strategies for those who successfully demonstrate their competence (Darling-Hammond, 1984; Ebadi, 2000; Lieberman, 1990). Recent studies on teacher turnover have emphasized teacher autonomy, administrative support, fewer student discipline problems, and teacher involvement in school governance may improve teacher morale and teacher career commitment (Ingersoll, 2001; Johnson & Birkeland, 2003; Liu & Ramsey, 2008; Tye & O'Brien, 2002). In the NTPS, 45% of teachers stated that "if I could get a higher paying job I'd leave teaching as soon as possible" and 52% of teachers indicated that they do not have the same enthusiasm with teaching as when they started (U.S. Department of Education, 2018). Public school teachers in the United States usually teach large classes and do not have the time for planning and preparation. More often than not, teachers are not provided with enough instructional support when they start teaching especially with the increase of accountability states require (Liu & Ramsey, 2008; Tye & O'Brien, 2002).

According to Locke (1976), job satisfaction is a positive or pleasant emotional state resulting from a person's appreciation of his/her own job. Satisfaction is strongly correlated with motivation and is closely related to personal and professional interests, culminating in success or in acquiring a social position. Job satisfaction is significant due to its association with the physical and mental wellbeing of employees. Satisfied employees are more likely to be creative and inventive bringing new ideas and innovations that will allow and help the organization to grow and evolve in time and in changing market conditions (Sharma & Jyoti, 2006).

Additionally, job satisfaction is closely related to behaviors such as productivity, absenteeism, turnover, organizational commitment, and employee relations. A teacher's attitudes and beliefs about teaching processes, ability to teach, and the ability of students to learn can influence instructional practices inside classrooms and ultimately student achievement (Banerjee et al., 2017; Tye & O'Brien, 2002). Teacher attitudes and beliefs, along with affect, are key constructs that define teacher job satisfaction. Therefore, it is extremely essential teachers to be satisfied with their profession.

According to the Metlife Survey of the American Teacher Annual Report (2013), there is a continuous decrease in teacher job satisfaction throughout the years while at the same time stress among teachers has increased since 1985. The role of the teacher is changing in the view of the social, economic, political and other pressures that are taking place in the last few decades (Markow et al., 2013). Teacher workloads are changing as a result of several factors including the mainstreaming of pupils with special educational needs, greater ethnic diversity in the classrooms, and larger class size.

Professional Development and Learning for Teachers

Professional learning for teachers is one way to support for the increasingly complex skills students need to learn in preparation for further education and work in the 21st century. Teachers need time and opportunities participate in effective professional development that will directly impact the students in their classroom (Desimone et al., 2002). However, many professional development (PD) initiatives appear ineffective in supporting changes in teacher practices and student learning (Darling-Hammond et al., 2017). Effective professional development can be seen as structured professional learning (PL) that results in changes in teacher practices and improvements in student learning outcomes.

As demands for deeper and more complex student learning have intensified, practitioners, researchers, and policy makers have begun to think more systematically about how to improve teachers' learning from recruitment, preparation, and support, to mentoring and other leadership opportunities (Darling-Hammond et al., 2017). Major questions remain about how teachers can learn these skills and how PD can play a role in improving teacher practice. Districts have spent a wide range of dollars on PD, and it is certainly true that PD does not always lead to professional learning despite its intent (Darling-Hammond et al., 2017; Yoon et al., 2007). Fullan (2010) argued that external approaches to instructional improvement are rarely powerful enough, specific enough, or sustained enough to alter the culture of the classroom and school.

Research in the United States found that most teachers receive PD of short duration, less than eight hours on a topic, usually in afterschool workshops. During the No Child Left Behind era, there was an increase in this short-term approach of PD and a decline in access to more sustained professional learning approaches (Loucks-Horsley & Matsumoto, 1999; Wei et al., 2010). These short, one-day PDs often make the learning superficial and disconnected from deep issues of curriculum and learning that can be viewed as fragmented for participants (Loucks-Horsley & Matsumoto, 1999; Yoon et al., 2007). Effective PD should have an annual duration ranging from 45 to 300 hours, and in most cases more than 100 hours of engagement with offsite and school-based components (Wei et al., 2010). Most district-supported professional development activities do not meet the needs of teachers with content, time, or ease of application back to the classroom (Desimone et al., 2002). The average time of professional development and activity was less than a week for teachers throughout the school year with professional learning that lacked coherence and active learning opportunities for participants (Desimone et al., 2002). At the same time, a growing number of studies established that well-designed PD can, when effectively implemented, lead to desirable changes in teacher practice and student outcomes (Wei et al., 2009).

Several researchers have sought to understand why some PD has proven insufficient to impact teaching practices and raise student achievement in schools. In their study of 4th to 6th grade teachers, Buczynski & Hansen (2010) discussed several barriers to the implementation of PD. The researchers challenged the notion that PD is only as effective as the teacher's will to employ the knowledge and skills gained. Instead Buczynski and Hansen found that teachers are willing to implement professional development practices in the classroom but often face hurdles that are beyond their control. Teachers may also face hurdles that are within their control and can be difficult to attend to given the challenging nature of their specific school environment (Desimone et al., 2002; Wei et al., 2009). Some barriers the researchers found: insufficient time allotted to teach curriculum that uses the newly acquired knowledge and skills, the need to teach mandated curriculum on a pacing guide, challenges of teaching English learners without specific PD to address students' learning needs, lack of resources, and classroom management issues (Buczynski & Hansen, 2010; Loucks-Horsley & Matsumoto, 1999). The researchers cited the biggest barrier with implementing PD was related to funding and resources available presented at the PDs.

Johnson and Fargo (2010) echoed equity issues with funding and obstacles to apply PDs in urban schools. External crisis such as school closures and uncertainty of employment add to the challenge teachers face daily along with implementing newly taught PD skills. The obstacles teachers face in schools may lead to broader issues that stem from systemic problems.

Birman conducted a study on professional development in mathematics and found that on average teachers received 8.3 hours of PD on how to teach mathematics. When looking at "in-depth" training on math topics, teachers received 5.2 hours of training during a twelve-month span during the 2003-2004 school year. Of elementary teachers, 71% participated in PD that focused on instructional strategies for teaching mathematics, but only 9% participated for more than 24 hours during a school year. Birman surveyed the teachers and 49% reported that they received focused and in-depth PD on mathematics.

Professional Learning Communities

Historically the trend in education typically consist of teachers in classrooms with no communication with other adults (Hord, 2008). Essentially teachers worked in isolation planning and teaching without collaborating with colleagues. For many years, teachers were given the authority to teach what they knew of the curriculum. During the 1980s, school systems experienced team teaching and open classrooms. Educators began to talk about teachers' workplace, knowledge and skills and a shift from isolation moved towards teacher interaction. Teacher interaction led to collaboration and sharing ideas and strategies, which led to an increase in teacher morale and motivation (Hord, 2008; Roberts & Pruitt, 2009).

There is a need for teachers to actively work in a professional group to increase their craft and overall commitment to the work demands of teaching (Louis et al., 1996). A school-based professional community can offer support and motivation to teachers as they work to overcome barriers and constraints that can be found in today's schools. In schools where professional community is strong, teachers put more effort into creating and sustaining opportunities for student learning. Kruse, Louis, and Bryk (1996) found five critical elements that are found in strong professional communities: reflective dialogue, de-privatization of practice, collective focus on student learning, collaboration, and shared norms and values.

Along with the five critical elements, certain physical structures and support from administration are needed to assist with developing strong professional communities. There must be time to meet and talk that is regularly scheduled and built into the school day (Eaker & Keating, 2015). Schools can increase teacher contact and collaboration by strategically placing grade-levels or departments close in proximity, or by having a common place for teachers to discuss education. The development of a professional community requires opportunities and encourages teachers to exchange ideas within and across their teams. Having a systematic communication structure can assist with the sharing of ideas (Kruse et al., 2009).

The term Professional Learning Community (PLC) began to be used in the 1990s after Peter Senge's book *The Fifth Discipline* (1990) had popularized the idea of learning organizations. The shift and key word added is "learning" into professional community. Senge's book focused on business corporations and argued that if corporations wanted to survive, they must change themselves into learning organizations that recognize the threats to their survival and the opportunities for continued growth. Learning communities are characterized by a shared vision among employees and management with team learning through group discussion of goals and problems (Hamos et al., 2009). Building a learning community requires organizational members to have access to resources as time to collaborate, ongoing leadership support, information, and ready access to colleagues (Senge, 2012).

One significant way humans learn is by working with others (Eaker & Keating, 2012). Essentially, Professional Learning Community is a process in which educators commit to work together to ensure high levels of learning for every student. To achieve this, teachers learn together about best practices to increase student achievement, applying what they know, and using evidence of student learning to make decisions and revisions in practices to help more students learn (Mattos, 2016).

Towards the late 1990s a large body of literature on PLCs had been published and school districts across the country had implemented PLCs. By 2000, PLC was a widespread movement that looked promising for school improvement (Eaker & Keating, 2012). Michael Fullan has noted that:

> …in the spread of PLCs, we have found that the term travels faster than the concept, a finding common in all innovations. The concept is deep and requires careful and persistent attention in thorough learning by reflective doing and problem solving. (Fullan, 2016, p. 229).

It is important that superficial PLCs, where educators call what they are doing professional learning communities without going very deep into learning and without realizing there is more work ahead, does not become the practice instilled at the school sites (Hamos et al., 2009).

It is agreed upon that the PLC process is not a program (DuFour, DuFour, Eaker, Many, & Mattos, 2016; Eaker & Keating, 2012, 2015). It is not something that can be purchased to yield student outcomes. Rather, it is the collective effort of collaborative teams to drive the work of a PLC. While many professional learning community efforts have been poorly implemented and superficial in their design and impact, there is evidence that PLCs can, when implemented with high degree of quality, support improvements in practice, along with student learning gains (Darling-Hammond et al., 2017; Hamos et al., 2009). DuFour et al. (2016) list three essential ideas that drive the work for a PLC in *Learning by Doing: A Handbook for Professional Learning Communities at Work*:

1. A focus on learning: The fundamental purpose of the school is to ensure that all students learn at high levels – grade-level or beyond.
2. A collaborative culture: Educators must work collaboratively and take collective responsibility for the success of each student.
3. A results orientation: The work of a PLC is results oriented where evidence of learning is used to inform and improve professional practice and response for students who need intervention or enrichment.

The ultimate purpose of PLC is to improve learning opportunities and outcomes for students. Teachers in learning communities engage in collaborative activities directed toward helping them improve their instructional practices. Students are likely to be the beneficiaries as teachers share ideas, learn innovative and better ways of teaching, and try newly learned approaches in the classroom (Roberts & Pruitt, 2009). Successful PLCs require mutual accountability where no students fall through the cracks and all teachers share in the responsibility for the success of all students (Donohoo et al., 2018). Well-implemented PLCs provide ongoing, job-embedded learning that is active, collaborative, and reflective (Darling-Hammond et al., 2017). Therefore, PLCs not only focus on student learning, but on adult learning as well (Barkley, 2019; Eaker & Keating, 2015). Kids will not learn more until the adults learn more. This focus on adult learning is reflective of a school culture where teachers continually become more knowledgeable and skillful at doing the complex work of their profession (DuFour et al., 2016).

According to Fullan (2000), successful change in elementary schools can take up to three years, while change in large secondary schools can take as much as double that time. There must be sustained commitment to positive change in order to experience transition from strong adoption and implementation to strong institutionalization (Fullan, 2000). The results of professional learning on student learning has been noted by several studies. Some studies have shown little or no impact of teacher practice on increased student learning, while many other students have Found that the level of student performance is consistent with the quality of their classroom instruction. Teachers and administrators must be willing to participate in professional learning and implement strategies that will help improve classroom instruction in order to increase student learning. In higher performing schools, teachers and administrators are interested in implementing new instructional strategies that support student learning and are engaged in the review of current research supporting those practices (DuFour & Eaker, 1998). DeFour (2011) emphasizes that in order to see increases in student achievement, professionals must make decisions focused on evidence and not comfort or personal preference.

Benefits of Analyzing Student Work and Student Data

While data has always played a role in school improvement, data historically was used yearly as a summative basis to evaluate the outcomes of the school year (Lange et al., 2012). Recently, student data is used throughout the year and form data driven decisions at the administrative and classroom level. The examination of student work is often a focus of productive Professional Learning Communities. The time spent analyzing work should include discussion about the teaching practices that led to the results and serve as opportunities for brainstorming and problem-solving within the team (Rasberry & Mahajan, 2008).

Analyzing student work collaboratively gives teachers opportunities to develop a common understanding of what good work is, what common misunderstandings students have, and what instructional strategies may or may not be working and for whom (Cohen & Ball, 1999; Wei et al., 2009). A study investigating three high-achieving schools that have continuously beaten the odds-on standardized tests found that teachers' use of multiple student data scores to collectively reflect upon and improve instructional practices in team meetings contributed to increases in student achievement (Strahan, 2003). Another study conducted by Saunders, Goldenburg, and Gallimore (2009) looked at nine Title I schools and students who were in classes where teachers teamed together in the grade-level outperformed their peers in six matched schools in the same large, urban district on standardized achievement tests.

Teachers that use a collaborative process to analyze student work begin to design work that ensure activities are engaging for students and are effective (Bella, 2004; Lange et al., 2012). With this process, teachers and teams begin to self-reflect with collegial support and move towards deepening their work as educators. The purpose throughout the collaborative process as educators is to rethink, refine, and refocus teacher practices using student data (Bella, 2004). When teams of teachers engage in the process of analyzing data to identify, prioritize, and address student learning, leadership is distributed throughout the organization (Lange et al., 2012). The skills of the individuals and the group are increased and create a persistent condition of improvement throughout the school (DuFour et al., 2016).

Once a collaborative culture has been established among teacher teams and across the school, it is important to further the collaboration on "what" teachers are collaborating about. The fact that teachers collaborate will do nothing to improve a school (DuFour et al., 2016; Harris & Adams, 2007). The purpose of collaboration is to help more students achieve at higher levels; this can be accomplished if teachers are engaged in the right work (DuFour et al., 2016). There are four essential questions that help focus the right work and drive the work of a PLC for teachers as they work in collaborative groups:

1. What do we want students to learn?

2. How will we know if they've learned it?
3. What will we do if they haven't learned it?
4. What will we do if they've demonstrated proficiency?

By focusing collaborative conversations around these four questions, teachers have the opportunity to calibrate their core instructional practices, the team can evaluate whether or not a teaching approach is meeting all students' needs (Harris & Adams, 2007). The outcome of these discussions could be to provide students with small group supplemental instruction within the classroom, focused instruction across grade level or content area, or to have the general educator and a specialist or support teacher work within the instructional day. It is important in PLCs teachers plan together, collaboratively deciding on appropriate interventions for students, planning units of instruction, sharing instructional strategies and materials, reflecting on the effectiveness of instructional practices that were utilized, and setting goals (Eaker & Keating, 2015). The ultimate outcome for teachers working in PLCs is the teacher learning first that will then impact and guide the student learning (Barkley, 2019).

Summary

This chapter provided a review of literature on four areas for research. A history of the curriculum standards was outlined, and the overall impact the mathematical standards have had on the classroom teachers' requirements to teach the standards. Based on data collected through various assessments, the National Mathematics Advisory Panel identified seven mathematical concepts that are challenging for students at the elementary level. Eight effective mathematical instructional practices were discussed at the Tier 1 level to meet the learning needs of all students in the classroom. The chapter also introduced Professional Learning Communities for the study to address teacher collaboration and data analysis with elementary mathematics. The next chapter discusses the methodology, research design, and data sources of the study.

CHAPTER 3: METHODOLOGY

Introduction

The objective of the research conducted was to test the research questions related to student achievement and understanding in mathematics:

1. How does a teacher's math background, job satisfaction, use of district adopted curriculum, and instructional practices impact student achievement?
2. What is the relationship between how much time teachers spend in Professional Learning Communities (PLCs) and student achievement in mathematics?

This chapter is organized into seven sections: (a) settings and participants, (b) sampling procedures, (c) instrumentation and measures, (d) reliability and validity, (e) data collection, (f) data analysis, and (g) ethical issues.

Setting and Participants

The unified school district used in this study (XXX district) is a diverse suburban Local Education Agency that encompasses 90 square miles. XXX district serves three cities and is comprised of 20 elementary schools, two K-8 schools, six junior high schools, and six high schools. The average daily attendance for the 2017-2018 was 27,069 with 49% of those qualifying under federal guidelines for free or reduced-price meals ("EdData - District Profile", 2018). In 2017-2018 school year, the district reported that 11% of its population were English Learners and that 67% identify as Hispanic, 24% Asian, and 7% other ("EdData – District Profile", 2018).

XXX district offers many learning settings, including the traditional classroom, virtual school for families needing alternatives, and regional occupancy programs (ROP) for high school students. In nearly all areas of student achievement, the district consistently exceeds county and state averages. While the state dropout rate in 2018 was 9.6%, this district was well under that with a dropout rate of 4.3%. In order to ensure confidentiality and participation, the study used pseudonyms for the district as well as school and participant names.

At the elementary level, the district invested heavily in building teacher capacity to address the rigor and relevance associated with 21st century learning and the shift to Common Core State Standards. A multi-tiered system of support (MTSS) for students needing intervention was built into the curriculum that included socio-emotional lessons, counseling services, and tiered academic intervention in 2014. At the elementary level, every school site received a full-time intervention teacher to service students needing additional reading support; the administrator had the ability to decide the grade levels receiving the additional support based on data and needs. The intervention teachers were trained in universal screening materials along with supplemental teaching curriculum to support the classroom teachers. School sites that receive Title I funds were allocated an additional full-time intervention teacher. Collectively, these actions aimed to bridge the achievement gaps for students across the district.

XXX district implemented the Common Core State Standards for mathematics and English Language Arts in 2013. Teachers were given support and materials until textbook adoptions were available for review and purchase. Specifically, in math, teachers utilized the textbooks in their classroom and supplemental materials were given to them from the district's math committee from 2013-2015. In Fall 2015, the entire district adopted a new math curriculum that aligned with the California Common Core State Standards.

The California Department of Education (2019) reported results for achievement on the CAASPP results from 2015 through 2018. Results for the district of students meeting or exceeding standards on the CAASPP mathematic assessment from 2015, 2016, 2017, and 2018 compared to the state of California can be found in Figure 2.

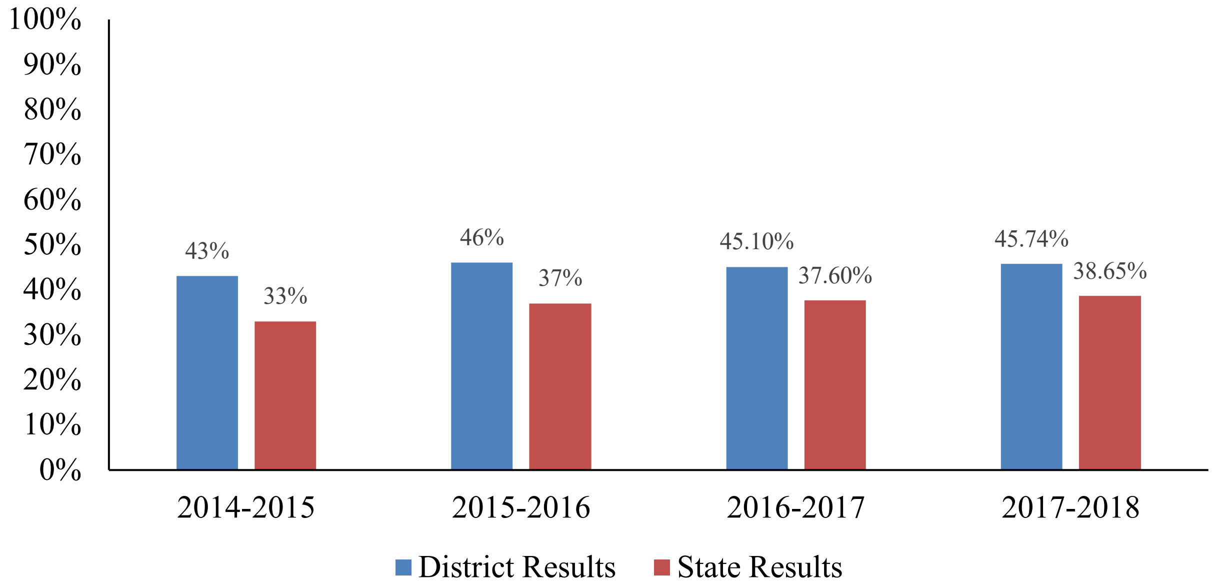


Figure 2: District CAASPP mathematics scores versus state scores. This figure shows students meeting or exceeding grade-level state standards on the CAASPP mathematics assessment over the last four years.

Sampling Procedures

The researcher used purposive and convenience sampling to identify the participants of the research study. Purposive sampling is utilized when settings, people, and activities are selected because they provide data that is specifically relevant to the research questions (Maxwell, 2013). The sample was convenient for the researcher because the researcher works in the district where the participants were asked to participate in the related study and research questions. Quantitative data was collected and reviewed by the researcher when the Director of Assessment in XXX district released school site comparison scores from 2017 to 2018 on California Assessment of Student Performance and Progress (CAASPP).

Based on the growth report released by the Director of Assessment, the researcher identified two elementary schools, School A and School C, that showed a 10% gain in mathematics on the CAASPP in 2017. The researcher selected two additional elementary schools, School B and School D, that had similar student demographics to School A and School C but showed less than 1% increase in mathematics on the CAASPP assessment for the 2017-2018 school year. These schools were selected to compare results from the quantitative and qualitative portion of the study to find similarities or differences that impact student achievement in mathematics. The administrators at these four schools were not new to their school sites and were able to give information regarding factors and school-wide initiatives that lead to the increase of scores on the CAASPP. Table 1 shows enrollment, number of teachers, unduplicated count, CAASPP Math 2017 scores, percent gained from CAASPP Math 2016-2017 school year, Title I information, and the year the school opened for the four schools.

Table 1

School Information from 2017-2018

School Information	School A	School B	School C	School D
Enrollment	710	514	486	664
Number of Teachers	21	18	16	22
Unduplicated count: Free and Reduced Lunch, English Learners, Foster Youth	618	414	176	226
% of students meeting or exceeding CAASPP Math Test 2018	23.8%	23.2%	68.6%	61.6%
% gain from CAASPP Math Test 2017	9.8%	0.56%	9.9%	0.01%

Title I	Yes	Yes	No	No
Year Opened	1980	1980	1995	1980

Instrumentation and Measures

The instruments used in this mixed-method research study consisted of (a) teacher online survey and (b) administrator interviews (see Appendix A and Table 2). Measures that were used were the 2017 California Assessment of Student Performance and Progress (CAASPP) results. The instrumentation and measures collected gave insights towards the research questions.

Instrumentation

Teacher Online Survey. The teachers at School A, School B, School C, and School D were contacted to participate in the study. The survey, *Teacher Survey – Mathematics and PLC*, was sent to the teachers via email and respondents were limited to one submission. An online survey was utilized as the instrument for data collection because it is the most effective method for "both response rate and reaching a high number of participants" (McMillan & Schumacher, 2010, p. 241). All responses were recorded on a Google Form that was exported into an excel spreadsheet. Each section of the instrument was developed to address the study's research questions. A goal of the survey was to identify participants' level of understanding of their comfort and background in mathematics, instructional practices and beliefs about mathematics, and Professional Learning Communities at their school site.

For the survey, 25 questions were adapted from the Trends in International Mathematics and Science Study (TIMSS) Teacher Questionnaire facilitated by the United States Department of Education as part of the instrument. The purpose of TIMSS is to "study the home, community, school, and student factors associated with student achievement in mathematics" (*United States – TIMSS 2015 Encyclopedia*, 2016). Data collected is to understand each country's context for learning through questionnaires that were completed by students, as well as their parents, teachers, and principals. All questionnaires were reviewed by the National Research Coordinators and by each country (*United States – TIMSS 2015 Encyclopedia*, 2016).

The first section of the teacher survey for this research included six questions regarding the participant's demographics and Likert scaled questions. The Likert scaled questions were adapted by the TIMSS and asked the participant's opinion on student learning, teaching responsibilities beyond the classroom, and job satisfaction. Likert-scaled questions ranged from *never* (1), *neutral* (3), and *always* (5) and the job satisfaction question consisted of the following responses: *never or almost never* (1), *rarely* (2), *sometimes* (3), *often* (4), *always or almost always* (5). The information gathered in this section will be used for research question one.

Section two consisted of twelve questions regarding teaching mathematics. Nine of the questions were adapted from the TIMMS Teacher Questionnaire and three questions were developed by the researcher. Questions included participant's use of instructional strategies and lesson design, instructional minutes, homework, and assessments. Participants were asked how often they ask students to complete the following utilizing the scale *never* (1) *neutral* (3) and *always* (5): listen to the teacher explain mathematics, memorize rules and procedures, work individually, work cooperatively, work in mixed and same ability groups, complete worksheets, solve problems from the textbook, write definitions, investigate and gather data, complete long term projects, prepare oral reports, and utilize supplemental materials. Homework questions utilized scaled responses of *never* (1), *once a week* (2), *twice a week* (3), *three times a week* (4), *four times a week* (5), and *daily* (6). Assessment questions included the use of technology to administer the test and assessment strategies.

Section three consisted of questions that addressed how the participant prepares to teach mathematics. This section had six questions and four of the questions were adapted from

TIMMS. Questions included time the participant spent the past two years attending professional development and the amount of time spent outside the classroom grading papers, meeting with parents, helping students, planning lessons, professional reading, and keeping grades up to date. Three Likert scaled questions were asked regarding the participant's opinion on skills students need to be successful in math, the participant's confidence in teaching math concepts, and the participant's confidence in assisting the various student abilities in their classroom. Responses ranged from *none at all* (1), *neutral* (3), and *a great deal* (5). One qualitative question was asked in this section that asked the participant's end-of-year goal for the students in their classroom.

Questions in section four were developed by the researcher to gain understanding of the participants use of the district adopted curriculum. There was a total of seven questions that asked the participants if they used the curriculum, how often they utilized the resources that were provided by the publisher in one instructional week, and if the participant used supplemental materials not provided by the district. One qualitative question was asked in this section with regards to the participant's satisfaction with the curriculum and an explanation of their response.

Section five consisted of six questions regarding the participants time spent in PLCs at their school sites. Likert scaled responses of *never* (1), *sometimes* (3), and *always* (5) were submitted on questions regarding frequency math is discussed during PLCs, interactions with other staff members beyond their grade-level, and support from others. Two questions addressed time spent in PLCs in a typical week.

Administrator Interviews. Interviews were conducted with the principals at School A, School B, School C, and School D to gain a deeper understanding on mathematics achievement from 2017 to 2018 on the CAASPP. The questions were constructed and grouped into five themes: background information, math instruction, participation in PLC, school site professional development, services and support, and other. Table 2 contains the questions for the semi-structured interview as well as how the questions are grouped.

Table 2

Administrator Interview Question Matrix

Domain of Questions	Survey Questions
Background Information	• Tell me about your background in education that has led you to your current role? • How long have you been an administrator? At what school sites? • How long have you been at your current site?
Math Instruction	• What math strategies did you observe your teachers use in the classroom? • What assessments were given in math? • What interventions and/or supports did your teachers use in math?
Participation in PLC	• Describe how your site utilized their weekly PLC time? • How often did teachers analyze math assessments/data? • Based on the 4 PLC questions, which area is a strength of your teams and which is an area of growth? • What assistance was needed from administration with regards to mathematics? • Were there any teacher concerns with math that was brought to administration's attention?
School Site Professional Development	• Did your school site utilize any Professional Development funds for math training? If so, how were the decisions made and what was the result? • What school wide initiatives were implemented to improve math instruction for student performance?
Services and Support	• Did your site utilize the instructional coach to improve math instruction? • Did your site utilize supplemental materials provided by the district?

Other	• Is there any additional information you want to add that you felt contributed towards your site's math achievement?

Administrators make many decisions to meet the needs of their stakeholders, and school site monies are used to meet the site's needs. There can be some flexibility with the school site's general funds, and if applicable Title I fund, and an interview was conducted to see if any resources were allocated towards improving mathematics at the site level.

The site administrators were not new to their school site and can speak to the vision and culture of their school site. Specific professional information, including school name and location, was intentionally withheld from this analysis to preserve and protect the anonymity of the participants.

The administrators were contacted via email to inform them of the study. They were emailed information about the study along with the participant consent form. Interviewees had the opportunity to choose a location for the interviews and each administrator chose their school site. Interviews were recorded, and the audio data was transcribed.

Reliability

Data comparison across the sampled population was conducted for reliability. The teachers and administrators were informed of the instrument prior to administering it. Administrators allowed time for their staff to complete the survey within four weeks. The researcher kept in communication with the administrators regarding survey completion and weekly reminders were sent to the teachers by their administrator. All responses on Likert scale questions were given an equivalent numerical value for computations.

The researcher recorded the administrator interviews and had the information transcribed by Rev. Member checking was conducted, and each administrator was sent their transcription for accuracy and validity of responses to the questions. The researcher also utilized an inter-coder agreement to ensure the coding was accurate and common themes were identified. The codebook was developed and "shared understanding of codes represents the coding analysis" of the multiple coders were used for the administrator interview and the teacher interviews (Creswell & Poth, 2018, p. 214).

Validity

The teacher survey that was used was based on the mathematics questions from the Trends in International Mathematics and Science Study under the United States Department of Education. This survey has been administered to sample public schools in various countries every four years since 1995 to determine how students in the United States compare to students in other countries. The questionnaire has been utilized in more than 60 countries in grades four and eight. A pilot study was conducted with 11 participants to test the survey and obtain feedback. The survey was created using Google Forms and a link was sent to participants that teach in XXX district but not at Schools A, B, C, or D. Any suggestions for improvement were recorded in the last question of the pilot survey. The researcher revised the survey based on the participants' feedback. The final survey was reviewed by four individuals with doctoral degrees.

All interviews were audio recorded and transcribed. All transcribed audio recordings were provided to the interviewees to ensure accuracy. The researcher used the same questions for each interview and only asked probing questions when necessary. The researcher made an intentional effort to talk less and listen to the responses from the administrators.

Possible threats to validity would be factors outside the school setting that impact the students and teachers that include home life and life changes. Research was conducted at four elementary schools in a suburban district and may be generalized in similar demographics. The results are "limited in generalizability" due to the constraints of completing the research (McMillan & Schumacher, 2010, p. 116).

California Assessment of Student Performance and Progress (CAASPP). California Assessment of Student Performance and Progress is a standardized achievement test that is given to students in grades 3-8 and 11. The test is administered annually during the testing window that is outlined by the state of California. In 2016-2017, the assessment became adaptive which meant that test questions become easier or more difficult based on how students answered. The mathematics portion consist of two tests: Computer Adaptive Test (CAT) and Performance Task (PT). The CAT portion of the test consist of thirty to sixty questions that require students to answer multiple choice, multiple responses, matching tables, short text, drag and drop, hot spot, table fill in, graphing, and equation/numeric type questions ("Smarter Balanced Question Types - Smarter Balanced Assessment System (CA Dept of Education)," 2018). The Performance Task assessment is used to better measure the student's depth of understanding, research skills, and complex analysis ("What is Smarter Balanced?," 2018).

Data Collection

The study was conducted using multiple instrumentations and measures. Both quantitative and qualitative methodology of data collection were conducted throughout the study. The researcher obtained permission to conduct the study from the Institutional Review Board (IRB) which outlined the guidelines for conducting research. Before data collection began, written consent from the school district office was granted to conduct the study.

Teacher surveys were sent to the participating teachers at School A, B, C, and D through electronic mail. The instrument was created with Google Forms and responses remained confidential. The teachers were informed that the survey was optional; participating teachers gave consent prior to completing the survey. Teachers were able to elect if they wanted to participate in a follow up interview with the researcher after the survey was completed. Administrators at the four school sites were contacted by electronic mail for their participation in the research study. All participants had the ability to pick the time and location to assist with their participation.

Research Question One

How does a teacher's math background, job satisfaction, use of district adopted curriculum, and instructional practices affect student achievement? To answer this question, the researcher utilized a teacher survey, conducted interviews with administrators, and analyzed student achievement in mathematics.

Teacher survey. The teacher survey was sent to all teachers at four different elementary sites. The survey questions addressed (a) demographics; (b) teaching mathematics; (c) preparing to teach mathematics; (d) district adopted curriculum; (e) Professional Learning Communities. To establish validity, teachers were told that their responses would be anonymous, aggregated with the other participants, and not shared with their site supervisor. Teachers were assured that school names would not be used in the study results. An email with the survey link was sent to the participants and individuals could only submit one response.

Administrator interviews. Interviews were conducted with the four site administrators. Interviews were recorded and participants were provided a transcription of their response. Parts of the interview that address research question one: (a) math instruction; (b) services and support; and (c) other – the site administrators were able to add any additional information that was not asked by the researcher for reasons they felt their school site improved in mathematics. The researcher also self-reflected each interview immediately afterwards to validate the data.

California Assessment of Student Performance and Progress (CAASPP). California Assessment of Student Performance and Progress results from all elementary schools were obtained for the 2016-2017 and 2017-2018 school years. Results were analyzed for changes in math scores.

Research Question Two

What is the relationship between how much time is spent in Professional Learning Communities (PLCs) and student achievement? To answer this question, the researcher utilized a teacher survey and conducted interviews with administrators and teachers.

Teacher survey. There were six questions on the teacher survey that addressed the participants time spent in PLCs and time spent discussing mathematics as a collaborative team. The survey sought to understand during their time, how were they progressing with the four essential questions when working in a PLC: (1) What do we want students to learn? (2) How will we know if they have learned? (3) What will we do if they don't learn? (4) What will we do if they already know it? (DeFour, DeFour, Eaker, Many, 2010).

Administrator interviews. Interviews were conducted with site administrators that showed an increase in student achievement in mathematics. Interviews were recorded and participants were provided a transcription of their response. Parts of the interview that address research question two: (a) participation in PLC; (b) school site professional development; and (c) other. The researcher also self-reflected each interview immediately afterwards to validate the data.

Data Analysis

Three measurements (teacher survey, administrator interview, and student assessment results) informed the first question: how does a teacher's math background, job satisfaction, use of district adopted curriculum, and instructional practices affect student achievement? Statements on the teacher survey were analyzed in part and in whole. Likert scaled questions were given a numerical value and a correlation analysis was conducted. The researcher computed correlations between the participants' responses to job satisfaction, teaching responsibilities, math background, teaching mathematics, use of curriculum, and instructional practices to see if any were indicators for student success. Administrative interviews were coded for common themes on instructional strategies observed during classroom walkthroughs and school wide implementation and support provided in mathematics.

A comparison between participant responses at the different school sites were conducted to determine if any factors had a statistical significance at the school sites that had a 10% gain on the 2018 CAASPP mathematics assessment, Schools AC, compared to the school sites that had a 1% gain, Schools BD. The researcher conducted one-way ANOVAs on responses from the teachers' preparedness to teach math concepts, teachers' confidence in teaching mathematics, and instructional strategies.

Three measurements (teacher survey, administrator interview, and student assessment results) were used to inform the second research question: what is the relationship between time spent in Professional Learning Communities (PLCs) and student achievement in mathematics? Statements on the teacher survey were analyzed in part and in whole. Likert scaled questions were given a numerical value and a correlation analysis was conducted. The researcher computed correlations and one-way ANOVAs between the responses based on the four essential questions in a PLC: (1) What do we want students to learn? (2) How will we know if they have learned? (3) What will we do if they don't learn? (4) What will we do if they already know it? (DeFour, DeFour, Eaker, & Many, 2010). Administrator interviews were coded for common themes on school site professional development, staff's participation in PLCs, and other factors they felt attributed towards student achievement. See Figure 3.

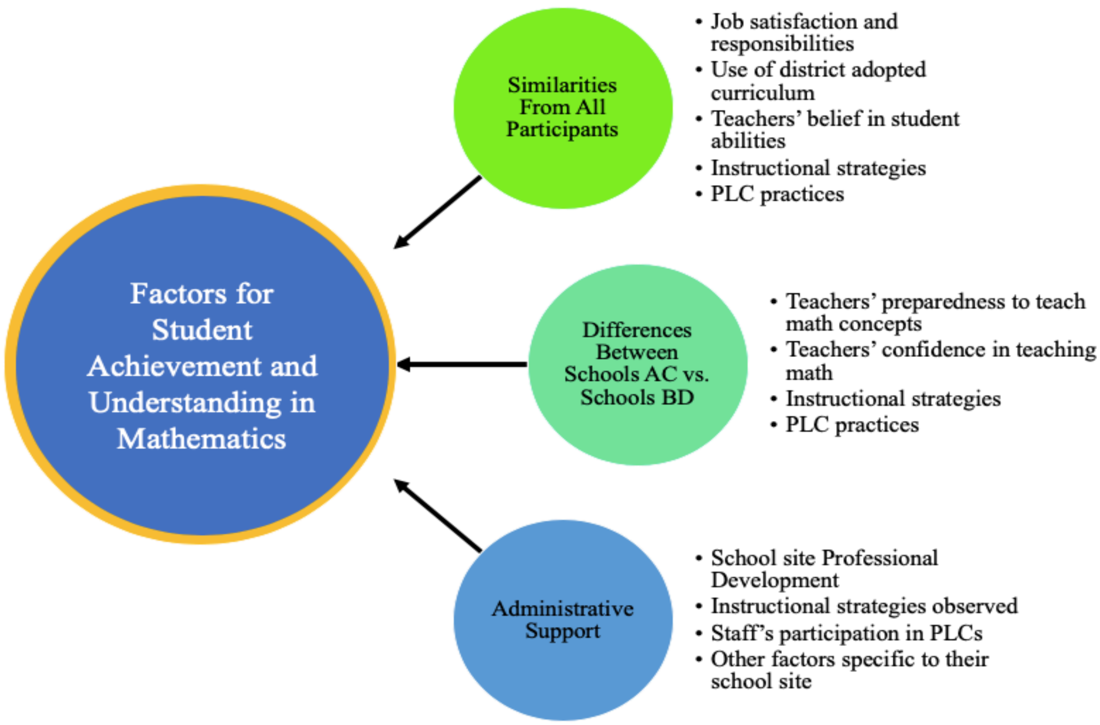


Figure 3. Comparison of Participant's Responses. Hathuc 2019

Teacher Survey and Administrator Interviews

Coding was conducted on all qualitative results. Themes were identified throughout the responses from the survey and interviews. A chart was included in a column for the results of each item on the survey. The results of each theme were averaged for Likert scaled questions. A one-way ANOVA and Pearson correlation of the data were conducted on the results from each theme in the survey. The researcher sought to determine what factors attributed towards student achievement in mathematics and if there were any similarities and differences amongst the participants' responses.

All interviews were recorded and transcribed for accurate coding. The data collected from the administrators were organized into tables using Microsoft Excel for further analysis. The researcher listed all responses, identified common themes, and grouped the data according to common themes. Based on the administrators' responses, the researcher sought to find the following themes based on the literature review of evidence-based practices in mathematics for research question one: (a) explicit, systematic instruction method, (b) visual representation, (c) schema instruction, (d) metacognitive strategies, (e) math talks, (f) multiple methods to solve problems, (g) support productive student struggle, and (h) academic vocabulary and writing. The researcher also sought to find common themes on professional development and Professional Learning communities for research question two. See Figure 4.

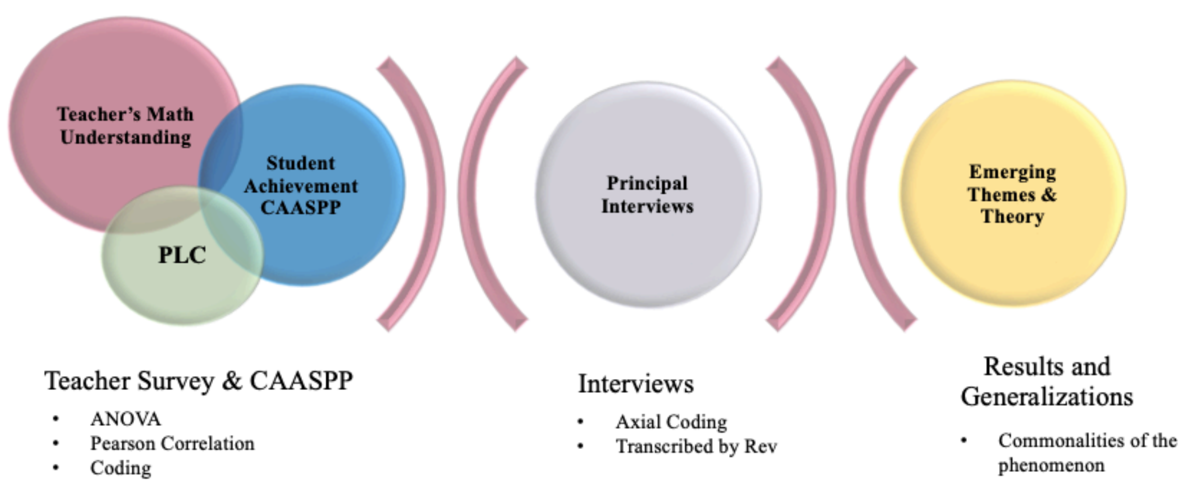


Figure 4. Data Analysis of Quantitative and Qualitative Data. Hathuc 2019

Ethical Issues

There was no known physical, psychological, or sociological risks that might occur because of their participation in this study. To minimize risks, informed consent was collected from participants prior to any collection of data. Confidentiality of participants was maintained to avoid emotional risks. All names were redacted prior to delivery to the researcher. All data and materials collected from participants were stored in a locked filing cabinet for the duration of the study and destroyed at the completion of the study.

The researcher was an elementary mathematics teacher in XXX district from 2013-2016 and worked at one of the school sites that was identified for this study based on the percentage of growth on the CAASPP. Although the researcher has working relationships with some of the teachers at the school site, teachers were selected based on CAASPP results from 2018.

The researcher was also on the math adoption committee in 2014. The district adopted a math textbook that the researcher had input on while on the committee. While conducting this study, the researcher is an administrator for XXX district and is the Coordinator of Elementary Curriculum and Instruction. The administrators and teachers that participated in the study are given directives and initiatives from the Office of Elementary Curriculum throughout the year, and responses could have been influenced in some capacity.

Summary

This chapter provided a description of the methodology for this mixed method research. Additionally, the chapter provided a rationale for this design and described a comparison between four schools for the research. The participants were chosen based on their CAASPP data in mathematics for the 2017-2018 school year and school site demographics. This chapter included the description of the research design and instrumentation was discussed. The researcher also presented the validity and reliability of the instruments used in the study. Also discussed in this chapter were the data collection procedures used in this study. The data analysis methods were included as the final section of this chapter. The following chapter contains the results of the data analysis.

CHAPTER 4: FINDINGS

Introduction

The intent of this study was to investigate perceived factors in Tier 1 mathematics instruction that led to an increase in math scores on the California Assessment of Student Performance and Progress (CAASPP) assessment at four elementary schools. The researcher sought to analyze teacher responses of their beliefs and ability to teach mathematics, their opinions on student ability to learn mathematics, and instructional strategies used to teach mathematics. The teacher survey was distributed to all teachers at the four elementary schools fulfilling the quantitative requirement. School A had 67% of the staff complete the survey (*n*=14), School B had 78% of the staff complete the survey (*n*=14), School C had 75% of the staff complete the survey (*n*=12), and 36% of the staff completed the survey from School D (*n*=8). Each participant from the four schools received a participant code (See Appendix E for demographic information of the teachers who completed the survey that include the participant code, the grade-level each participant teachers, age, and number of years taught rounded to the nearest whole number.)

At school site A, 14 teachers took the survey. Of these 14 teachers, three taught Kindergarten, one taught first grade, three taught second grade, two taught third grade, two taught fourth grade, one taught fifth grade, and two taught sixth grade. The teachers age ranged from 24-57 and their years of experience ranged from 1-27 years.

At school site B, 14 teachers took the survey. Of these 14 teachers, nine teachers have classrooms that consist of one grade level. One teacher taught kindergarten, two taught second grade, two taught third grade, two taught fourth grade, and two taught sixth grade. The remaining five teachers who participated in the survey service students in multiple grade levels.

One teacher has a fifth and sixth grade combination class, two teachers are intervention teachers who support students in kindergarten through sixth graders, and two teachers were special education teachers servicing all students with Individualized Education Plans at the school site. The age range of the participants were 27-62 and their years of experience ranged from 4-32.

At school site C, 12 teachers took the survey. Of these 12 teachers, one taught kindergarten, one taught first grade, two taught second grade, three taught third grade, two taught fourth grade, two taught fifth grade, and one taught sixth grade. The teachers age ranged from 38-63 and the years of experience ranged from 3-37.

At school site D, eight teachers took the survey. Of these eight teachers, six of the teachers have classrooms that consist of one grade level. One taught kindergarten, one taught first grade, one taught third grade, one taught fourth grade, two taught fifth grade. One intervention teacher participated in the survey and services students in grades first through sixth. One special education teacher participated in the survey and supports grades kindergarten through sixth grade. The teachers age ranged from 33-55 and the years of experience ranged from 2-26.

The researcher also sought to understand the school site administrators' specific leadership strategies in order to determine common themes that led to the improvement of mathematics instruction at their school site. The researcher interviewed the four administrators to acquire the qualitative data for the mixed-method study.

The researcher interviewed the four administrators at their school sites. The sites were selected based on their growth on the CAASPP and the administrator was there for the 2016 and 2017 school year.

School A's administrator has been in education for 34 years and has been at her current site for 27 years. She has been a teacher at the school site, an intervention teacher at the school site, and currently serves as the principal. She had a one-year gap at her current site when she served as an assistant principal at another elementary school within the district before returning as the principal. She has been an administrator for a total of five years.

School B's administrator was a high school science for ten years and then a high school assistant principal for twelve years. After 22 years at the high school level, she felt she needed a change and became an elementary principal at her current site. She has been at her site for two and a half years.

School C's administrator began her career as an instructional aide for students in kindergarten through third grade and later an instructional aide for junior high. She then obtained her teaching credential and taught junior high math and Language Arts. She taught for four years and then became an outreach consultant for two years where she assisted on Student Study Teams, attendance issues, and worked with high risk students. After the two years, she became the Dropout Prevention Specialist and eventually the dean of discipline for two years at the junior high level. She was hired in XXX district as an assistant principal after 17 years at her former district. After one year as an assistant principal, she became a principal and has a total of seven years as an administrator. She has been at her current site for three years.

School D's administrator taught high school Spanish for eight years and then became a high school assistant principal. She was an assistant principal for six years serving at the high school and junior high level. She then moved on to become the principal at her current site and has been there for five years.

Research Question One

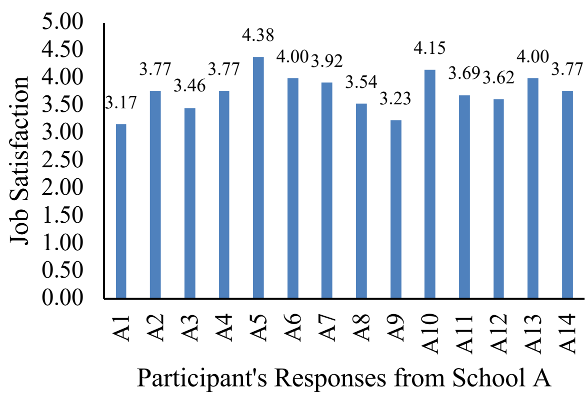
How does a teacher's math background, job satisfaction, use of district adopted curriculum, and instructional practices affect student achievement? The researcher utilized the teacher survey responses to determine the different constructs of the research question. The survey was able to capture responses to job satisfaction, teacher's math background, curriculum usage, and instructional practices. Site administrators gave qualitative data on math instruction they observed in the classroom and provided feedback on what services and support their teachers needed to teach mathematics.

Responses to Research Question One: Teacher Survey

Job satisfaction and responsibilities. The survey consisted of five statements regarding job satisfaction and participants responded to each statement by selecting (1) *never or almost never*, (2) *rarely*, (3) *sometimes*, (4) *often*, (5) *or very often or always*. The survey also consisted of eight statements regarding the participant's feelings towards teaching about class size, material to teach throughout the day, time, parents, etc. Participants responded to the statements by selecting (1) *never*, (3) *neutral*, (5) *or a lot*. The researcher calculated the average for each participant's responses to the 13 questions.

The researcher also asked seven questions regarding hours spent per week fulfilling job duties beyond teaching. Contractually, elementary teachers in XXX district work seven hours with a break for lunch. These hours are spent with students and does not include the various tasks beyond teaching. The seven questions on the survey sought to see how many additional hours per week a teacher spends grading student work, planning lessons individually, meeting with students and parents outside the class time, professional development, and keeping gradebooks up to date. The participants responded to each statement by selecting *never, 0-1* *hour, 1-2 hours, 3-4 hours*, or *more than 4 hours*.

Fourteen teachers from school site A completed the survey. Participant A1 and A9 had the lowest reported score in job satisfaction for School A. Participant A3 and A8 spent the least amount of time fulfilling job duties with 7 hours per week. See Figure 5 for School A's participant responses as indicated by their participation code.



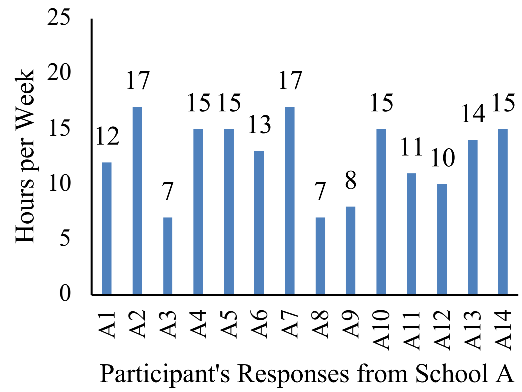


Figure 5. Survey responses to job satisfaction and hours per week spent fulfilling responsibilities beyond classroom instruction for School A

At school site B, 14 teachers completed the survey. Participant B12 spent the least amount of additional time beyond contractual hours with three hours per week. B12 also reported to have the lowest job satisfaction when compared to the other teachers at School B who also completed the survey. See Figure 6 for School B's participant responses as indicated by their participant code.

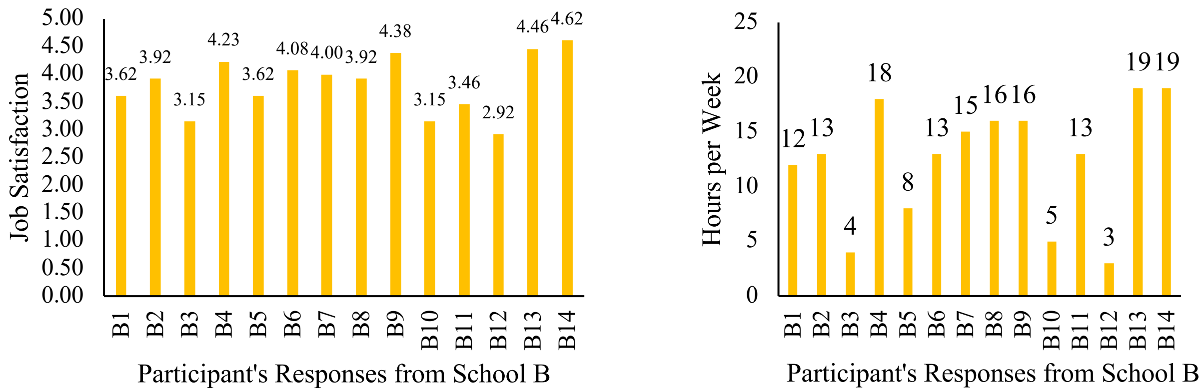


Figure 6. Survey responses to job satisfaction and hours per week spent fulfilling responsibilities beyond classroom instruction for School B

Twelve teachers from school site C completed the survey. Participants C9 and C11 reported having the lowest job satisfaction at School C when compared to the other teachers who completed the survey. Participant C11 reported spending the least amount of additional time at four hours per week beyond contractual hours. See Figure 7 for School C's participant responses as indicated by their participant code.

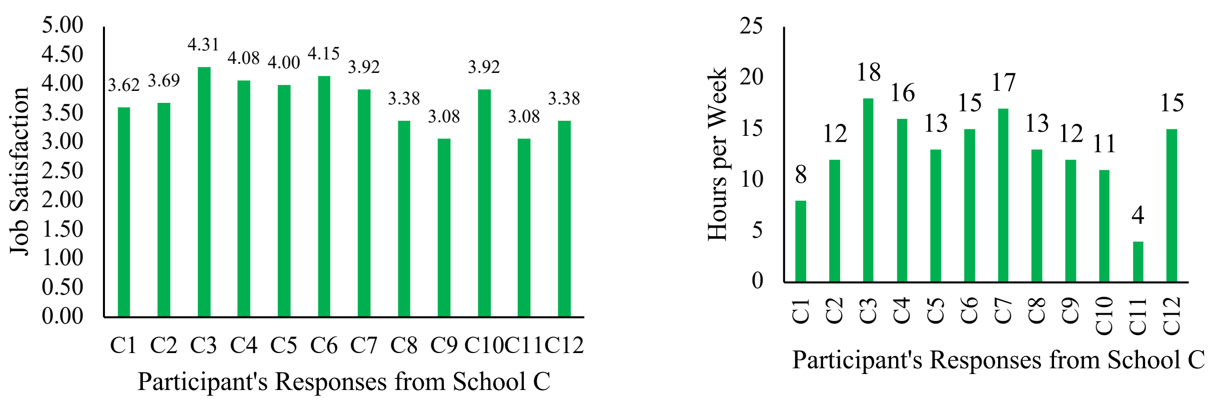


Figure 7. Survey responses to job satisfaction and hours per week spent fulfilling responsibilities beyond classroom instruction for School C

At School D, eight teachers completed the survey. Participants D1 and D5 reported having the least job satisfaction when compared to the other teachers at School D that completed the survey. Participant D1 reported spending the least amount of time beyond contractual hours fulfilling duties beyond teaching with one hour per week. See Figure 8 for School D's participant responses as indicated by their participant code.

When comparing all four school sites, the overall average response for job satisfaction is 3.77. At school site A and school site B, 57% of their participants' responses fell above the average (*n*=8). At school site C and school site D, half of the teachers' responses fell above the average and half of the teachers' responses fell below the job satisfaction average. Participant B12 reports the lowest job satisfaction out of all four schools (*M*=2.92) and Participant D3 had the highest average (*M*=4.77).

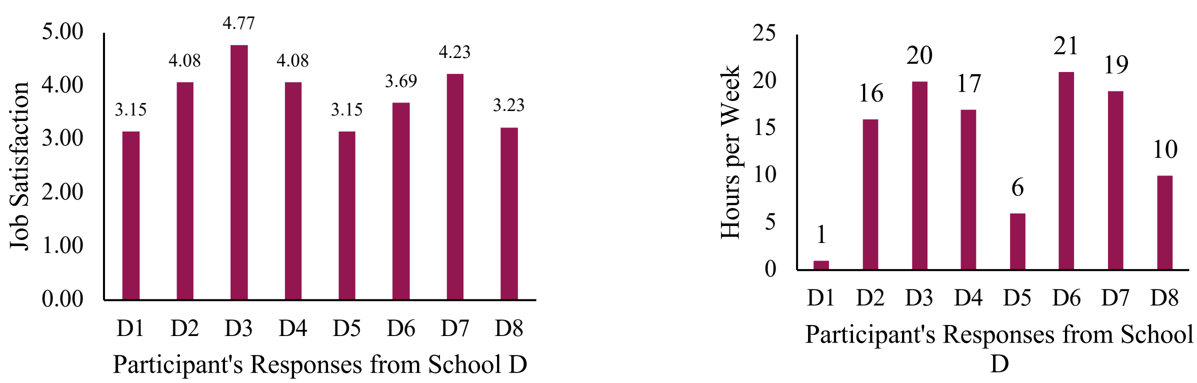


Figure 8. Survey responses to job satisfaction and hours per week spent fulfilling responsibilities beyond classroom instruction for School D.

On average, teachers from all four schools spent 12.79 hours per week working beyond contractual hours completing duties to needed to prepare for their work. Participant D1 spent the least amount of time beyond contractual hours grading student work, planning lessons individually, meeting with students and parents outside the class time, professional development, and keeping gradebooks up to date at one hour per week.

At School A, eight teachers spent more time grading student work, planning lessons individually, meeting with students and parents outside the class time, professional development, and keeping gradebooks up to date than 12.79 hours; at School B, eight teachers spent more time grading student work, planning lessons individually, meeting with students and parents outside the class time, professional development, and keeping gradebooks up to date than 12.79 hours; at School C had seven teachers spent more time grading student work, planning lessons individually, meeting with students and parents outside the class time, professional development, and keeping gradebooks up to date than 12.79 hours; and at School D had five teachers spent more time grading student work, planning lessons individually, meeting with students and parents outside the class time, professional development, and keeping gradebooks up to date than 12.79 hours. Participants D3 and D6 reported spending the most time per week with grading, planning, and keeping gradebooks up to date with more than 20 hours.

A Pearson correlation was computed to assess the relationship between the participants' job satisfaction and the additional hours spent beyond classroom instruction to complete duties for all responses. In Figure 9, a scatterplot summarizes the results.

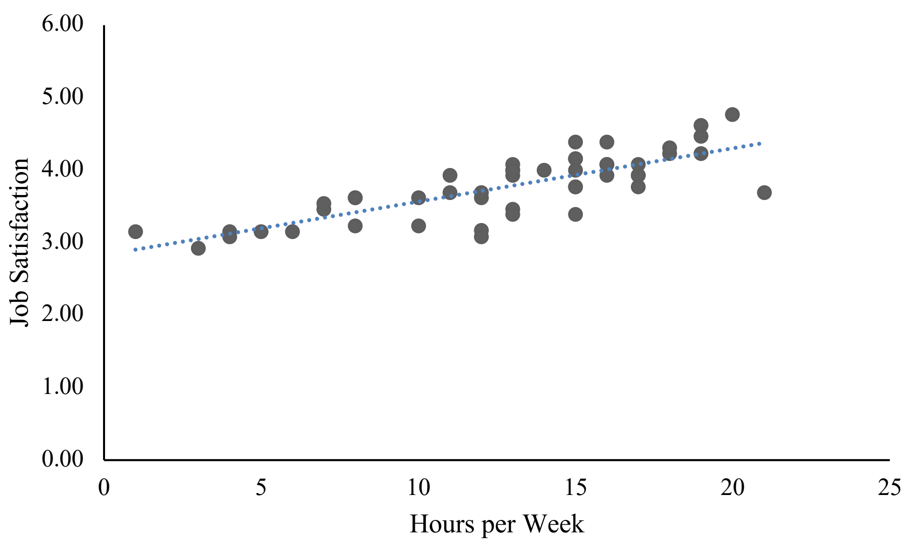


Figure 9. Scatterplot depicting a correlation between participant's job satisfaction and hours spent beyond classroom instruction fulfilling duties (N=48, r = 0.845, p=2.2109^{-11})

Results of the Pearson correlation indicated that there was a strong positive association between a teacher's job satisfaction and hours spent beyond classroom instruction to fulfill the duties of being a teacher r (46) = 0.791, p <0.001. The variables "job satisfaction" and "hours spent a week" had a positive linear, moderate, co-variance. As the number of hours spent beyond the classroom instruction increased, job satisfaction increases, and vice versa.

Teacher's math background. Since elementary teachers hold a multiple subject teaching credential, they can teach any grade level. Participants were asked seven questions about how prepared they felt teaching different concepts in mathematics based on the Common Core State Standard domains which include fractions, decimals, percentages, ratios and proportions, measurement, geometric figures, algebraic representation, interpretation of data in graphs, and simple probability. Participants ranked their responses from *none at all* (1) through *a great deal* (5). The researcher averaged the participants' responses to the seven questions and compared the results from Schools A and C (10% increase on CAASPP) with Schools B and D (less than 1% increase on CAASPP). See Figure 10.

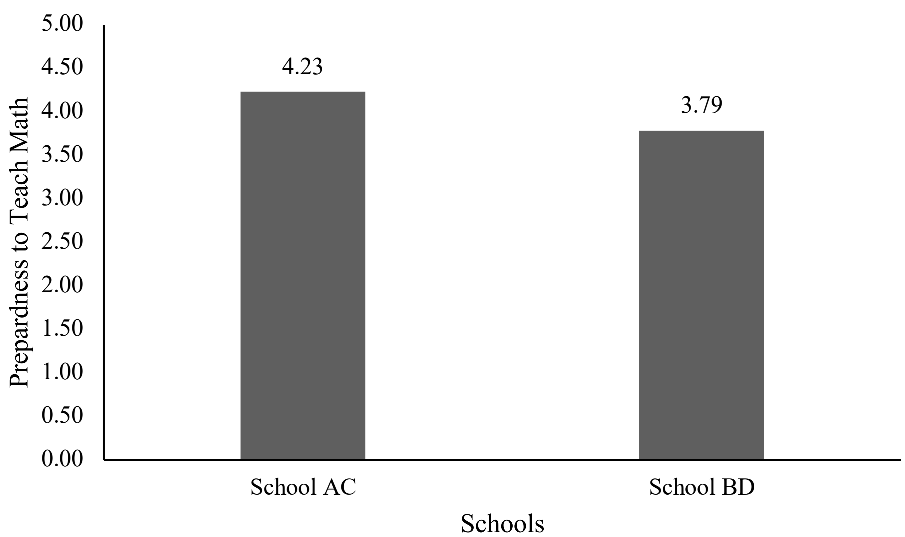


Figure 10. School responses on preparedness to teach math concepts on a Likert-scale of 1-5

A one-way analysis of variance (ANOVA) was completed and Bonferroni post-hoc test revealed significant differences between the teachers in Schools A and C (M=4.231) and Schools

B and D (*M*=3.786) in their preparedness to teach the various concepts in mathematics at the elementary level. The results revealed a significant main effect for the schools that showed a 10% increase and the schools that increased less than 1% $F(1, 46) = 5.32$, $p= 0.026$. See Table 3.

Table 3

ANOVA results on teachers' confidence to teach math concepts

Source of Variation	*df*	*SS*	*MS*	*F*	*p-value*
Between Groups	1	2.3604	2.3604	5.3221	0.0256
Within Groups	46	20.4011	0.4435		
Total	47	22.7615			

Use of district adopted mathematics curriculum. Teachers in XXX district use Common Core state approved curriculum in mathematics. Teachers who teach kindergarten through fifth grade have curriculum that was adopted in 2014. Teachers who teach sixth grade use a different adoption that was adopted in 2015. Sixth grade in XXX district follows the math curriculum of the junior high schools. Based on the pilot and adoption protocol set by the union and district, sixth grade adopted a different curriculum than the other grades at the elementary school. The survey asked participants how often in a calendar week, Monday through Friday, do they use the provided resources from the publishers. Responses ranged from *never* (1) to *daily* (6). See Figure 11 for participant responses kindergarten through fifth grade and Figure 12 for responses from sixth grade teachers.

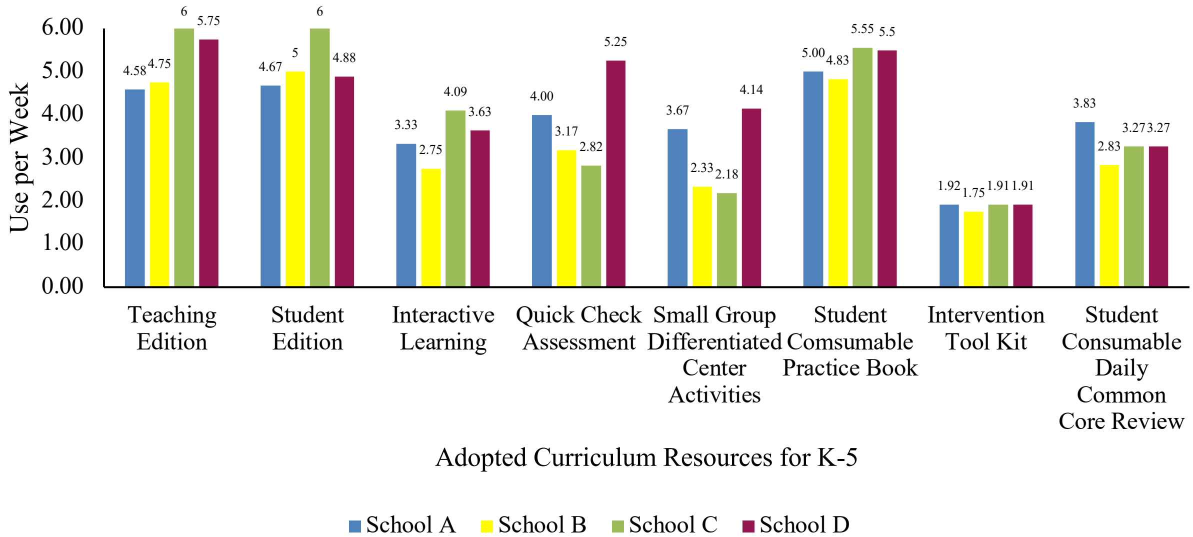


Figure 11. Use of curriculum resources in a calendar week for kindergarten through fifth grade classrooms.

Overall, the teaching edition, student edition, and student consumable practice book were utilized the most at all four schools throughout the week during math instruction. All four schools indicated that the intervention tool kit was the resource used the least by teachers. The quick check assessment resources had the largest range amongst the schools with School D using it almost daily and School C using it about 1-2 days a week.

A Likert-scaled question also asked how satisfied the participants felt with the provided resources. Responses ranged from *completely unsatisfied* to *complete satisfied*; respondents were asked to provide a narrative to their response. Those that use the kindergarten through fifth grade adoption felt the adoption "lacks rigor and spiral review" and the curriculum "does not align with the assessment." Some teachers reported that the curriculum "teaches all the standards and has everything they need for students to meet/exceed standards."

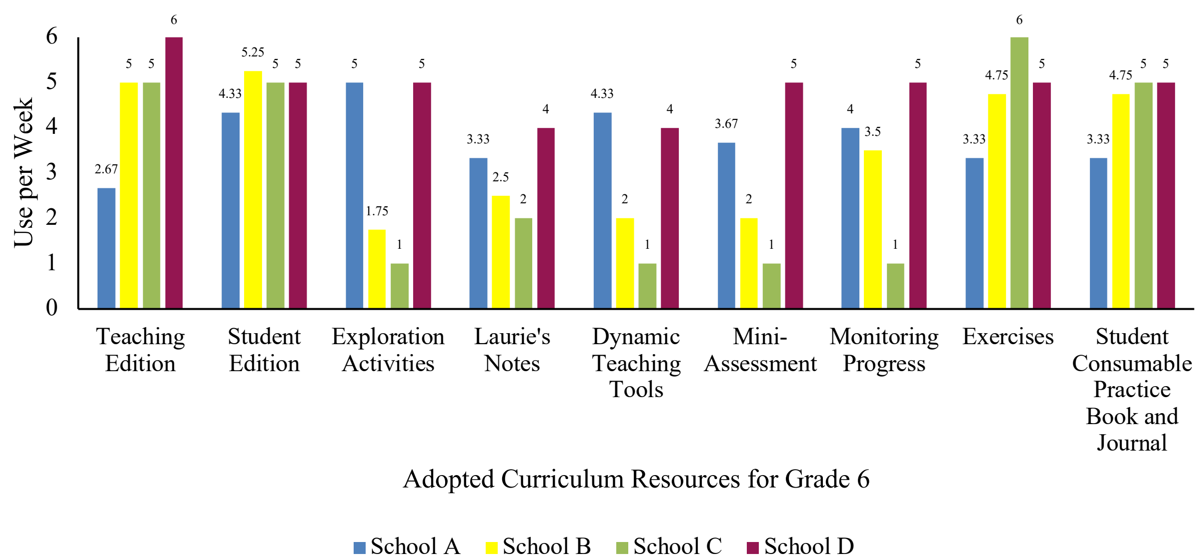


Figure 12. Use of curriculum resources in a calendar week for sixth grade classrooms.

Overall, sixth grade teachers used a variety of the provided resources from the publishers. The resource that was used consistently among the four schools was the student edition. The other resources varied significantly between the school sites. School D appears to utilize all the resources provided by the publisher the most. School C uses the publisher's resources the least indicating teachers never use the exploration activities, dynamic teaching tools, mini-assessment, and progress monitoring. A Likert-scaled question asked how satisfied the participants felt with the provided resources. Responses ranged from *completely unsatisfied* to *completely satisfied*;

respondents were asked to provide a narrative to their response. Teachers using the sixth-grade adoption felt that it was “rigorous” and “cumbersome to navigate.”

A Pearson correlation and an ANOVA analysis were conducted to determine if there were any statistically significant differences with curriculum usage between all four schools and between Schools AC and Schools BD. All results were insignificant with $p > 0.05$.

Instructional strategies and lesson design. The survey asked the participants about their beliefs about what skills students need to be good in mathematics and their own confidence in improving math understanding for students. There were six belief statements participants responded to regarding students’ ability in mathematics. There were nine belief statements participants responded to regarding their own confidence while teaching mathematics. See Table 4 for the question stem and responses from the survey. The participant responded to each statement using a Likert scale of *none at all* (1), *neutral* (3), and *a great deal* (5).

The researcher wanted to discover if there were differences in responses from Schools A and C, demonstrated a 10% increase on the CAASPP, versus Schools B and D, demonstrated less than 1% increase on the CAASPP. A one-way ANOVA was conducted for the six student ability questions and there was not a statistically significant difference between the responses.

A one-way ANOVA was conducted for the nine teacher confidence questions between Schools A and C, demonstrated a 10% increase on the CAASPP, versus Schools B and D, showed less than 1% increase on the CAASPP. There were three statistically significant differences amongst the responses. See Figure 13 for the first statistically significant difference; teacher responses towards providing challenging tasks for high achieving students.

Table 4

Belief Statements on Student Ability and Teacher Confidence from Teacher Survey

Question/Statement Stem	Response
To be good in mathematics at school, how important do you think it is for students to…	1. …remember formulas and procedures 2. …think in sequential and procedural manner 3. …understand mathematical concepts, principles, and strategies 4. …be able to think creatively 5. …understand how mathematics is used in the real world 6. …be able to provide reasons to support their solutions
In teaching mathematics to your class, how would you characterize your confidence in doing the following?	1. Inspiring students to learn mathematics 2. Showing students a variety of problem solving strategies 3. Providing challenging tasks for the highest achieving students 4. Adapting my teaching to engage students' interest 5. Helping students appreciate the value of learning mathematics 6. Assessing student's comprehension of mathematics 7. Improving the understanding of struggling students 8. Making mathematics relevant to students 9. Developing students' higher-order thinking

A one-way ANOVA was completed, and Bonferroni post-hoc test revealed significant differences between the teachers in Schools A and C (M=4.42) and Schools B and D (M=4.05) in their ability to provide challenging tasks for the highest achieving students in their class. See Table 5. The results revealed a significant main effect for the schools that showed a 10% increase and the schools that increased less than 1% on the CAASPP $F(1,46)=6.92$, $p=0.0116$.

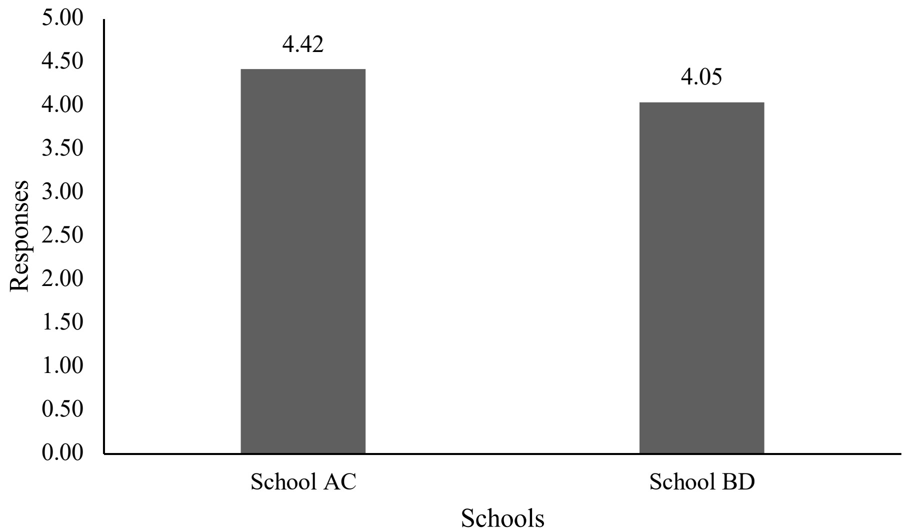


Figure 13. Teacher responses towards providing challenging tasks for the highest achieving students.

Table 5

ANOVA results from teacher responses to providing challenging tasks for highest achieving students in their class

Source of Variation	*df*	*SS*	*MS*	*F*	*p-value*
Between Groups	1	1.6993	1.6993	6.9171	0.0116
Within Groups	46	11.3007	0.2457		
Total	47				

The next statistically significant response for teachers' confidence in Schools A and C versus Schools B and D was the teachers' ability to adapt their teaching to engage students' interest in mathematics instruction. See Figure 14.

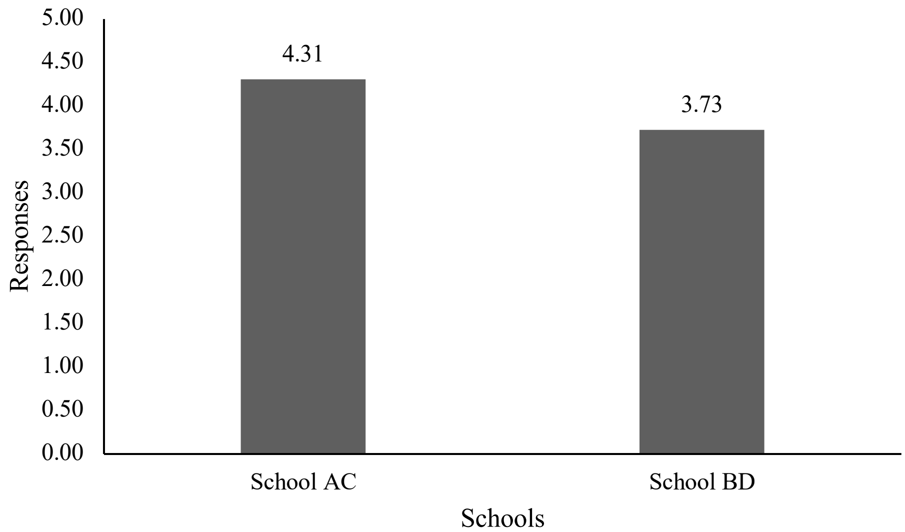


Figure 14. Teacher responses towards adapting their teaching to engage students' interest

A one-way ANOVA was completed, and Bonferroni post-hoc test revealed significant differences between the teachers in Schools A and C (*M*=4.31) and Schools B and D (*M*=3.73) in their ability to adapt their teaching to engage the students' interest in the lesson. See Table 6. The results revealed a significant main effect for the schools that showed a 10% increase and the schools that increased less than 1% on the CAASPP F (1,46)=6.62, p=0.0134.

Table 6

ANOVA results for participants' response to adapt teaching to engage students

Source of Variation	*df*	*SS*	*MS*	*F*	*p*-value
Between Groups	1	4.0146	4.0146	6.6185	0.0134
Within Groups	46	27.9021	0.6066		
Total	47	31.9167			

The last statistically significant differences in responses from school site A and C versus school site B and D was the teachers' confidence to help students appreciate the value of learning mathematics. See Figure 15.

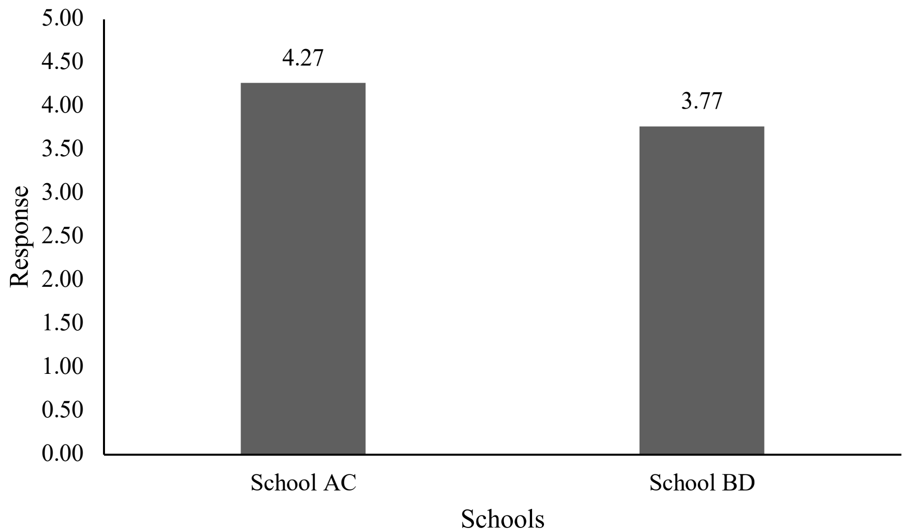


Figure 15. Teacher responses on their confidence to help students appreciate the value of learning mathematics.

A one-way ANOVA was completed, and Bonferroni post-hoc test revealed significant differences between the teachers in Schools A and C (M=4.27) and Schools B and D (M=3.77) in their ability to adapt their teaching to engage the students' interest in the lesson. See Table 7. The results revealed a significant main effect for the schools that showed a 10% increase and the schools that increased less than 1% on the CAASPP $F(1,46)=5.01$ $p=0.0301$.

Table 7

ANOVA results on teachers' confidence to help students appreciate mathematics

Source of Variation	*df*	*SS*	*MS*	*F*	*p*-value
Between Groups	1	2.9377	2.9377	5.0088	0.0301
Within Groups	46	26.9790	0.5865		
Total	47	29.9167			

The following factors had insignificant statistical impact for teacher confidence between Schools A and C, demonstrated 10% gain on CAASPP, and Schools B and D, showed less than 1% growth on CAASPP: inspiring students to learn mathematics; providing challenging tasks for the highest achieving students; assessing student's comprehension of mathematics; improving the understanding of struggling students; and developing students' higher-order thinking skills.

The researcher also sought to discover if there was a relationship between the participant beliefs on student ability and teacher confidence. An average was computed for the seven student ability questions and an average was computed for the nine teacher ability questions. A Pearson correlation was conducted, and Figure 16 summarizes the results.

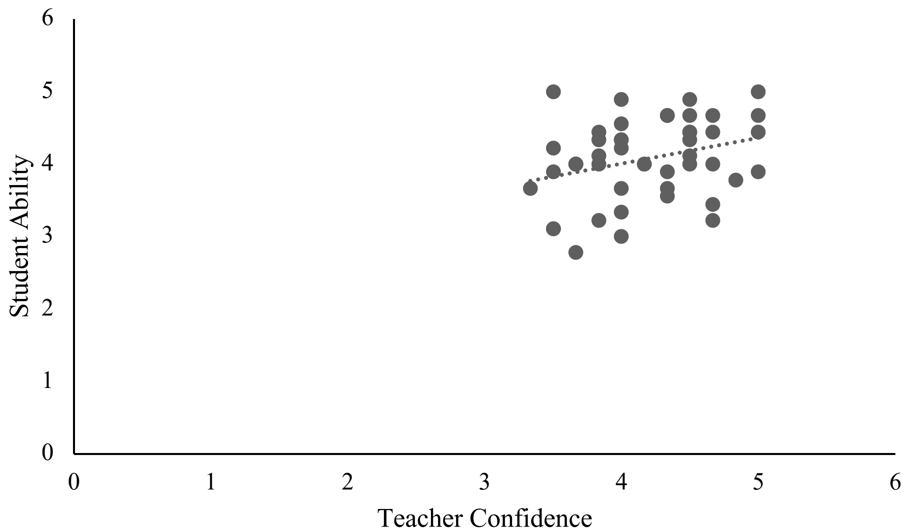


Figure 16. Scatterplot depicting a correlation between participant's responses on student ability and teacher confidence (*N*=48, *r*=0.305, *p*=0.035)

Results of the Pearson correlation indicated that there was a moderate positive association between a teacher's belief on student abilities to be good in mathematics and their own confidence to teach mathematics *r*(46)=0.305, *p*=0.035. The variables have a positive linear, moderate, co-variance. The stronger a teacher feels about their ability to teach mathematics effectively, the easier it is for them to believe that their student will succeed in mathematics. Research has found when a teachers' confidence increases due to successes and support, student achievement increases as well (Donohoo et al., 2018; Goddard et al., 2004). Also, teachers have to set expectations for themselves and set high student expectations for what kids need to learn; to do this, the teacher needs to have individual efficacy on their ability to teach the concepts well (Barkley, 2019).

The survey had 19 questions regarding activities used during mathematics instruction and student engagement activities. Participants selected how often they used each strategy per week ranging from *never or almost never* (1) to *always or almost always* (5). The researcher calculated the percentage for each strategy and activity by school site. The researcher intentionally mixed questions on the survey, but for analysis purposes responses are chunked into four themes: (a) engagement strategies before the lesson, (b) teacher directed strategies, (c) engagement strategies during the lesson, and (d) student centered activities.

Engagement strategies prior to beginning instruction allows students to make connections to their learning and become absorbed in the lesson. The survey contained two questions regarding engagement strategies prior to instruction. Table 8 indicates the responses from Schools A, B, C, D, and combined responses for the percent the strategies are used in an instructional week. Teachers from the four school sites bridge new learning with the students' prior knowledge or preconceived ideas.

Table 8

Engagement Strategies Before the Lesson (*N*=48)

Instructional Strategy and Student Engagement	School A (*n*=14)	School B (*n*=14)	School C (*n*=12)	School D (*n*=8)	All Schools (*n*=48)
Relate the lesson to students' daily lives	81.43%	81.43%	83.33%	77.5%	81.25%
Link new content to students' prior knowledge	88.57%	81.43%	90%	87.5%	86.67%

The lowest strategy reported was from School D, relating the lesson to students' daily lives, at about 77.5% of the week. A Pearson correlation was computed to determine if there was a relationship between relating the lesson to students' daily lives and linking new content to students' prior knowledge and there is a moderate positive correlation, $r(46)=0.507$, $p=0.0002$.

Five strategies from the survey focused on teacher directed and guided strategies that are used during mathematics instruction. These strategies are needed in order to teach students new concepts and ideas but should be balanced with other instructional strategies to ensure conceptual understanding for students. The responses for the strategies used during an instructional week are listed in Table 9. Overall, all schools indicated that having students memorize rules, procedures, and facts is used the least throughout the week at 59.17%. The strategy that is used the most was having students work on problems with direct guidance from the teacher. The instructional strategy with the widest range was having students listen to the teacher explain how to solve a problem with School C using the strategy 85% of the week and School D using the strategy 67.5% of the week.

Table 9

Teacher Directed Strategies

Instructional Strategy and Student Engagement	School A (*n*=14)	School B (*n*=14)	School C (*n*=12)	School D (*n*=8)	All Schools (*n*=48)
Listen to me explain new mathematics content	71.43%	81.43%	85%	75%	78.33%
Listen to me explain how to solve problems	71.43%	80%	85%	67.5%	76.67%
Memorize rules, procedures, and facts	50%	61.43%	65%	62.5%	59.17%
Work problems (individually or with peers) with my guidance	78.57%	78.57%	85%	87.5%	81.67%

Work problems together in the whole class with direct guidance from me	82.86%	81.43%	88.33%	85%	84.17%

A Pearson correlation was conducted to determine if there were any relationships between the five teacher directed strategies. Table 10 lists the strategies that had statistically significant outcomes. There were nine statistically significant correlations between the teacher directed and guided strategies. There was a strong correlation between listening to the teacher explain how to solve a problem and listening to the teacher explain new math content, $r(46)=0.821$, $p<0.0001$.

Table 10

Correlation Between Teacher Directed Strategies (N=48)

Variable vs. Variable	*R*	*p*-value
Listen to me explain how to solve problems vs. Listen to me explain new mathematics content	0.8291	0.0000*
Memorize rules, procedures, and facts vs. Listen to me explain new mathematics content	0.4037	0.0044
Memorize rules, procedures, and facts vs. Listen to me explain how to solve problems	0.3139	0.0298
Work problems (individually or with peers) with my guidance vs. Listen to me explain new mathematics content	0.3199	0.0266
Work problems (individually or with peers) with my guidance vs. Listen to me explain how to solve problems	0.3040	0.0357
Work problems (individually or with peers) with my guidance vs. Memorize rules, procedures, and facts	0.3997	0.0049

Work problems together in the whole class with direct guidance from me vs. Listen to me explain new mathematics content	0.6467	6.8327^{-7}
Work problems together in the whole class with direct guidance from me vs. Listen to me explain how to solve problems	0.5678	0.0000*
Work problems together in the whole class with direct guidance from me vs. Work problems (individually or with peers) with my guidance	0.5255	0.0001

Note. *$p<0.0001$*

There was a moderate correlation between having the class work together on problems with guidance from the teacher and listening to the teacher explain how to solve problems, $r(46)=0.5678$, $p<0.0001$. There was a moderate correlation between working problems together with guidance from the teacher and having students work individually or with a peer along with teacher support, $r(46)=0.5255$, $p=0.0001$. Having students work problems together with guidance from the teacher and listening to the teacher explain new math content were moderately correlated, $r(46)=0.6467$, $p=6.8327^{-7}$.

Weak correlations exist between the following variables: working on problems with direct guidance from the teacher and memorizing rules, procedures, and facts, $r(46)=0.3997$, $p=0.0049$; working on problems individually or with peers with guidance from the teacher and listening to the teacher explain how to solve math problems, $r(46)=0.3040$, $p=0.0357$; memorizing rules, procedures, and facts and listen to the teacher explain how to solve problems, $r(46)=0.3139$, $p=0.0298$; working on problems individually or with peers with guidance from the teacher and listening to the teacher explain new math concepts, $r(46)=0.3199$, $p=0.0266$; and memorizing rules, procedures, and facts and listening to the teacher explain new math content, $r(46)=0.4037$, $p=0.0044$.

The next theme that was analyzed was engagement strategies during the lesson. The three strategies listed in Table 11 are embedded within a lesson to allow students to be more active in their learning. Participants indicated that they use visual representations and completing word problems the most throughout the week. The participating teachers from School C had students complete word problems frequently throughout the week (96.67%).

Table 11

Engagement Strategies During the Lesson

Instructional Strategy and Student Engagement	School A (*n*=14)	School B (*n*=14)	School C (*n*=12)	School D (*n*=8)	All Schools (*n*=48)
Use visual representation	84.29%	82.86%	86.67%	82.5%	84.17%
Complete word problems	72.86%	84.29%	96.67%	85%	84.17%
Incorporate metacognitive strategies	65.71%	71.43%	78.33%	70%	71.25%
Conduct math talks and discussions	68.57%	68.57%	88.33%	60%	70.83%

Pearson correlations were conducted to determine if there was a relationship between the three engagement strategies that are used during the lesson. Having students complete word problems and the use visual representations such as manipulatives, number lines, pictures, graphic organizers, etc. were weakly correlated, $r(46) = 0.29$, $p=0.045$. There was a moderate correlation with students using metacognitive strategies and using visual representations, $r(46) = 0.499$, $p>0.001$; a moderate correlation with students conducting math talks and using visual representations, $r(46) = 0.433$, $p=0.002$. Having students complete word problems and incorporate metacognitive strategies has a moderate correlation, $r(46) = 0.478$, $p<0.001$. There was a moderate correlation with students conducting in math talks and using metacognitive strategies, $r(46) = 0.538$, $p<0.001$.

The last theme for instructional strategies was student centered activities. The five instructional strategies listed in Table 12 asked if the teachers provide students opportunities to work with greater depth and understanding of math concepts beyond recall. Typically, these strategies are used to extend students' understanding of mathematics and it is used after initial instruction. Overall, the strategies that were reported being used the most were asking students to explain their answers (87.08% of the week) and encouraging students to express their ideas in class (89.17% of the week). Having students verbalize their responses can serve as a formative assessment for teachers. The strategy that was used the least by all four schools was having students work on problems without an immediate solution with 52.08% of the week.

Pearson correlations were computed to assess the relationship between the five student centered activities and significant strategies are listed in Table 13. There was a moderate correlation between students completing challenging exercises and having students explain their answers $r(46)=0.4945$, $p=0.0004$. There was a moderate correlation between asking students to decide their own problem solving procedure and asking students to explain their answers $r(46)=0.5358$, $p<0.0001$; there was also a moderate correlation between asking students to decide their own problem solving procedure and asking students to complete challenging exercises beyond instruction $r(46)=0.6958$, $p=4.02942^{-8}$.

Table 12

Student Centered Activities

Instructional Strategy and Student Engagement	School A (*n*=14)	School B (*n*=14)	School C (*n*=12)	School D (*n*=8)	All Schools (*n*=48)
Ask students to explain their answers	87.14%	85.71%	93.33%	80%	87.08%
Ask students to complete challenging exercises that require them to go beyond the instruction	64.29%	61.43%	80%	60%	66.67%
Ask students to decide their own problem-solving procedures	70%	67.14%	78.33%	70%	71.25%
Encourage students to express their ideas in class	88.57%	90%	90%	87.5%	89.17%
Work on problems with no obvious solution	47.14%	55.71%	58.33%	45%	52.08%

A weak correlation occurred between encouraging students to express their ideas in class and having students pick their own problem solving procedure $r(46) = 0.3229$, $p=0.0252$. There were two weak correlations with having students work on problems with no obvious solution: asking students to complete challenging exercises beyond instruction $r(46) = 0.2946$, $p=0.0421$; asking students to decide their own problem solving procedure $r(46) = 0.2871$, $p=0.0478$.

There were four correlations among the student centered activities that had insignificant statistical impact: encourage students to express their ideas in class vs. ask students to explain their answers; encourage students to express their ideas in class vs. ask students to complete challenging exercises beyond instruction; work on problems with no obvious solution vs. ask students to explain their answers; and work on problems with no obvious solution vs. encourage students to express their ideas in class.

Table 13

Correlation Between Student Centered Activities (N=48)

Variable vs. Variable	*R*	*p*-value
Ask students to complete challenging exercises that require them to go beyond instruction vs. ask students to explain their answers	0.4945	0.0004
Ask students to decide their own problem-solving procedures vs. ask students to explain their answers	0.5358	0.0000*
Ask students to decide their own problem-solving procedure vs. Ask students to complete challenging exercises beyond instruction	0.6958	4.02942^{-8}
Encourage students to express their ideas in class vs. Ask students to decide their own problem-solving procedure	0.3229	0.0252
Work on problems with no obvious solution vs. Ask students to complete challenging exercises beyond instruction	0.2946	0.0421
Work on problems with no obvious solution vs. Ask students to decide their own problem-solving procedure	0.2871	0.0478

*Note. *p<0.0001*

Participants indicated they have students work in mixed ability groups more than having students work in same ability groups during mathematics instruction. See Table 14.

Table 14

Student Grouping During Mathematics Instruction

Instructional Strategy and Student Engagement	School A (*n*=14)	School B (*n*=14)	School C (*n*=12)	School D (*n*=8)	All Schools (*n*=48)
Work in mixed ability groups	70%	81.43%	81.67%	65%	75.42%
Work in same ability groups	68.57%	67.14%	63.33%	57.5%	65%

Responses to Research Question One: Administrator Interviews

Instructional strategies and administrative support. The researcher interviewed four principals for the qualitative phase of the study. The interview protocol consisted of 16 open ended questions. Two sections of the interview were used to address research question one. Table 15 displays responses from site administrators of the various math strategies observed during classroom observations.

Common themes from administrator interviews. After looking at the transcription of the interviews from the administrators, the researcher was able to identify common strategies that were observed during classroom observations. These included math talks, visual representations, multiple methods to solve a problem, differentiated instruction, and conceptual understanding.

Math talks. All school sites mentioned some type of math discussion and the site administrators building their teachers' capacity to help students' conceptual understanding in mathematics. School A, B, and D spent time training their staff on conducting math talks with students. The site administrators found evidence of math talks occurring in the classroom through their classroom visits and observations.

School C models their math talks after a video titled "My Favorite Wrong" where the teacher spends time with the class going over student mistakes and the class has to find the error and correct it. All four schools have created a space where students can openly discuss mathematics and demonstrate their understanding verbally. When students talk, they think and talking provides students with practice and an opportunity to clarify their understanding.

Visual representations. The use of manipulatives was mentioned by two sites (School B and School D) which gives students concreate examples of visual representations. The administrator in School C mentioned that the staff is working on conceptual understanding and including "hands on type of things" instead of the traditional "rote" work in the classrooms.

Table 15

Site Administrator's Responses Towards Math Strategies Observed in the Classroom

Administrator	Observations Shared
School A	"We have been doing a lot of Math Talks. That's a big thing and you can find those in quite a few rooms, or if not all of them at one time or another."
	"Many of my grade-levels, they teach a whole lesson for a very short amount of time, the basic concept, and then they're doing a lot of math centers. That gives the teacher time to pull back each group. It gives the teacher the time, instead of the traditional teacher just being up their instructing."
	"We had math intervention after school where the kids come with their homework and if they didn't understand it then the intervention teacher would pull kids back either one-on-one or small groups."
School B	"Manipulatives, number talks, small group instruction, and reteaching"
	"Direct instruction, think-pair-share"
	"I've seen the use of whiteboards for checking for understanding with non-volunteers. The [teachers] use interactive notebooks for mathematics. They've done buddy math as well. The older kids will help and do collaboration with the younger ones and teach them math."
School C	"We've really been pushing on hard is the conceptual knowledge. So, helping our teachers to understand that, that is a huge component. A lot of times they want to go back to the rote stuff, but we've really been pushing that. So, a lot of conceptual, hands on type of things."

	"We've also been focusing on error analysis. We've been doing student led error analysis. Students go through and identify errors as a group. We kind of modeled it after… My Favorite Wrong… that's what we used to work with our teachers in doing that, is that model for error analysis. So that was big the conceptual hands-on error analysis."
School D	"Manipulatives, academic vocabulary, close reading within problem solving"
	"We started the last couple years with math talks… commit to two or three times a week."
	"Also looking at conceptualizations, really looking at that. It's providing different ways to answer the questions, as well as to show their work. They can have two or three different ways to show their work, so the teacher will provide two or three different ways to give examples on how to answer the question."

Multiple methods to solve problems. The site administrator from School D mentioned the use of this strategy in the classrooms at their site. The teacher provides "two or three different ways to solve a problem" which helps students understand that there are multiple methods to solve problems.

Differentiated instruction. School A and School B shared that their teachers utilize small group instruction during mathematics time. This allows the teacher to work with a few students to develop mathematical understanding.

Conceptual understanding. School C and School D mentioned the push for conceptual understanding with mathematics. Both administrators shared that they have spent time working with their teachers to deepen their understanding to bring back to the classroom.

Research Question Two

What is the relationship between how much time is spent in Professional Learning Communities (PLCs) and student achievement? The researcher used the teacher survey to answer this research question. The survey was able to capture specific time spent in PLCs and also the four essential questions for PLCs. Site administrators gave qualitative data for their staff's participation in PLCs and also school site Professional Development in mathematics. The researcher also asked the administrators to identify any additional factors that could have impacted the student achievement at their school site.

Response to Research Question Two: Teacher Survey

Time spent discussing mathematics. XXX district's teacher contract states that teachers must spend 45 minutes a week working in Professional Learning Communities. The 45 minutes are built into the contracted hours as students are released early once a week. The researcher asked participants to indicate within the 45 minutes, how often they spent discussing mathematics with their grade-level teams. See Figure 17. The majority of the participants spent less than half the contractual PLC time discussing mathematics with their grade-level teams; 28 teachers indicated that they spent 20 minutes or less. 15 teachers indicated they spent 21-30 minutes discussing mathematics and one teacher stated her team discussed mathematics for more than 40 minutes.

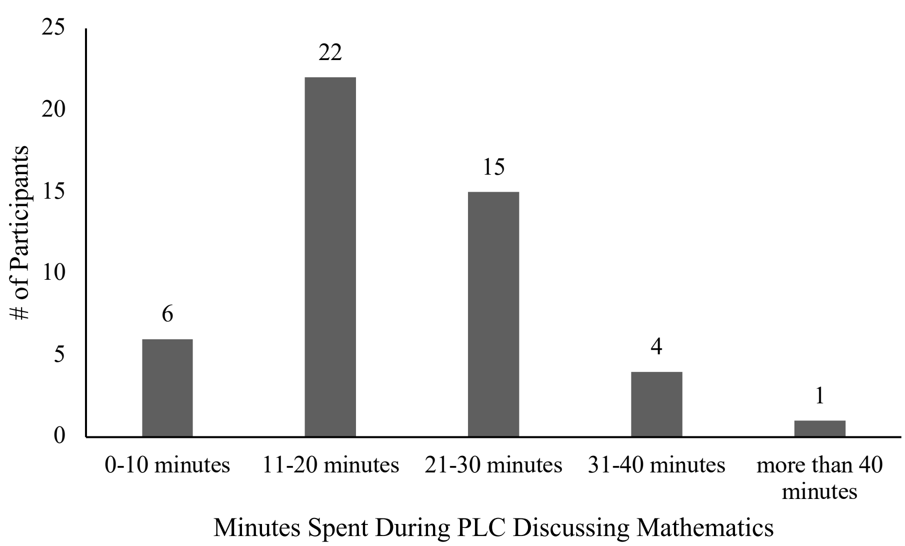


Figure 17. Time spent discussing mathematics in contracted PLC time.

A follow up question asked teachers if they spend time beyond the contracted 45 minutes to discuss mathematics. In School A, 79% (*n*=11) of the participants indicated that they spend additional time throughout the week discussing mathematics with their grade-level teams. The duration ranged from 10-20 additional minutes per week to 60-90 additional minutes per week. For School B and School C, 64% (*n*=9) and 75% (*n*=9) of the participants indicated they spend additional time ranging from 10 minutes to daily. School D had 63% (*n*=5) of the participants spending time throughout the week to discuss mathematics. Their responses indicated 20 minutes to an hour. All four schools have more than half of their teachers collaborating beyond their contractual obligations discussing mathematics.

Four essential questions in PLCs. The survey included twelve questions that align with the four essential questions in a PLC: (1) What do we want students to learn? (2) How will we know if they have learned? (3) What will we do if they don't learn? (4) What will we do if they already know it? (DeFour, DeFour, Eaker, Many, 2010). Participants responded to the twelve questions and a percentage was calculated based on their response to indicate how they work in PLC teams.

The teachers at all four schools demonstrated comfort with discussing PLC questions one and two –"what they want students to learn? and how they know students learned it"? The responses from each school can be seen in Table 16. Overall, School D appeared to have collaborated in grade level teams the least (70%) when compared to the other schools. The teachers in School D indicated that they spent less time than Schools A, B, and C in discussing instructional strategies, discussing how to teach a topic, and collaborating and preparing instructional materials. However, School D adjusted lesson plans based on assessment results the more often when compared to the other three schools.

Table 16

Question 1 and 2 – What do we want students to learn? How will we know if they have learned?

	School A (*n*=14)	School B (*n*=14)	School C (*n*=12)	School D (*n*=8)	All Schools (*n*=48)
Discuss instructional strategies	84.29%	74.29%	78%	65%	76.67%
Discuss how to teach a particular topic	70%	72.86%	70%	60%	69.17%
Collaborate in planning and preparing instructional materials	77.14%	77.14%	75%	70%	75.42%
Compare assessment results	81.43%	68.57%	75%	70%	74.17%
Change lesson plans based on assessment results	74.29%	75.71%	73.33%	77.5%	75%

A one-way analysis of variance (ANOVA) was completed and Bonferroni post-hoc test revealed significant differences between the teachers in Schools A and C (M=4.0769) and Schools B and D (M=3.5454) in discussing instructional strategies in their grade-level teams. The results revealed a significant main effect for the schools that showed a 10% increase and the schools that increased less than 1% $F(1, 46) = 4.15$, $p= 0.047$. See Table 17. Nancy Frey discussed with Steve Barkley on his podcast, Ponder Out Loud (2019), that if surgeons did not discuss their practices and watched surgeries, there would be a missing link to their learning and ability to improve; this idea applies to teachers in improving their teaching practices as well. Teachers that discuss their teaching practices and have the opportunity to observe each other teach have a better idea on how to move their students forward in the PLC process (Barkley, 2019).

The following factors did not have statistically significant differences in responses between Schools A and C and Schools B and D: discuss how to teach a particular topic, collaborate in planning and preparing instructional materials, compare assessment results, and change lesson plans based on assessment results.

Table 17

ANOVA results for discussing instructional strategies in PLCs

Source of Variation	*df*	*SS*	*MS*	*F*	*p-value*
Between Groups	1	3.3660	3.3660	4.1510	0.0474
Within Groups	46	37.3007	0.8109		
Total	47	40.6667			

The teachers at the four schools were comfortable in discussing PLC questions three and four – “what needs to be done if students need additional support?” and “if they have already mastered the content?*;* see Table 18. School A spent the least amount of time discussing reteaching and enrichment opportunities (67.14%) compared to the other schools. However, School A spent more time than the other schools discussing student grouping after assessments (70%).

A Pearson correlation was computed to determine if there was a relationship between discussing groupings and deciding reteaching and enrichment opportunities for teachers. There is a moderate correlation between the two topics, $r(46) = 0.6638$, $p = 2.7145^{-7}$.

Table 18
Question 3 and 4 – What will we do if they don't learn? What will we do if they already know it?

	School A (n=14)	School B (n=14)	School C (n=12)	School D (n=8)	All Schools (n=48)
Decide reteaching and enrichment opportunities	67.14%	75.71%	75%	72.5%	72.5%
Discuss grouping students based on assessment results	70%	68.57%	66.67%	67.5%	68.33%

There were five questions from the survey that focused on building teacher capacity when working in Professional Learning Communities. The discussions in PLCs should focus on the four questions stated earlier, but in order to meet students' needs teachers must be willing to discuss their work and help each other. If one teacher can yield positive assessment results, it is valuable for that teacher to share the strategies used with the team in hopes to positively impact more students.

Overall, the teachers shared their own teaching experiences the most with their grade level teams. All four schools reported visiting other classrooms occur the least. The strategy with the widest range of responses was working with teachers from other grade levels to ensure continuity with School D at the lowest (32.5%) and School C at the highest (61.67%). See Table 19 for responses from Schools A, B, C, and D on building teacher capacity.

A Pearson correlation was conducted to determine if there was a relationship between the different survey questions for building teacher capacity. A moderate correlation exists for teachers sharing their teaching experiences and working as a group to try new ideas, $r(46)=0.5289$, $p=0.0001$. Sharing teaching experiences and working as a group to implement curriculum was moderately correlated, $r(46)=0.5287$, $p=0.0001$. Working together to try new ideas and working as a group to implement curriculum had a moderate correlation, $r(46)=0.5841$, $p=0.0001$. There was a weak correlation between visiting other teacher's classrooms and working with teachers from other grades to ensure continuity in learning, $r(46)=0.3859$, $p=0.0057$.

Table 19

Building Teacher Capacity

	School A (*n*=14)	School B (*n*=14)	School C (*n*=12)	School D (*n*=8)	All Schools (*n*=48)
Share what I have learned about my teaching experiences	78.57%	68.57%	75%	65%	72.5%
Visit another classroom to learn more about teaching	40%	44.29%	35%	25%	37.5%
Work together to try new ideas	74.29%	70%	65%	40%	65%
Work as a group on implementing the curriculum	74.29%	75.71%	68.33%	57.5%	70.42%
Work with teachers from other grades to ensure continuity in learning	37.14%	55.71%	61.67%	32.5%	47.92%

There were six statistically insignificant relationships for building teacher capacity: sharing teaching experiences vs. visiting another classroom, sharing teaching experiences vs. working with teachers from other grades, visiting another classroom vs. work as a group to implement curriculum, working together to try new ideas vs. working with teachers from other grades, and working as a group to implement the curriculum vs. working with teachers from other grades.

Responses to Research Question Two: Administrator Interviews

Staff's participation in PLC. The four administrators were asked to share how their school site utilizes the weekly PLC time. Contractually, teachers must participate in the 45-minute PLC session and one monthly staff meeting. As an administrator, these meetings are the only time where the entire staff will be together for any training, professional development, or meetings without having to be compensated. The researcher wanted to see how each school site utilized the 45-minute PLC session and what the teachers were doing during this time. See Table 20 for the administrator's responses.

Strengths of each school. The researcher asked each administrator what their staff's strength was based on the four PLC questions. School A, School B, and School D shared that the area of strength is PLC question one; what do they want students to learn? The teachers were intentionally meeting and talking about data. The teachers are utilizing assessments to drive their data points and discussions. School C's strength is PLC question two; how will we know students have learned it? The teachers were familiar with looking and analyzing data to identify students and their instructional needs.

Area of growth for each school. The researcher also asked each administrator to identify an area of growth for their based on the four PLC questions. School A and School D shared an area of growth for their staff would be PLC question four; what do we do if students already know the material or after intervention is completed? School B's area of growth is question three and four; the staff needs to work on differentiating instruction for students who need additional support and those that have demonstrated mastery. School C believes her staff can get better at PLC question one – what do we want students to learn? She wants to see her staff improve on first best instruction and pinpointing within the standard what students need help with.

Common themes from administrator interviews. After looking at the transcription of the interviews from the administrators, the researcher was able to identify common themes from each school site's staff PLC participation.

Table 20

Site Administrator's Responses Towards Their Staff's Participation in PLC

Administrator	Responses Shared
School A	"They've been bringing data, and they look at their data. They're really planning around that. They've been writing CFAs. This actually has been really, really good. You can see them around the FAST scores, there'll be all looking at their benchmarks when they first finish that. They'll bring their CFAs to group. I mean they're using it the way it's supposed to be. They're doing a pretty good job with it."
	"Once a month, we do whole group. More if I need it, but I try to let them stay in their small groups, and they just stay in the classroom, and then my AP and I walk the classrooms to interact with them."
School B	"So the majority of our weekly PLC times is by grade level. But as of last year, and we've done more this year, we have implemented more vertical articulation. I do take a handful of them and when I say handful, I want to say probably four or probably four or five in throughout the year where we do an all staff PLC of some sort. The only rule was is that they had to meet at their grade level chairs room. So that my AP and I can then go visit them and make sure we knew where they were, so we weren't having to go through all the classrooms."
	"I don't think, well I know for a fact, prior to me it was never, it was not common practice to analyze data. I really don't think they really dove deep into the data. They just kind of threw all the data on this sheet."

School C	"So, the way they've been utilizing the weekly PLC time is to identify the essential standards. And we're moving into just the planning and the instruction component, understanding that best instruction is going to get us the most bang for our buck. So really working together as a team and creating units, or our plans, for instruction and remediation. So they've been doing that during PLC. I've really focused on giving them that PLC time for PLC."
	"It's been a little bit of whole group. And then most of the time it's grade level groups, and vertical articulation. So, we've been doing a lot of vertical articulation. The idea of Kinder met with first, and towards the end of the year. If there was only one thing that kinder could do for you in these last six weeks of school, what would it be that you want them to do? Just setting goals and working like that, in each grade level above and below that they'd been meeting with for that vertical articulation."
School D	"When we had the big goals, when we talked about SBAC, I would get them all in a group. There were times when we did also separate to discuss FastBridge. I would discuss with that teacher individually and I would discuss it as a grade level. Sometimes I did meet with them by grade level or by grades four, five, and six, primary and elementary. So it would vary but it was just trying to plant the seed of what discussions should be happening when they are meeting with their teammates."

Vertical articulation. A common theme that was brought up by administrators from School B and School D is facilitating vertical articulation with their staff during PLC time. This allows the staff to discuss instructional needs with the adjacent grade-levels to the grade-level they are teaching.

Whole group PLC. Every school site conducts whole group PLCs at least once a month. When the administrator sees a need to have discussions with the entire staff, they will arrange for the time to be spent whole group. All administrators mentioned that they honor the PLC time and usually will let their staff work in small groups or grade-level teams unless they really need them.

Data. Every school site mentioned data being discussed and used during PLCs. The School A administrator talked about her staff working on writing Common Formative Assessments (CFAs). In order for her teachers to do this, they must bring their data and analyze the data and teams. The administrator at School B talked about her staff getting comfortable at looking at their data over the past two years. It was not "common practice to analyze data" prior to her leadership. School C's administrator shared that the strength of her staff is their ability to analyze data. The staff at the site is able to "pinpoint and figure it out quickly" with next steps after looking at the data. School D's administrator sets up small groups or individually meets with teachers to discuss SBAC scores and FastBridge data; FastBridge is the universal screening tool that has been adopted by XXX district for the past five years.

School site professional development and learning. The principals at the four schools were asked to share how they led their staff towards improvement in mathematics and planning for school site professional development. See Table 21 for principal responses.

Common themes from administrator interviews. After looking at the transcription of the interviews from the administrators, the researcher was able to identify common practices for professional development.

Table 21.

School Site Support/Professional Development and Needs for Mathematics Instruction

Administrator	Support Shared
School A	"We pulled grade-levels out for the whole day and did a training. [We] went through the standards with the textbook… what you don't need, what you do need, and all that kind of stuff. I think that was big. And the teachers loved that. They really started to see the correlation, and it took pressure off of them. I know

	after we met with fifth grade, for example, they realized that the most questions was something they were teaching at the very last minute. They redid their entire pacing and planning." "We had a math assembly for each grade-level. It was all hands on. The students would go from station to station and they each had an hour that day. That was pretty awesome. And then that night, we did it with the parents. The students brought their parents for a family nigh and did math with their child." "I think the big thing has really for them to drill down and looking at the data, and the trying to make connections between and resorting the whole math lessons, and structures, and that kind of stuff. I think those have really been small group instruction."
School B	"Additional manipulatives which I put into our school plan to purchase." "All staff, PLC or staff meeting work, was math related." "Full time intervention teacher that focuses on mathematics for students grades one through six."
School C	"And then the other one is our data chats, I think is a huge component as well. Not looking at a student, as a good student or a bad student, but this is what the student knows, and this is what the student needs help with, I think is kind of a key component. Instead of just looking at, oh he's a good student. Looking at the data. The data doesn't lie."

	"We should know how students are going to perform on that assessment before we ever get there. And helping teachers to understand that homework is not a good judge of a student's ability, because they get support and help with that."
	"So, one of the things that we looked at this year is standardizing our approach to word problems and performance tasks. So we want to teach the kids one way and build and build and build and build instead of having them learn one way in Kindergarten, a different way, First grade a different way, and second grade a different"
School D	"After the district provided professional development for them, I allowed release time on things that they felt they needed to follow up on, to build on, or they felt there was a need. They were able to choose. They had all day, or they can break it up in two days, two half days. So some grade levels choose math in regards to again, how we're going to teach these things because we see that these are major concerns."
	"We had a grade level do a number talk for their grade level and everyone else participated as a way to just get comfortable of different ways on providing number talks in the different grade levels. We did that at staff meetings.

Grade-level professional development. School A and School C provided their staff professional development in mathematics by grade-level. This allowed the PD to be specific to the teachers' needs and in a small group environment. School A and School C both mentioned the use of data during the PD. As mentioned by the administrator at School C, "the data doesn't lie."

School D provided grade-level PD for the teachers at their site, but the teachers were able to pick which subject area to focus on. Therefore, mathematics could have been a focus if the grade-level chose that subject area. The grade-level PD focused on planning and how to bring the new learning back to the classroom.

School-wide professional development. School A held school-wide assemblies by grade-level that focused on mathematics. Each grade-level spent an hour working on hands on mathematics for an hour; then in the evening the students brought their parents to experience the same type of learning.

School B's administrator incorporates mathematics at every monthly staff meeting or whole-staff PLCs. School D also mentioned using staff meetings to model math talks and building the teacher's capacity there. School C utilized their staff meetings to standardized approaches and teaching across grade-levels.

Additional factors that contributed towards student achievement. The researcher asked the administrators if there were any additional factors that could have impacted their achievement results that they have not shared during the interview. Table 22 contains the responses from each administrator.

Common themes from administrator interviews. After looking at the transcription of the interviews from the administrators, the researcher was able to identify some common themes amongst the four schools with factors that could have impacted student achievement in mathematics.

Table 22

School Wide Initiatives or Other Information that Contributed Towards Math Improvement

Administrator	Initiatives Shared
School A	"That definitely would be student engagement, which is with our Kagan and definitely PBIS. Definitely those two I believe is what's helping to really change." "You know what, a lot of it is just changing the culture of the school, changing the culture of, just the discipline expectations. I mean you can't teach if you don't have a classroom under control. Just mutual respect, teachers also respecting students. I think I've been really big on pushing for my teachers to understand where our kids are coming from. And it doesn't mean they got free passes to things, but I think understanding their background, and being conscious of that, has been a big thing as well."
School B	"Staff training on UA time. Teachers really expressed, well their biggest concern with UA time is how do we find the time to develop five different lessons for the kids. So they really struggled with that. And it was genuine, it wasn't the, "I'm just being lazy and I don't want to do it." It was genuine, they were struggling with it. My instructional coach did a lesson

on how simple it could really be. And the teachers were divided into five different groups and did their rotation just like the students would in a classroom. So we modeled that for them."

"I think the key factors that helped us with it was just talking more about it. So the teachers felt like they weren't alone, in their own classrooms trying to figure it all out. So providing that time to collaborate and learn from each other, having that support from the instructional coach and administration to say, "We're in this together." But also administration saying, "You know what, we're not letting up." So we've got to do it. This is a non negotiable. And it's not because we want to win some award or anything like that, it's because that's what our kids deserve and that's our approach 100% of the time."

School C "Error analysis PD"

"I think my teachers' dedication, and a little bit of their competitiveness, and just wanting to do the best and be the best, and do what's right for students I think is a huge component. And when they see that it's working and that it's the right thing to do for students then they get on board. And that's really nice. So we try to celebrate their success, and their willingness to give extra time to do extra things to do ... because that I think is something that's unique. I'm shocked all the time at the

	willingness of teachers to do after school clubs and things free, coming from a Title One school where everybody wanted to get paid for everything. It's a completely different perspective. But, yeah, having a great staff really, really benefits, and helps get these things move forward."
School D	"The number talks. We want [the teachers] three times a week do a number talk. We looked at thinking maps with math, when measuring or things of that nature. So they used some thinking maps with math as well." "I think celebrating. You have to acknowledge the things that they have done in order for them to be challenged with something else. That's one of the things that I always did is that I had celebrations at every staff meeting, and that we did look at what are the things that we were doing well, but that we're not there yet."

Culture. All site leaders mentioned a factor towards the improvement of their math scores was due to the attitudes and willingness of their staff. School A's site administrator has been with the staff for thirty-four years as a teacher, assistant principal, and now principal. She has watched the culture shift for decades and the same is true now as the leader of the school. She accredits Positive Behavior Interventions and Support (PBIS) assisting with how teachers interact with students. She has needed “teachers to understand where our kids are coming from” and is slowly “changing the culture of the school.”

School B’s administrator created a safe space for her staff to feel comfortable and “not alone trying to figure it all out.” Administration has provided time for the teachers to “collaborate and learn from each other” with the support from the “instructional coach and administration to say, "We're in this together."”

School C and School D mentioned celebrating successes with their staff and acknowledging the work the teachers are doing for their students. School C’s administrator appreciates her staff and their “willingness to give extra time to do extra things to do ... because that I think is something that's unique.” School D focuses every month at their staff meeting to celebrate the progress her staff is making on the vision and school-wide initiatives being implemented.

All four schools credit the culture established at their school site for the improvement of student’s understanding in mathematics. The conditions that teachers care about are strongly related to improvement such as “having effective leaders, good colleagues, resources, and opportunities to learn and to build collective efficacy that has a positive impact on students” (Fullan, 2010, pg. 87).

Summary

The data presented in Chapter 4 reveal the participants responses towards teaching mathematics and participation in Professional Learning Communities. Forty-eight teachers participated in the survey and provided feedback on their background and job satisfaction, teaching mathematics, preparing to teach mathematics, use of district adopted curriculum, and participation in Professional Learning Communities. Four administrators were interviewed and asked to provide information regarding mathematics instruction observed, school site professional development, and staff participation in Professional Learning Communities.

The results from the study were analyzed in whole to determine commonalities amongst all school sites that attributed towards student achievement. The results from the study were also analyzed in part to compare responses from the two school sites that demonstrated a 10% increase on the CAASPP to the school sites that had less than 1% increase on the CAASPP mathematics assessments.

CHAPTER 5: DISCUSSION

Introduction

The purpose of this study was to discover factors that attributed to effective Tier 1 instructional strategies that contribute to students' understanding of mathematics at the elementary level. Using Malcom Knowles' Andragogical theory, the study focused on the classroom teachers' Tier 1 instruction after the implementation of the Common Core State Standards and their response to professional development and support provided by their site administrator. The researcher sought to determine if a teacher's job satisfaction, preparedness to teach mathematics, instructional strategies, and participation in Professional Learning Communities and professional development impacted their teaching practices.

The results of the study show that there are contributing factors that can assist with student achievement in mathematics at the Tier 1 level. Chapter 5 presents a summary of the study, a discussion of the data analysis, implications for practices, recommendations for future research, how the theoretical framework impacted the study, and conclusions.

The study was conducted at four elementary schools in XXX district that all showed an increase on the CAASPP mathematics assessment from 2017 to 2018. The teachers at the four school sites were invited to participate in the study through a survey that was distributed electronically via email. A total of 77 teachers received the electronic survey and 48 teachers completed the survey. The questions focused on their teaching background, mathematics instruction, preparedness to teach mathematics, use of district provided curriculum, and participation in Professional Learning Communities (PLCs). The administrators at all four school sites had tenure at their site and could speak on the vision and school-wide initiatives implemented under their leadership and direction. Each administrator was individually interviewed to ensure privacy and confidentiality. The researcher asked questions based on observations and working with the teachers at their site with math instruction, participation in PLC, school site professional development in mathematics, and services and support used and provided to the teachers. The administrators were asked their opinion regarding factors that they felt that contributed towards their site's math achievement.

Discussion of the Findings

The following section will focus on the conclusions based on the data provided in chapter four. Throughout this study, the researcher focused on existing literature regarding teacher preparation, mathematical concepts students struggle with, research-based Tier 1 instructional strategies in mathematics, and practices within a Professional Learning Community. Additionally, the researcher examined the impact of administrative support provided at the school site on teachers' classroom practices.

Acknowledgement of Limitations and Delimitations

Due to the convenience sample of this study, the results and findings may not be generalized to all elementary schools. The study population came from four schools in a suburban district located in southern California; therefore, it may not be possible to replicate the results of this study to all school populations. The study's findings may have been influenced by many variables that were outside of the researcher's control that could have changed the outcome of the students' achievement on the CAASPP, such as duration of daily mathematics instruction, the level of collaboration amongst the teachers at the grade-level, the degree of mathematical knowledge and ability of the teachers, available resources the site administrator spent towards mathematics at the school site, student aptitude and attitude towards mathematics, demographics of the student population, and resources provided by parents outside of school. In addition, the researcher did not personally observe classroom instruction and relied on administrators' feedback for responses and teachers' belief.

Primary Findings

The primary finding in this study might explain the disparities between the 2018 CAASPP math scores at four schools. School A and School C showed a 10% increase on the CAASPP assessment from 2017 to 2018. School B and School D showed less than 1% increase. School A and B have similar demographics and receive Title I funding; School C and D have similar demographics. The next two sections will answer the research questions.

Discussion of Themes for Research Question One

Research question one asks, "How does a teacher's math background, job satisfaction, use of district adopted curriculum, and instructional practices impact student achievement?"

Math background. Based on the teacher survey, a one-way ANOVA was conducted between the responses from School A and School C versus the responses from School B and School D. There was a significant difference between the teachers' responses for feeling prepared to teach the various concepts in mathematics at the elementary level. The results indicated that the teachers at School A and School C felt more prepared and their schools showed a 10% gain on the 2018 CAASPP.

As discussed in chapter two, elementary teachers generally are not prepared to teach mathematics (Angus, Olney, & Ainley, 2007). According to Greatness by Design Report (2012), once a teacher is hired, professional development opportunities in California vary widely in quality. The administrators at School A and School C, which demonstrated 10% increase on the CAASPP, provided targeted and specific professional development for grade-level teams to build teacher capacity. The administrator from School A assisted the teacher teams to align the mathematics curriculum and grade-level standards for strategic planning. The teams also looked at CAASPP data and release questions to develop year-long pacing guides.

School C's administrator focused grade-level Professional Development (PD) on PLC question number two; how do we know students learned the content by conducting data chats. During the PD, teachers "come and bring data to the table and we have discussions about the student" and then the team plans strategic instruction during Universal Access (UA) time. The administrator also looked to see how they could assist with intervention by providing student check-ins. She conducts these data chats every trimester and "every single grade level is doing some type of universal access now through the data chats."

Administrators from School A and School C worked on building collective teacher efficacy amongst their grade level teams. After each administrator spent dedicated time with the teachers, the teachers felt the need to act, refine their practice and planned next steps. Also, the teachers gained clarity and had consensus with what needed to occur in teaching mathematics moving forward. Bandura named this human behavior as collective efficacy, which he defined as "a group's shared belief in its conjoint capability to organize and execute the courses of action required to produce given levels of attainment" (Bandura, 1997, p. 477). Collective efficacy amongst teacher teams have shown an increase in student achievement (Donohoo et al., 2018).

Job satisfaction. The teachers who completed the survey answered questions on a Likert scale from *never or almost never* (1), *rarely* (2), *sometimes* (3), *often* (4), or *very often or always* (5). Based on the scale, the researcher set a threshold of three or higher as an indicator of satisfaction towards their job. Out of the 48 participants who responded, 98% (*n*=47) of the teachers' average response was higher than three. Fourteen teachers' responses were above a four for job satisfaction. Overall, the teachers find fulfillment in their job despite the additional hours needed to prepare for their job.

According to Locke (1976), job satisfaction is a positive or pleasant emotional state resulting from a person's appreciation of his/her own job. Based on the data collected (Figure 9) there was a strong positive correlation (r=0.845) between a teacher's job satisfaction and hours spent beyond classroom instruction to fulfill the duties, such as grading student work, planning lessons, meeting with students and parents outside of the class, professional development, and keeping gradebooks up to date based on the teacher survey conducted.

The four schools' administrators attributed their positive school culture as a factor towards student achievement; a positive workplace directly impacts job satisfaction. School C's administrator shared that she is "shocked all the time at the willingness of teachers to do afterschool clubs and things free; coming from a Title I school where everybody wanted to get paid for everything, it's a completely different perspective." School D's administrator celebrates successes with their staff and acknowledges the work the teachers are doing for the students. School B has a support structure where the teachers feel that they are "in this together." School A attributes PBIS as a factor that has helped establish how teachers interact with students.

Use of district adopted curriculum. The findings (Figure 11 and Figure 12) from this research indicate a non-significant difference between the usage of the district adopted curriculum in the classrooms and student achievement. The responses did not have consistent reporting from teachers in all grade levels. Teachers reported conflicting viewpoints on the helpfulness, thoroughness, and rigor of the district adopted curriculum. Overall, the findings suggest the curriculum has very little impact on students' understanding of mathematics.

Instructional practices. A teacher's attitude and beliefs about teaching processes, ability to teach, and the ability of students to learn can influence instructional practices inside classrooms and ultimately student achievement (Banerjee, Stearns, Moller & Mickelson, 2017; Tye & O'Brien, 2002). Based on the responses gathered from the teacher survey, there was a moderate positive association (r=0.305) between a teacher's confidence to teach mathematics and the teacher's belief in the importance of mathematics for student success. The more confidence a teacher has in their own ability to teach math concepts, the more the teacher believes students need to master concepts in mathematics to be successful. A teachers' confidence increases due to individual success and support provided by colleagues and administrators; therefore, positively increasing student achievement with the process (Donohoo et al., 2018; Goddard et al., 2004). By placing importance on specific math skills, the teacher may spend additional time to ensure their students have mastered these skills by strategically planning lessons, reteaching, or differentiating lessons throughout the year.

When looking specifically at the responses for teacher confidence, the researcher wanted to uncover if there were any differences in the responses from School A and C, which both demonstrated a 10% increase on the 2018 CAASPP, compared to School B and D which both had an increase of less than 1%. Three of the statements had statistically significant differences (Figure 13, Figure 14, and Figure 15) providing challenging tasks for the highest achieving students, adapting teaching to engage student interest, and helping students appreciate the value of learning mathematics. Since the teachers in School A and School C have more confidence in challenging the students who demonstrate mastery and adapting their teaching to engage students, they are more likely to differentiate their pacing and lessons in mathematics. Differentiation can benefit a broad spectrum of learners in areas such as achievement, attendance, discipline, satisfaction with school, and college application and attendance rate (Tomlinson, 2015). If a student is engaged in their learning, they will want to attend school and continue to learn.

Also discussed in Chapter 2 were eight evidence-based instructional strategies that assist with students' understanding of mathematics. Of the eight, five strategies were used in the four elementary schools. The five strategies were explicit instruction, visual representation, math talks, multiple methods to solve problems, and metacognitive strategies. The three that were not used were schema instruction, support productive student struggle, and academic vocabulary and writing. The findings from this research question indicate a non-significant difference between the responses from the schools with a 10% increase (School A and School C) when compared to the schools with a 1% increase (School B and School D). Although there was not a difference with instructional strategies, all four schools showed improvement on the CAASPP and the strategies used impacted students.

Explicit, systematic instruction. All schools indicated that they use explicit, systematic instruction. Teaching mathematics in this manner can be highly effective and can significantly improve a student's ability to perform mathematical operations as well as solve word problems (Archer & Hughes, 2011; IRIS Center, 2018). Also, students with or at risk for mathematics disabilities have demonstrated greater gains in classrooms that provided explicit instruction compared to other instructional approaches (Doabler et al., 2015; Baker, Gersten, & Lee, 2002; Gersten et al., 2009; National Mathematics Advisory Panel, 2008).

The researcher found that the teachers who participated in the survey have students listen to them explain new math concepts 78.33% of the week, and the teachers have students listen to them explain how to solve problems 76.67% of the week. These two strategies were strongly correlated, $r(46)=0.8291$, $p<0.0001$. It is important that part of the day is spent directly teaching students concepts to reduce ambiguous processes (Bruce & Grimsley, 1987). However, it is important that explicit instruction is purposefully planned and is of high quality where the teacher provides scaffolds and feedback based on student needs.

Visual representation. The teachers reported using visual representations such as manipulatives, number lines, pictures, graphic organizers, etc. in mathematics about 84.17% of the week (Table 11). Effective use of manipulatives bridges the gap between informal math and formal math (Boggan, Harper, & Whitmire, 2010).

Math talks. Conducting math talks helps teachers understand their students' methods and can provide information for lesson planning and design; this kind of formative assessment is a powerful approach to raising standards (Black & Wiliam, 1998; Thompson, 2004). Math talks allow students to talk about their mathematical thinking and are essential for developing understanding and making connections between mathematical ideas, skills, and procedures. Extending math talk opportunities also allows students to apply their conceptual knowledge to deepen understanding (Frey & Fisher, 2011).

The teachers in the study reported utilizing math talks and discussions 70.83% of the week (Table 11). Math talks and discussion was the only strategy that was consistently reported by the site administrators at the four schools. When asked about math strategies used in the classroom, the administrator from School A shared that her teachers "have been doing a lot of math talks. That's a big thing and you can find those in quite a few rooms, if not all of them at one time or another." Administrators B and D reported that they incorporate math talks during staff meetings.

XXX district provided professional development in 2016 on math talks to every teacher and administrator at the elementary level. According to the teachers who participated in the survey, 27% (n=13) indicated that the only professional development or learning they have received the past two years was provided by the district. Ten participants indicated they did not receive any trainings in mathematics the past two years.

Metacognitive strategies. Metacognitive processing allows people to select and invent strategies explicitly by thinking about their understanding of the task demands, their available cognitive resources, and their own experience in solving similar problems (Pennequin, Sorel, Nanty, & Fontaine, 2010). Young students pay attention to how quickly they solve a problem, not necessarily accuracy (Efklides & Vlachopoulos, 2012). Metacognitive strategies can help students learn how to plan a problem, monitor whether their approach is working, and modify their approach if it is not working or if their answer is incorrect (Cardelle-Elawar, 1992). The participants in this study report incorporating metacognitive strategies 71.25% of the week.

Correlations between visual representation, math talks, and metacognitive strategies. There was a moderate correlation (r=0.433) with students conducting math talks and using visual representations. Using metacognitive strategies and using visual representations were moderately correlated (r=0.499). There is a moderate correlation (r=0.538) with students conducting math talks and using metacognitive strategies. These strategies support the literature discussed in chapter two as effective during Tier 1 instruction. There was not one specific strategy that showed a stronger statistical significance that improved student achievement.

Summary of Research Question One

Tier 1 instruction refers to instruction that is given to all students. This study and research question one looked at the effect of a teacher's math background, job satisfaction, adopted curriculum, and specific instructional strategies have on student achievement. Overall, the study found the biggest difference amongst the participants was the teachers' confidence to teach mathematics has a positive impact on students. The teachers in this study which reported having more confidence participated in specific grade-level professional learning in mathematics led by their administrator. This work led to grade level collaboration and gave teacher clarity on next steps needed for instruction. The study also found that the participants who reported finding satisfaction in their work tended to work more hours beyond their contractual obligations preparing for their work. The use of district adopted curriculum did not have statistical significance on student outcomes. Certain instructional strategies positively impacted student achievement; there was not a specific strategy that was used in School A and School C that contributed to the 10% increase on the CAASPP that School B and School D did not use. This further supports the impact on the need to build teacher clarity through specific grade-level learning in mathematics.

Discussion of Themes for Research Question Two

Professional Learning Communities (PLCs) are designed around three big ideas and four critical questions that place student learning, collaboration, and results at the center of the work being done in collaborative groups (Kanold et al., 2018). Schools and districts that commit to the work to establish effective PLCs circle around the following three big ideas: (a) a focus on learning, (b) a collaborative culture, and (c) a results orientation. Additionally, teacher teams within a PLC focus on four critical questions: (1) What do we want students to learn? (2) How will we know if they have learned? (3) What will we do if they don't learn? (4) What will we do if they already know it? (DeFour et al., 2016). The four critical questions help teacher teams identify potential gaps that exist amongst colleagues in terms of instruction, rigor, assessments, and, ultimately, student learning.

Research question two asks, "What is the relationship between time spent in Professional Learning Communities (PLCs) and student achievement in mathematics?"

Teacher responses. The teachers' contract in XXX district require weekly PLC time of 45 minutes. Most of the participants (46%) report spending 11-20 minutes of the contracted time discussing mathematics and 31% of the participants have spent 21-30 minutes. More than 50% of participants at each school site reported spending additional time throughout the week, ranging from a few minutes a week to daily, discussing mathematics with their colleagues.

When analyzing the results from the survey regarding the PLC questions, one response had a statistically significant difference from school site A and school site C versus school site B and school site D. A one-way ANOVA revealed a significant main effect for the schools that showed a 10% increase and the schools that increased less than 1% in discussing instructional strategies with colleagues, $F(1, 46) = 4.15$, $p = 0.047$. Teachers that discuss their teaching practices and have the opportunity to observe each other teach have a better idea on how to move their students forward in the PLC process (Barkley, 2019).

When looking at all the responses regarding PLCs, the teachers at the four schools report moderately working effectively in PLCs. On average, the responses were all above 60% but did not exceed 85%, indicating there is not an area of strength or weakness when looking at all four schools combined. The findings from this research question indicate a non-significant difference between the responses from School A and C versus School B and D. The responses may indicate that the teachers are continuing to understand the PLC process and need to continue to focus their discussions on the four essential questions and have collective team commitments and a deep understanding of each question. Collaborative teams that address the four critical questions of a PLC provide every student in the grade level equitable learning experiences and expectations, opportunities for sustained perseverance, and robust formative feedback regardless of the teacher he or she receives. Teacher teams must reflect together and act together to improve the likelihood of equitable mathematics learning experience for every student (Kanold et al., 2018).

Administrator responses. Each administrator report conducting PLCs differently based on their staff's need. All four administrators mentioned the use of data amongst their teams and providing release time for their teachers. At the time of the study, School A had a whole-staff PLC once a month. The rest of the month the teachers stay in their grade-levels and she "walk[s] the classrooms to interact with them." At the time of the study, School B had majority of the weekly PLCs in grade-levels and held whole-school PLCs four or five times a year. School C had her teachers mostly working in grade-level groups for vertical articulation. School D had whole group PLCs for discussions with CAASPP but would break into smaller groups and grade-level depending on the topic. It is important that administrators are cognizant of the time they allocate for teams to do their work and trust that their teachers are engaged in the PLC work (Barkley, 2019). Administrators should participate as a member of learning communities to help the teachers improve on their work as professionals.

A common theme with School A and School C, with the 10% increase, was that their administrators had targeted and specific professional development with their teachers. The professional development had clear intentions and direction from the site leader along with supports and scaffolds so the teachers could immediately implement the PD in their classrooms. School A focused their grade-level PD on PLC question one; what do we want students to learn?

School C focused their grade-level PD on PLC question three and four; what do we do if they don't learn and what will we do if they already know it?

Discussion of Results According to the Theoretical Framework

The theoretical framework in this study is Malcom Knowles' Andragogical theory. One of the assumptions within the theory is readiness to learn. Adult learners are ready to learn the things they "need" and engage the learner with content that is relevant in their present life (Cox, 2015). School A and School C, which both had a 10% gain on the CAASPP Mathematics assessment, conducted grade-level professional development that was provided by their site administrator. School A focused their time aligning grade-level standards to the curriculum and assisted with planning and pacing. The administrator shared that the "teachers loved that [grade-level analysis of where the math standards fell in the adoption and then the teachers worked on planning and pacing]. They really started to see the correlation, and it took pressure off of them." After the grade-level professional development at School A, the teachers exhibited another assumption in Andragogical theory: orientation to learning. This suggests that adults want to take what is taught to them and apply it immediately to their life (Pappas, 2013). The site administrator at School A shared that "after we met with fifth grade, they realized that the most questions was something they were teaching at the very last minute. They redid their entire pacing and planning." The grade level had collective clarity on what standards needed to be taught throughout the year after the PD.

School C had similar outcomes after their grade-level professional development. The administrator reported holding grade-level data chats every trimester where the teachers come and they bring data to the table, and we have discussions about the students. We look at the data and I ask the teachers, "What do you think? How do you think [the student] is going to perform?

Does he need intervention? Does he need support?" Or maybe it's just [a student] that needs goal setting with administration." From there, the teachers work in their grade-level teams to provide "some type of universal access through the data chats" once a week.

Knowles (1984) suggested that adult learners should develop learning objectives based on the learner's needs, interest, and skill levels and look for the individual's specific needs and interest. This idea can be viewed as differentiation within the classroom for student learning. Administrators from School A and School B, both Title I schools, shared that their teachers utilize small group instruction or math centers during mathematics instruction. This allows time for teachers to work with a small group of students focusing on their specific needs. School B and School C administrators shared that their school has within the master schedule Universal Access (UA) time where students can receive targeted support or enrichment depending on their needs with a teacher at that grade level. However, it should be noted that UA at both schools includes English and mathematics support.

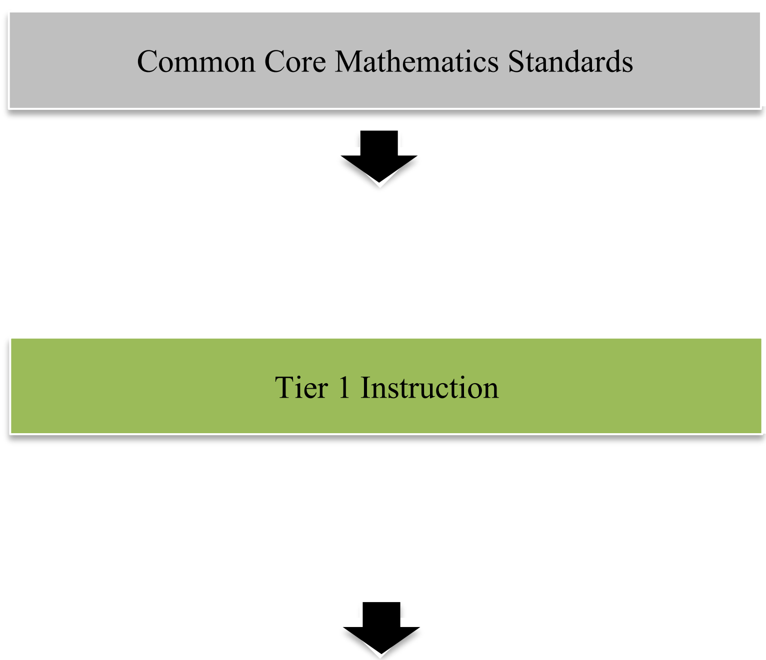
Implications for Practice

The foundation of a successful system of intervention and support is effective initial teaching referred to as Tier 1 instruction (Gregory et al., 2016). Tier 1 instruction is the teaching and learning that occurs in the classrooms for all students. If a student demonstrates needing additional support beyond Tier 1, the multi-tiered system of support structure allows the student to receive additional assistance known as Tier 2 or Tier 3 support. A student participating in Tier 2 or Tier 3 still receives Tier 1 instruction. Therefore, it is important to note that supplemental and intensive intervention cannot compensate for ineffective initial teaching, which requires differentiated instruction to meet the needs of each student (Gregory et al., 2016). The goal of a tiered system of support is to improve academic and behavioral outcomes for all students and provide research-supported early intervention services so that difficulties may be corrected before the student requires special education services (Jimerson et al., 2016; Witzel & Clarke, 2015).

Resources and documentation on Tier 1 mathematics has been predominantly found at the secondary level (grades 7 and beyond) and research has not been as common for Tier 1 mathematics instruction at the elementary level. Most of the research found at the elementary level addressed literacy and social-emotional understanding. Mathematics research that was available at the elementary level has focused on intervention and students with disabilities. The researcher was able to find research and information for Tier 1 mathematics at the elementary level in countries outside the United States. This provided the opportunity and need to conduct this study.

The study was designed to examine the leadership and support provided by administration, professional development opportunities, and time spent in Professional Learning Communities, that was used in the classroom as Tier 1 instruction after the Common Core Mathematics Standards were implemented (See Figure 18). Tier 1 represents the core instructional program that is available to all students. While Tier 1 should meet most students' needs a majority of the time, invariably some students will need additional time and support to succeed in core instruction (Gregory et al., 2016). Since all students have access to Tier 1 instruction by the teacher, the researcher wanted to understand what perceived factors attribute towards student achievement and understanding.

Based on the results of the study, administrators need to work with their teachers on specific professional learning to improve their understanding of mathematics at the elementary level. Professional learning should be relevant to the site's needs and provide clarity for the teachers, next steps for the team, and have measurable outcomes where follow up and feedback can be given. It is recommended that the professional learning is given by the administrator so there is consistency amongst expectations. Also, involving the administrator opens communication and allows for follow up and feedback after the professional learning day has been completed. Administrators need to be able to do the work with their teachers and continue to build their own understanding of curricular needs and changes as they arise. It is important that administrators continue to visit classrooms, provide informal feedback for teachers, and have clarity for themselves of the work happening in the classroom. By doing this work, the teachers will gain individual and collective efficacy and add to the culture at the school site; administrators will be able to support and understand the needs of their staff and can indirectly increase job satisfaction.



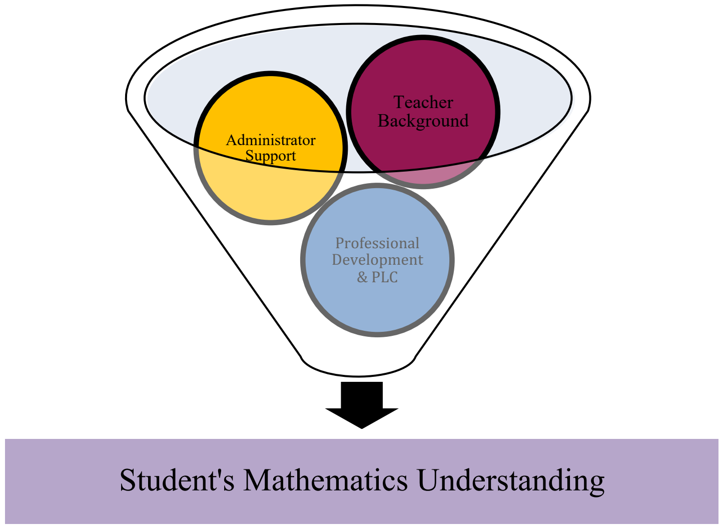


Figure 18. Research funnel. Hathuc 2019

The results also indicated that 48% of the participants did not seek any additional professional learning to further their understanding in mathematics. Twenty-seven percent of the participants reported that the only professional learning they received was the one provided by XXX district on math talks. The teachers in the study reported using math talks in their classroom 70.83% of the week. Therefore, it would be beneficial if districts provided learning opportunities for teachers in mathematics where administrators are to attend and work with their teachers. Additionally, after the district provided training, school site administrator should continue the learning at their school site in grade-level teams that is specific to the needs of the school.

Recommendations for Further Research

To enhance the generalization of the results, the researcher recommends: (a) replication of the study in other schools; (b) replication of the study focusing on a specific grade-level; (c) replication of the study in middle and high school; (d) replication of the study in another district; (e) larger sample size; (f) researcher-conducted classroom observations and focuses on Multi-

Tiered System of Support with an emphasis on Tier 1 and a specific design for intense intervention; (g) focusing on utilizing the PLC process and intervention.

Also, in the current study, an ANOVA was used to test whether the means for the schools were taken from the same sampling distribution. In future research, it might be interesting to consider a multivariate analysis (MANOVA) in which the vectors of the means of the schools are sampled. This would explore how the independent variables influence some of the patterning of response on the dependent variables. The sample size in the current study did not allow for this analysis.

Longitudinal, demographic, and growth data gathered for this study could provide the bases for numerous studies. For example, this study examined teacher and administrator's viewpoints, opinions, and practices that attributed to math achievement; a similar study could be replicated focusing on teacher and student viewpoints, opinions, and practices. Other demographics (i.e. gender, ethnicity, English Language Learner status, gifted and talented, or special education identification) could be analyzed under the same parameters of this study.

Another potential study could be collecting data at all elementary schools in the district and comparing the results from schools that improved in mathematics versus those that dropped in mathematics based on the CAASPP.

Conclusions

Mathematics is an essential life skill that is needed for everyday life. An individual's math journey begins at an early age and elementary mathematics is the foundation for students. The understanding of mathematics and its challenges begin at an early age and will continue to widen without attention and focus (Kanold et al., 2018). The perceived factors of effective Tier 1 mathematics instruction at the elementary level according to the results of this study include teachers who work collaboratively in teams with an administrator who is supportive and provides intentional professional development can increase student achievement in the classroom (Donohoo et al., 2018). The teachers that participated in specific grade-level professional development from their site administrator with support and scaffolds, felt more prepared to teach the concept and subject and ultimately increased student achievement. It is beneficial for teachers in grade-level teams to openly discuss the instructional strategies used in the classroom. Having a positive working environment leads to job satisfaction that also indirectly impacts student achievement.

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APPENDIX

Appendix A: Quantitative Survey

The questionnaire is designed to provide information about teachers' professional experiences, opinions, and classroom activities.

Part I - About the Participant

The following questions will give general information about the participant to the researcher and their thoughts about being a teacher.

2. **How old are you?**

   ____

3. **By the end of this school year, how many years will you have been teaching altogether? Round to the nearest whole number.**

   ____

4. **What grade do you currently teach?**

   ____

5. **How often do you feel the following way about being a teacher?**
   Mark only one oval per row.

	Never or almost never	Rarely	Sometimes	Often	Very often or always
I am content with my profession as a teacher	⬭	⬭	⬭	⬭	⬭
I find my work full of meaning and purpose	⬭	⬭	⬭	⬭	⬭
I am enthusiastic about my job	⬭	⬭	⬭	⬭	⬭
My work inspires me	⬭	⬭	⬭	⬭	⬭
I am proud of the work I do	⬭	⬭	⬭	⬭	⬭

Please indicate your opinion by marking a response on the scale. The scale responses ranges from 1=Never, 3=Neutral, and 5=A lot.

6. **Indicate the extent to which you agree or disagree with each of the following statements**
Mark only one oval per row.

	1	2	3	4	5
There are too many students in the class					
I have too much material to cover in class					
I have too many teaching hours					
I need more time to prepare for class					
I need more time to assist individual students					
I feel too much pressure from parents					
I have difficulty keeping up with all the changes to the curriculum					
I have too many administrative tasks					

7. **In your view, to what extent do the following limit how you teach your class?**
Mark only one oval per row.

	1	2	3	4	5
Students lacking prerequisite knowledge or skills					
Students suffering from lack of basic nutrition					
Students suffering from not enough sleep					
Disruptive students					
Uninterested students					
Students with physical disabilities					
Students with mental disabilites					
Students with emotional disabilities					
Students with psychological disabilities					

Part II - Teaching Mathematics

The following questions are to inform the researcher about the participant's experience about teaching mathematics to students.

8. **How many students are in your class?**

____

9. **In a typical day, how much time do you spend teaching mathematics to the students in your class?**
Mark only one oval.

- Less than 45 minutes
- 45-60 minutes
- 61-75 minutes
- 76-90 minutes
- 90-120 minutes
- More than 120 minutes

10. **How often do you do the following in teaching this to your class?**
Mark only one oval per row.

	Never or almost never	Sometimes	Neutral	Most of the time	Always or almost always
Relate the lesson to students' daily lives					
Ask students to explain their answers					
Bring interesting materials to class					
Ask students to complete challenging exercises that require them to go beyond the instruction					
Link new content to students' prior knowledge					
Ask students to decide their own problem solving procedures					
Encourage students to express their ideas in class					

11. In teaching mathematics to your class, how often do you ask students to do the following?
Mark only one oval per row.

	Never or almost never	Sometimes	Neutral	Often	Always or almost always
Listen to me explain new mathematics content	⬭	⬭	⬭	⬭	⬭
Listen to me explain how to solve problems	⬭	⬭	⬭	⬭	⬭
Memorize rules, procedures, and facts	⬭	⬭	⬭	⬭	⬭
Work on problems for which there is no immediate obvious method of solution	⬭	⬭	⬭	⬭	⬭
Work problems (individually or with peers) with my guidance	⬭	⬭	⬭	⬭	⬭
Work problems together in the whole class with direct guidance from me	⬭	⬭	⬭	⬭	⬭
Use visual representations (manipulatives, number lines, pictures, graphic organizers, etc.)	⬭	⬭	⬭	⬭	⬭
Complete word problems	⬭	⬭	⬭	⬭	⬭
Incorporate metacognitive strategies	⬭	⬭	⬭	⬭	⬭
Conduct math talks and discussions	⬭	⬭	⬭	⬭	⬭
Work in mixed ability groups	⬭	⬭	⬭	⬭	⬭
Work in same ability groups	⬭	⬭	⬭	⬭	⬭

Homework

The following questions are about homework in your class.

12. How often do you assign mathematics homework?
Mark only one oval.

- ⬭ Never
- ⬭ once a week
- ⬭ twice a week
- ⬭ three times a week
- ⬭ four times a week
- ⬭ five times a week

13. **How many minutes of mathematics homework do you usually assign your students?**
Mark only one oval.

- less than 15 minutes
- 15-30 minutes
- 31-60 minutes

14. **How often do you assign each of the following kinds of tasks?**
Mark only one oval per row.

	Never	Once a week	Twice a week	Three times a week	Four times a week	Daily
worksheets or practice book pages from the adoption						
problems/question sets in textbook						
writing definitions or other short writing assignment						
small investigation(s) or gathering data						
individual long term projects						
preparing oral reports either individually or as a small group						
supplementary materials						

15. **How often do you do the following with the mathematics homework assignments for your class?**
Mark only one oval per row.

	Never	Once a week	Twice a week	Three times a week	Four times a week	Daily
Correct assignments and give feedback to students						
Discuss the homework in class						
Monitor whether or not the homework was completed						

16. **How often do students complete their homework?**
Mark only one oval.

	1	2	3	4	5	
Never						Always

Assessments

The following questions are about assessments in your class.

17. **How much importance do you place on the following assessment strategies in mathematics?**

Mark only one oval per row.

	Unimportant	Somewhat important	Important	Very important	Critical
Observing students as they work	◯	◯	◯	◯	◯
Asking students to answer questions during class	◯	◯	◯	◯	◯
Short, regular written assessments	◯	◯	◯	◯	◯
Longer tests (eg.topic tests or exams)	◯	◯	◯	◯	◯
Long-term projects	◯	◯	◯	◯	◯

18. **How often do your students take mathematics test on computers or tablets?**

Mark only one oval.

- ◯ Never
- ◯ Once a year or less
- ◯ Twice a year
- ◯ Three times a year
- ◯ Once a month
- ◯ More than once a month

19. **To what extent do you depend on classroom assessment results?**

Mark only one oval per row.

	Never or almost never	Rarely	Sometimes	Often	Very often or always
To modify your instruction	◯	◯	◯	◯	◯
To give grades	◯	◯	◯	◯	◯
To report to parents	◯	◯	◯	◯	◯
To determine the learning needs of each student	◯	◯	◯	◯	◯

Part III - Preparing to Teach Mathematics

The following questions are to inform the researcher about professional development and the participant's comfort with mathematics instruction.

20. **What professional development have you attended in mathematics the past 2 years? (e.g. webinars, conferences, courses, instructional practices, etc.)**

____

Please indicate your opinion by marking a response on the scale. The scale responses ranges from 1=None at all, 3=Neutral, and 5=A great deal.

21. **To be good at mathematics at school, how important do you think it is for students to**
Mark only one oval per row.

	1	2	3	4	5
remember formulas and procedures	◯	◯	◯	◯	◯
think in sequential and procedural manner	◯	◯	◯	◯	◯
understand mathematical concepts, principles, and strategies	◯	◯	◯	◯	◯
be able to think creatively	◯	◯	◯	◯	◯
understand how mathematics is used in the real world	◯	◯	◯	◯	◯
be able to provide reasons to support their solutions	◯	◯	◯	◯	◯

22. **In teaching mathematics to your class, how would you characterize your confidence in doing the following?**
Mark only one oval per row.

	1	2	3	4	5
Inspiring students to learn mathematics	◯	◯	◯	◯	◯
Showing students a variety of problem solving strategies	◯	◯	◯	◯	◯
Providing challenging tasks for the highest achieving students	◯	◯	◯	◯	◯
Adapting my teaching to engage students' interest	◯	◯	◯	◯	◯
Helping students appreciate the value of learning mathematics	◯	◯	◯	◯	◯
Assessing students comprehension of mathematics	◯	◯	◯	◯	◯
Improving the understanding of struggling students	◯	◯	◯	◯	◯
Making mathematics relevant to students	◯	◯	◯	◯	◯
Developing students' higher-order thinking skills	◯	◯	◯	◯	◯

23. **How well prepared do you feel you are to teach**
Mark only one oval per row.

	1	2	3	4	5
fractions, decimals and percentages?	◯	◯	◯	◯	◯
ratios and proportions?	◯	◯	◯	◯	◯
measurement - units, instruments, and accuracy?	◯	◯	◯	◯	◯
geometric figures?	◯	◯	◯	◯	◯
algebraic representation?	◯	◯	◯	◯	◯
interpretation of data in graphs, charts, and tables?	◯	◯	◯	◯	◯
simple probability?	◯	◯	◯	◯	◯

24. **Approximately how many hours per week do you normally spend on the following**
Mark only one oval per row.

	Never	0-1 hour	1-2 hours	3-4 hours	more than 4 hours
preparing or grading student tests or exams					
reading and grading other student work					
planning lessons by yourself					
meeting with students outside of classroom time (e.g. tutoring, guidance)					
meeting with parents					
professional reading and developent activity (e.g. seminars, conferences, etc.)					
Keeping students' records up to date					

25. **At the end of the school year, what do you hope your students are able to do?**

Part IV - District Adopted Math Curriculum

The following questions are to inform the researcher about the participant's usage of the adopted curriculum. Kindergarten through Fifth grade has Pearson enVision and sixth grade has Big Ideas.

26. **Do you use the adopted textbook in your class (Pearson enVision or Big Ideas)?**
Mark only one oval.

- Yes
- No

27. **Do you follow the district pacing guides for mathematics?**
Mark only one oval.

- Yes
- No

The following question is based on Pearson enVision only. If you do not use Pearson, skip to the next question.

28. **In a calendar week, Monday to Friday, how often do you use the following resources provided by the publisher?**
Mark only one oval per row.

	Never	Once a week	Twice a week	Three times a week	Four times a week	Daily
Teaching Edition	⬭	⬭	⬭	⬭	⬭	⬭
Student Edition	⬭	⬭	⬭	⬭	⬭	⬭
Interactive Learning	⬭	⬭	⬭	⬭	⬭	⬭
Quick Check Assessment	⬭	⬭	⬭	⬭	⬭	⬭
Small Group Differentiated Center Activities	⬭	⬭	⬭	⬭	⬭	⬭
Student Comsumable Practice Book	⬭	⬭	⬭	⬭	⬭	⬭
Intervention Tool Kit	⬭	⬭	⬭	⬭	⬭	⬭
Student Consumable Daily Common Core Review	⬭	⬭	⬭	⬭	⬭	⬭

The following question is based on Big Ideas only. If you don't use Big Ideas, skip to the next question.

29. **In a calendar week, Monday to Friday, how often do you use the following resources provided by the publisher?**
Mark only one oval per row.

	Never	Once a week	Twice a week	Three times a week	Four times a week	Daily
Teaching Edition	⬭	⬭	⬭	⬭	⬭	⬭
Student Edition	⬭	⬭	⬭	⬭	⬭	⬭
Exploration Activities	⬭	⬭	⬭	⬭	⬭	⬭
Laurie's Notes	⬭	⬭	⬭	⬭	⬭	⬭
Dynamic Teaching Tools	⬭	⬭	⬭	⬭	⬭	⬭
Mini-Assessment	⬭	⬭	⬭	⬭	⬭	⬭
Monitoring Progress	⬭	⬭	⬭	⬭	⬭	⬭
Exercises	⬭	⬭	⬭	⬭	⬭	⬭
Student Consumable Practice Book and Journal	⬭	⬭	⬭	⬭	⬭	⬭

30. **How satisfied are you with the components provided by the publisher?**
Mark only one oval.

	1	2	3	4	5	6	7	
Completely unsatisfied	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Complete satisfied

31. Please provide a narrative for your response on the satisfaction with the curriculum.

32. Do you use any other resources to help with your math lesson? (e.g. worksheets, lesson materials, projects)

Mark only one oval.

- Yes
- No

33. If yes, what resources do you use and where do you get these resources?

Part V - Professional Learning Communities

The following questions address your time in Professional Learning Communities

34. During the contracted 45 minutes of PLC per week, on average how many minutes are spent discussing mathematics?

Mark only one oval.

- 0-10 minutes
- 11-20 minutes
- 21-30 minutes
- 31-40 minutes
- more than 40 minutes

35. Does your team meet to discuss mathematics beyond the 45 contractual time? If so, how many minutes per week does your team discuss mathematics?

Please indicate your frequency by marking a response on the scale. The scale responses ranges from 1=Never, 3=Sometimes, and 5=Always.

36. **When discussing mathematics in PLC how often does the team**

Mark only one oval per row.

	1	2	3	4	5
compare assessment results					
discuss instructional strategies					
change lesson plans based on assessment results					
decide reteaching and enrichment opportunities					
discuss grouping students based on assessment results					

37. **How often do you have the following types of interactions with other teachers at your school site?**

Mark only one oval per row.

	1	2	3	4	5
Discuss how to teach a particular topic					
Collaborate in planning and preparing instructional materials					
Share what I have learned about my teaching experiences					
Visit another classroom to learn more about teaching					
Work together to try out new ideas					
Work as a group on implementing the curriculum					
Work with teachers from other grades to ensure continuity in learning					

38. **How much support in mathematics do you receive from the following**

Mark only one oval per row.

	1	2	3	4	5
Administration					
Site Instructional Coach					
Grade Level Chair					
Tech Trainers					
Elementary Curriculum Office					

Appendix B: Informed Consent – Quantitative Survey

Perceived Factors of Effective Tier 1 Mathematics Instruction at the Elementary Level

The study in which you are being asked to participate is designed to investigate effective Tier 1 instruction in mathematics and participation in Professional Learning Communities. This study is being conducted by Corinna Ho-yan Lee Hathuc under the supervision of Dr. Belinda Karge, PhD professor of Doctoral Studies at Concordia University. This study has been approved by the Institutional Review Board, Concordia University Irvine, in Irvine, CA. Please read this form carefully and ask any questions you may have before agreeing to take part in the study.

PURPOSE: The purpose of this mixed-method phenomenological study is to discover what effective Tier 1 instructional strategies at the elementary level and time spent in Professional Learning Communities that attribute towards students' understanding of mathematics. The general topics in this study will pertain to adult learning theory, the shift in Mathematical standards, professional development, and school site grade-level teams.

DESCRIPTION: You are being asked to complete a survey regarding mathematics in your classroom at your school site. The survey instrument that has the following types of questions: multiple choice questions, Likert survey questions, and open response questions. Participants will complete the survey instrument which will be a data collection point for this study.

PARTICIPATION: Participation in this study is voluntary and can be discontinued at anytime. Refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled, and the subject may discontinue participation at any time without penalty or loss of benefits, to which the subject is otherwise entitled.

CONFIDENTIALITY: Participants confidentiality will be maintained using aliases and composite profiles so that individuals cannot be identified. Participants records identifying the participants will be maintained by storing the records in a locked filing cabinet. Electronic records will be maintained in the researcher's password-protected computer.

DURATION: The total time of participation is approximately 20 minutes to complete the survey.

RISKS: To ensure confidentiality of the study, the researcher will provide the participants with anonymous surveys (data cannot be linked to individual participants by name) and use of pseudonyms. Surveys will not collect any identifying information such as names, school site, job title, or email address from the survey participants. Study data will only be accessible to the researcher and the faculty advisor (Dr. Belinda Karge).

BENEFITS: By participating in this research, participants will help expand the body of research on this topic. In addition, participants will receive a copy of the study's findings and recommendations in the form of a completed dissertation to help their current practice as educational leaders

CONTACT: This study has been reviewed and, approved by the Instructional Review Board at Concordia University, Irvine. Also, if you have any questions about the study, or if you would like additional information to assist you in reaching a decision, please feel free to contact me at corinna.hathuc@eagles.cui.edu

RESULTS: The results will be published in the researcher's doctoral dissertation at Concordia University, Irvine. The findings could potentially lead to improvement.

CONFIRMATION STATEMENT:

I understand that I must be 18 years of age or older to participate in your study, have read and understand the consent document and agree to participate in your study.

Appendix C: Informed Consent – Administrator Interview

Perceived Factors of Effective Tier 1 Mathematics Instruction at the Elementary Level

The study in which you are being asked to participate is designed to investigate effective Tier 1 instruction in mathematics and participation in Professional Learning Communities. This study is being conducted by Corinna Ho-Yan Lee Hathuc under the supervision of Dr. Belinda Karge, PhD professor of Doctoral Studies at Concordia University. This study has been approved by the Institutional Review Board, Concordia University Irvine, in Irvine, CA. Please read this form carefully and ask any questions you may have before agreeing to take part in the study.

PURPOSE: The purpose of this mixed-method phenomenological study is to discover what effective Tier 1 instructional strategies at the elementary level and time spent in Professional Learning Communities that attribute towards students' understanding of mathematics. The general topics in this study will pertain to adult learning theory, the shift in Mathematical standards, professional development, and school site grade-level teams.

DESCRIPTION: If you agree to participate in this study, the researcher will conduct an interview with you. The interview will include questions about your job, math instruction in observed in the classroom, teacher's participation in Professional Learning Communities, and any school site professional development that pertains to mathematics. This interview will take approximately 30 minutes to complete. With your permission, this interview will be audio recorded.

PARTICIPATION: Participation in this study is voluntary. You may skip any questions that you do not want to answer. Refusal to participate will involve no penalty or loss of benefits to which you are entitled. You may discontinue participation at any time.

CONFIDENTIALITY: The records of this study will be kept private. Any report will not include information that will make it possible to identify you. All recorded interviews will not include the participant's name. The researcher will know the identities of participants, but pseudonyms will be used during data analysis and discussion. Research records will be kept in a locked file and on the researcher's password protected laptop. Only the researcher will have access to data records. The audio recording will be destroyed after it has been transcribed, which is anticipated to be within three months of the recording.

DURATION: The total time of participation is approximately 30 minutes.

RISKS: No risks are anticipated by you participating in this study other than those encountered in day-to-day life.

BENEFITS: There are no potential benefits to employees for participating in this research study.

CONTACT: This study has been reviewed and, approved by the Instructional Review Board at Concordia University, Irvine. Also, it has the support of If you have any questions about the study, or if you would like additional information to assist you in reaching a decision, please feel free to contact me at corinna.hathuc@eagles.cui.eu

Appendix D: National Institutes of Health Certificate

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Corinna Hathuc** successfully completed the NIH Web-based training course "Protecting Human Research Participants."

Date of Completion: 09/12/2018

Certification Number: 2924970

NIH National Institutes of Health
Office of Extramural Research

CONFIRMATION STATEMENT:

I understand that I must be 18 years of age or older to participate in your study, have read and understand the consent document and agree to participate in your study.

SIGNATURE: ____________________________________ DATE: ___________________

Appendix E: Teacher Demographic Data

	Participant Code	Grade-Level	Age	Years of Teaching
School A	A1	K	31	10
	A2	K	57	27
	A3	K	29	5
	A4	1	43	10
	A5	2	31	5
	A6	2	25	6
	A7	2	51	27
	A8	3	36	12
	A9	3	50	20
	A10	4	40	14
	A11	4	52	27
	A12	5	41	5
	A13	6	24	1
	A14	6	44	22
School B	B1	K	30	7
	B2	2	38	15
	B3	2	50	20
	B4	3	37	5
	B5	3	27	6

	B6	4	55	31
	B7	4	49	21
	B8	5/6	36	8
	B9	6	42	4
	B10	6	62	30
	B11	1-6	60	32
	B12	4-6	33	10
	B13	K-6	40	13
	B14	K-6	35	8
School C	C1	K	55	33
	C2	1	53	28
	C3	2	46	20
	C4	2	62	34
	C5	3	42	21
	C6	3	59	37
	C7	3	50	25
	C8	4	63	30
	C9	4	38	20
	C10	5	41	3
	C11	5	40	13
	C12	6	49	25
School D	D1	K	44	21
	D2	1	55	26

D3	3	41	20
D4	4	45	11
D5	5	44	10
D6	5	33	7
D7	1-6	48	2
D8	K-6	38	12