FACT FLUENCY: A MIXED METHODS APPROACH TO IMPROVE QUALITY OF MATHEMATICS TEACHERS' INSTRUCTION

A Record of Study

by

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ABSTRACT

The purpose of this study was to impact teachers' understanding of fact fluency and students' opportunities to practice their mathematics facts in two third-grade, two fourth-grade and two fifth-grade classes at R. C. Neal Elementary School located in Bryan, Texas. I used a mixed methods embedded approach to investigate the effects of a ten-session professional development on fact fluency, teachers' understanding and students' opportunities to practice their facts. I led the professional development while also performing the role of investigator in the project. I used qualitative methods in the form of structured interviews of all participant teachers during phase one of the study to investigate teachers' understanding of fact fluency. I then gathered observational data from walk-throughs in the participants' classrooms, then quantified the strategies observed. During phase 3 of the study, I used qualitative methods in the form of structured interviews to determine the effectiveness of the professional development sessions. This findings from this study showed that the ten-session professional development session was effective in increasing teachers' understanding of fact fluency and strategies. The data also indicated that there was an increase in students' opportunities to practice fact strategies in the classrooms. The overall findings from this study indicate that the study was effective for both teachers and students.

DEDICATION

I dedicate this record of study to my husband, Jason Bailey and my two handsome sons, Cayden and Cooper. Thank you Jason for always believing in me and motivating me to keep pushing through even when I thought I could not make it. I wouldn't have made it without your love, support and patience. Cayden and Cooper, thank you for encouraging and motivating me. You two inspire me daily to be the best mom I can be, and even though I tried not to let my course work effect our family time, I want you two to know that all of the sacrifices that were made were in hopes to someday inspire you to do great things.

I also want to thank my family and friends. None of this would have been possible without your love and support. I have one of the greatest support systems a person could ask for, and I thank God daily for each and every one of you. You all have inspired me to achieve more than I ever could have imagined.

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Contributors

This work was supervised by a record of study committee consisting of Dr. Mary Margaret Capraro [Chair], Dr. Robert M. Capraro [Co-Chair], Dr. Lynn M. Burlbaw of the Department of Teaching, Learning and Culture and Dr. Glenda Musoba of the Department of Educational Administration and Human Resource Development.

All work conducted for the record of study and the data collected, and analyzed in Chapter III was completed by the student independently.

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CHAPTER I

INTRODUCTION

Reforming education has been a topic of discussion lately, especially when it comes to mathematics. Mathematics professional development has been viewed by policymakers and education researchers as an essential component of mathematics education reform (Polly, 2012). Many researchers, such as Drew Polly, D.L. Ball, and H.C. Hill, have research findings that teachers have poor understanding of mathematics topics in the United States. They have used these findings to substantiate the claim that better and more effective preservice preparation and inservice professional development enhancements in mathematics are needed (Ball, Bass, & Hill, 2004). In the past, a typical solution for poor teacher understanding would be to require teachers to study more mathematics, including additional coursework (Ball, 2005). Many times, however, additional coursework has failed to provide a focus on specific content knowledge for teaching mathematics, unlike professional development for teachers, which has been found to be an effective strategy. One of the common topics identified by Ball (2005) is teacher understanding of what mathematical fluency means and ways to build fluency in students. Fact fluency is an important tool used by effective and successful problem solvers.

The Problem Space

At Neal Elementary mathematics teachers do not have an understanding of fact fluency and generally do not provide opportunities for students to develop fact fluency in

their classroom learning experiences. Many teachers lack the understanding of what fluency means and how to build fluency within students. Teachers assume that fact fluency is timed tests and many of the students on our campus often practice in this manner. These tests typically take a form of a page with thirty equations. For many of our students this can be discouraging, especially for the ones who have learned inefficient procedures and do not possess conceptual understanding because they have not been introduced to strategies that will aid them in becoming fluent with their facts. Our campus faces serious problems with widespread underachievement in mathematics because the teachers do not have an understanding of fact fluency. Understanding that we cannot continue to do the same things and get different results has led me to this problem space. Teachers need to understand what fact fluency is and provide their students opportunities to develop fact fluency in their classrooms.

The Problem of Practice

Context

R.C. Neal Elementary is located in the city of Bryan, centrally located in the state of Texas, Texas, in the largest district in Brazos County. The school district serves 23 campuses that consist of four high schools, four middle schools and 15 elementary schools that educate a diverse population. The total population of Bryan is 80,913 with a racial distribution of 40.7% white, 38.2% Hispanic, 15.5% African American, 2.9% Asian, 2.2% two or more races, and 0.10% Native Hawaiian and Other Pacific Islander alone. Bryan, Texas has a median household income of $38,522. R.C. Neal Elementary

serves 488 students in a Kindergarten through 5th grade. The racial distribution of the students at Neal Elementary is 70.2% Hispanic, 25.2% African American, 3.9% White, 0.6% American Indian, and 0.2% two or more races. Of the student population, 78.1% of the students are identified as at-risk and 96.1% classified as economically disadvantaged. Forty-nine and nine tenths percent of the students at Neal Elementary are identified Limited English Proficiency (LEP). In 2016, the individual school received an accountability rating of "met standard" while the Bryan Independent School District also received an accountability rating of met standard.

The principal at R. C. Neal Elementary has currently served in this role for the past three years. She appears to be very supportive of her teachers and works hard to ensure that all students are successful. Prior to assuming the role of principal, she was an Assistant Principal at this school for two years. She displays a passion for learning which seems to be contagious among to her staff and students while providing the teachers and staff with a monthly goodie such as candy, soda, snack that is attached to a motivational note or quote. This model supports her philosophy that it is just the little things that make all the difference and that if you take care of your people they will take care of you.

Professional development is a focus for the campus. The average teacher receives at least one hour of professional development in the core disciplines each week. Weekly lesson design sessions are held for each grade level along with after school Professional Learning Communities (PLCs) which are held on Wednesday's. Teachers are not paid to attend professional development sessions, but many teachers do attend

out of district trainings where their travel expenses and registration fees are reimbursed. Some of the professional conferences that teachers have attended this past year include Conference for the Advancement of Mathematics Teaching (CAMT), Conference for the Advancement of Science Teaching (CAST), and Eric Jensen's Teaching with Poverty in Mind Conference. The principal ensures that every PLC is a learning opportunity for all attending. She works to meet each teachers' needs by asking for feedback at the beginning of the year to find out their professional needs and asks for feedback throughout the school year. The principal also has teachers present at some of the PLC's to build capacity. Additionally, the principal has added an every other Wednesday, during conference period whereby teachers attend a PLC that focuses on a need observed during walk-throughs. For example, a PLC that is on the calendar for this month focuses on Successful Stations. Because it is an expectation that teachers teach in small group, students must be in stations. To ensure that the monthly focus is implemented in classrooms, the focus is looked for and noted during weekly walk-throughs. The principal ensures that all PLCs focus on a need of the teachers and the school so that is not perceived as a waste of time by the teachers. She believes that everything we do must align with the campus goals and is always what is best for students.

Initial Understanding

After numerous walk-throughs and classroom observations conducted by instructional coaches and campus administration, it was observed that at Neal Elementary mathematics teachers do not have an understanding of fact fluency and do not provide opportunities for students to develop fact fluency in their classroom learning

experiences. From these observations, the assumption made is that many teachers lack an understanding of what fluency means and how to build fluency within students. After talking with teachers, I found they refer to fact fluency as timed tests and many of the students on our campus often practice in this manner. These tests typically take a form consisting of a page with thirty equations. I have observed many of our students feeling discouraged, especially the ones who have learned inefficient procedures and do not understand at the conceptual level because they have not been introduced to strategies that will aid them in becoming fluent with their facts. My assumption is that our campus faces serious problems with widespread underachievement in mathematics because the teachers do not have an understanding of fact fluency. Understanding that we cannot continue to do the same things and get different results has led me to this problem space. From observations and walk-throughs, teachers need to understand what fact fluency is and provide their students opportunities to develop fact fluency in their classrooms.

Relevant History of the Problem

When looking into attempts currently in place or that have been made previously to reconcile the problem, I was unable to find any information or professional development that focused on increasing teacher content knowledge of fact fluency and/or fact fluency teaching strategies. I am aware that daily fact practice, for three to five minutes, is a district expectation stated in the district mathematics guidelines. However, there has been no formal training at the district nor the campus level on understanding fact fluency and/ or fact fluency strategies. As a campus, we have provided some ideas on how teachers can include fact fluency in their classrooms,

whether it be at a work station or as a three to five-minute whole group session, however, we have not provided any professional development on what actual fact fluency is nor fact fluency teaching strategies.

Stakeholder Groups and Values

The stakeholders in this study are the mathematics teachers in grades 3-5 at Neal Elementary along with the students, and curriculum coordinators and coaches. After conducting numerous walk-throughs and having discussions with teachers and administrators, it became evident that mathematics teachers do not have an understanding of fact fluency. Although teachers have students practicing their facts, they are not providing students with strategies to help students become fluent with their facts. Because much research has been done on student achievement in mathematics, not much has been researched on how to increase teachers' content knowledge with fact fluency instruction.

During conversations with the stakeholders, the types of values that emerged mostly were under obligation to organization and obligation to clients. During the conversations with the teachers, I was not surprised that the majority of the statements were under these two value categories. The teachers that I spoke with have a desire to do what is best for students at all times. The values, individualism, participation and helping were not surprising because the teachers on our campus work hard to do what is best for each individual child and also want every stakeholder to be an active participant in the students' learning.

Values that are most important to me in this situation fall under the two categories, Social and Political Values and Professional Values. In regards to my ROS, the values that align with the focus are obligation to clients, individualism and participation. It is important that teachers do what is best for the students by providing students with individual plans and strategies that will help them be successful in developing fact fluency. Along with providing them with individual plans and strategies, it is important to provide stakeholders, the teachers, with the content knowledge on what fact fluency is and how they can use specific fact fluency strategies to support their students.

Problem Statement

Audience

The audiences that will benefit from my study will be mathematics teachers, students, and curriculum coordinators/coaches. Teachers will benefit from this study because they will gain or enhance their understanding of fact fluency. They will also learn strategies they can implement in their classrooms to increase opportunities for students to practice their facts. Students for many years will benefit from this study. Over the course of many years, students will be provided with increased opportunities to practice their facts, not just using memorization and recall. Students will also be introduced and taught strategies that help them to understand the conceptual leel of facts rather than just memorizing. Curriculum coordinators/coaches will benefit from this study, because they will be able to use the information from this study to coach teachers to increase and enhance their understanding of fact fluency. Coordinators/Coaches will

also be able to incorporate the strategies used in this study during model lessons and in professional learning communities (PLCs) for their teachers to implement in their classrooms.

Ideal Scenario

Teachers at Neal Elementary School want all students to succeed. Student success is evident because they attend professional development sessions throughout the year to increase their content knowledge in mathematics. Stakeholders, who include teachers and administrators, should understand fact fluency and how to effectively teach students how to become fluent. Currently, teachers provide practice to students in the form of timed tests with daily practice that does not provide strategies to help students be successful. In an ideal situation, teachers would understand fact fluency and provide students opportunities for daily practice using strategies, however they lack a understanding and use timed tests as a measure of student fluency of facts.

The Real

It is difficult for the ideal vision to be realized at this time because although all stakeholders want all students to be successful, there is a lack of understanding of fact fluency. Additionally, because teachers do not truly understand fact fluency, students are not provided the opportunity to practice their facts daily nor provided with strategies to help them in becoming fluent. If this problem becomes worse, teachers will continue their same practices of having students practice facts by using timed tests.

Research Questions

The problem for this study was identified by our instructional leadership team after they analyzed observational data collected from walk-throughs in mathematics classrooms. Teachers on my campus use timed tests and believe that the tests help students learn basic facts. They are giving tests to students whom do not understand the conceptual level of fact fluency. Teachers have requested help from the district mathematics coordinator and the campus' mathematics instructional coach (who is also the author of this proposal) to provide professional development specifically focused on increasing their understanding of fact fluency. They also have requested professional development on developing strategies they can utilize in the classroom.

Guiding questions. I used three questions to guide my design of this embedded mixed methods design for this study. My first question asks specifically about the teachers' understanding of fact fluency and their use in the classrooms: 1) How do teachers understand fact fluency and in what ways do they provide opportunities for students to practice their facts? Data were collected to answer the second and third questions to identify areas of improvement and effectiveness of the intervention: 2) How do teachers perceive the overall effectiveness of the professional development on increasing their understanding of fact fluency? And 3)What are the strategies teachers are able to implement in their classrooms that are focused on fact fluency?

Roles and Personal Histories

My background. My current professional position is the Elementary Mathematics Instructional Coach on the campus of Neal Elementary. As the

mathematics instructional coach, I work closely with the District Elementary Mathematics Coordinator and provide professional development for teachers throughout the district. The stakeholders that I worked with during my study were mathematics teachers in grades 3, 4 and 5 on the campus of Neal Elementary. I do not have a supervisory relationship with these stakeholders. As the instructional coach, I model lessons for mathematics teachers, and conduct walk-throughs in mathematics classrooms providing feedback to assist teachers in growing professionally. During walk-throughs I also look for alignment of lessons as well as evidence of effective instructional strategies being implemented in classrooms. I am also responsible for delivering professional development to teachers on my campus as well as disaggregating data.

Purpose of Study

I addressed teachers' lack of understanding about fact fluency in this study. Fact fluency, while targeted as being important in mathematical problem solving, is not often seen in, mathematics instruction in elementary/middle/high school classrooms. Actually, mathematics teachers in my school do not provide opportunities for students to develop fact fluency from their mathematics learning experiences. The research design of the study was an embedded mixed method, intervention design, and it involved collecting qualitative data before and during the intervention phases of the study. In the initial qualitative phase of the study, I collected qualitative data at the beginning to explore teachers' understanding of fact fluency before the intervention begins using structured interviews. Then during the intervention, ten professional development sessions that lasted between thirty-minutes to one-hour every week over a ten-week

period were conducted by myself, the researcher. I collected observational data throughout the ten weeks to understand the perceptions of teachers' experiences with the intervention and was analyzed quantitatively using descriptive statistics. The results were represented in a graph. At the end of the school year, qualitative data was collected using a structured interview that was conducted with all 3rd-5th grade mathematics teachers at Neal Elementary. The interviews were used to determine if the professional development sessions were beneficial in increasing teachers' knowledge of fact fluency as well as increasing students' opportunities to practice their facts

Significance of Study

During professional development sessions I was hoping for teachers to gain an understanding of what fact fluency was and how it helped their students become fluent with their facts. Participants were able to not only watch as I modeled the strategy, but they were also given a time to practice using the strategy. They also worked with colleagues to develop the strategy and plan for implementation in their classrooms. This mixed methods record of study can help inform teachers of strategies that helped their students become fluent in their basic mathematics facts. This could potentially increase students' problem solving skills in mathematics. Likewise, the strategies implemented during this study could be expanded across the district to increase teachers' understanding of fact fluency and effective strategies for their students.

CHAPTER II

LITERATURE REVIEW

Conceptual Framework

I used constructivism as the philosophical worldview to ground the design of this study. According to Creswell and Clark (2011), "Constructivism focuses on the understanding or meaning of phenomena, formed through participants and their subjective views" (p. 40). The researchers go on to talk about how constructivism is shaped "from the bottom up" (p. 40)– from individual perspectives to broad patterns and, ultimately, to broad understandings (Creswell & Clark, 2011). In my study, I interviewed participants at the beginning to determine their knowledge of fact fluency and from the data collected planned professional development to potentially increase their content knowledge.

According to Eisenhart (1991), "a conceptual framework is a skeletal structure of justification, rather than a skeletal structure of explanation based on formal logic (i.e., formal theory) or accumulated experiences (i.e., practitioner knowledge)" (p. 209). She also discussed that "conceptual frameworks facilitate a more comprehensive way of investigating a research problem" (Eisenhart, 1991, p. 211). A conceptual framework helps to provide a focus and is a tool that helps one interpret information. Lester (2005) wrote, "I propose that we view the conceptual frameworks we adopt for our research as sources of ideas that we can appropriate and modify for our purposes as mathematics educators" (p. 460). After reading Eisenhart and Lester, I have decided that I would use

a conceptual framework for my study and Figure 1 contains the conceptual framework I developed.

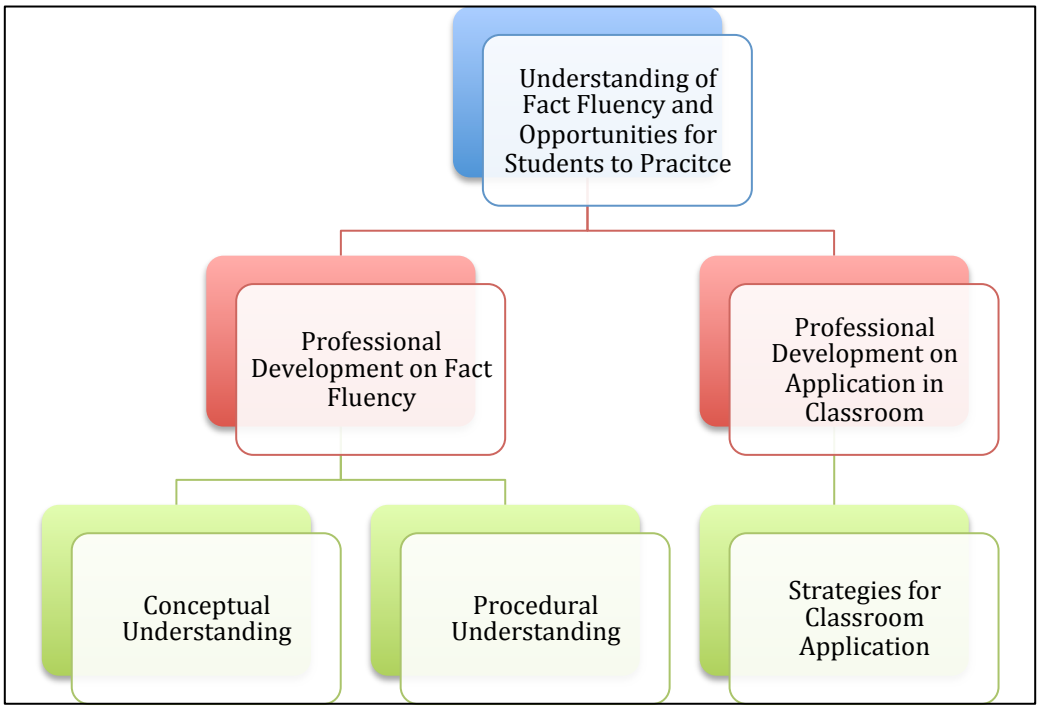

Figure 1. Conceptual framework

I wanted teachers to understand fact fluency and provide opportunities for students to practice these strategies with their students in the classroom and the conceptual framework helped break down the essential parts. To be successful, I believe that sustained professional development needs to be held for these mathematics teachers to gain an understanding of fact fluency while learning effective strategies for to implement with their students. Two types of professional development were delivered: 1) Professional development to increase teachers' understanding of fact fluency and 2) Professional development that modeled strategies for teachers to use in their classroom that potentially provided students with opportunities to practice fact fluency. The

professional development that was offered built teachers' content knowledge while providing them with effective strategies to implement in their classrooms.

Importance of Reform in Mathematics

Fact fluency is important for upper elementary students. National Council of Teachers of Mathematics (NCTM, 2000) wrote that between third and fifth grade, students need to develop fluency with basic whole numbers to be able to mentally compute similar problems. According to Keiser (2016) students should be fluent in all operations by the completion of fifth grade. In order for students to be successful problem solvers and enjoy mathematics challenges (Bystrom 2010), they need to be fluent in their basic mathematics facts because "mathematics fact fluency is central to higher-level mathematics as decoding is to reading" (Musti-Rao & Plati, 2015, p. 419).

Reform in mathematics calls for a drastic change in both teaching and learning. Although there have been numerous studies on fact fluency (e.g., Van de Walle, 2014), the research is limited in regards to teachers' content knowledge and understanding of fact fluency through professional development. Studies completed by the National Center for Education Statistics (NCES) and the National Mathematics Advisory Panel showed that students struggle with basic computation in mathematics. Areas that need more attention in mathematics instruction include fluency of whole numbers and the automaticity of recalling basic facts within all four operations, addition, subtraction, multiplication and division. Van de Walle (2014) discussed how students must be provided with experiences that foster their love of learning mathematics, while building an understanding of the power mathematical knowledge brings to their everyday world.

It is vital for teachers to provide their students with opportunities to become fluent with their basic multiplication facts as they encounter the crucial concept of multiplication and division at the third-grade level. "Although there is general consensus that fluency is an important skill in the elementary grades, few curricula in the USA provide sufficient practice to ensure fast and efficient recall of basic mathematics facts" (Musti-Rao & Plati, 2015, p. 419). In classrooms across the U.S. students are struggling to reach the high levels of achievement in this day and age of increased accountability (Hawkins, Musti-Rao, Hughes, Berry & McGuire, 2009).

Understanding Fact Fluency

When looking at what procedural and basic fact fluency mean, there are various interpretations. Baroody (2006) described basic fact fluency as "the efficient, appropriate, and flexible application of single-digit calculation skills and . . . an essential aspect of mathematical proficiency" (p. 22). Musti-Rao and Plati (2015) refer to fluency in mathematics as "the ability to respond to mathematics facts in the four operations (i.e., addition, subtraction, multiplication, and division)" (p. 418). Going a little bit deeper with their definition, Poncy, McCallum and Schmitt (2010) wrote, "fluency is a term used to describe fast and accurate academic responding and is necessary to meet classroom demands across skills and subject areas" (p. 917). Likewise NCTM, *Principles and Standards for School Mathematics* (2000) document, the writers refer to computational fluency as one having an effective and accurate method for computing numbers. "Students exhibit computational fluency when they demonstrate flexibility in the computational methods they choose, understand and can explain these methods, and

produce accurate answers efficiently" (NCTM, 2000, p. 152.). According to Bass (2003), "computational fluency entailed bringing problem solving skills and understanding to computational problems" (p. 322). The computational approaches a student chooses to use should be grounded in mathematical thoughts the student understands. Some approaches a student may choose to use include, but are not limited to, base-ten number system, properties of operations and number relations. Results from Gojak (2012), indicated that "a student cannot be fluent without conceptual understanding and flexible thinking" (p. 1). So no matter which definition you reference, fact fluency in mathematics is flexibly solving problems efficiently and effectively because students have a deeper understanding of basic facts.

Conceptual Understanding Versus Procedural Understanding

In order to understand fact fluency, there has to first be an understanding of conceptual understanding and procedural understanding by teachers. "Developing fluency requires a balance and connection between conceptual understanding and computational proficiency. Computational methods that are over-practiced without understanding are forgotten or remembered incorrectly. Understanding without fluency can inhibit the problem solving process" (NCTM, 2000, p. 35). Kilpatrick, Swafford, and Findell (2011), provided a research review on how children learn mathematics, identified the five strands of mathematical proficiency as indicators that demonstrate the understanding of mathematics (Van de Walle, Lovin, Karp, & Bay-Williams, 2014). The five strands the National Research Council (2001) identified were: Conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and

productive disposition. These five strands are interdependent and interwoven, as the development of one strand aids the development of the other strands, so when one strand is not developed or a student is not proficient within a particular strand, the other strands are affected along with the child effectively learning mathematics.

Conceptual understanding and procedural competence are both important components of proficiency. O'Connell and SanGiovanni (2013) noted there are no "tricks" in mathematics and that understanding mathematics makes it easier. When teachers set up opportunities for students to discover rules or generalizations, students exercise reasoning skills as they are making sense of mathematical concepts. Once students understand the process of multiplication they are ready to focus on number patterns and relationships. By understanding the patterns and relationships of numbers, students will then be able to internalize the basic facts. Students should spend the majority of their time exploring patterns because this will help them develop multiplication facts in a more meaningful way rather than just memorization (O'Connell & SanGiovanni, 2013).

Developing both procedures and concepts are both important. "Procedural fluency and conceptual understanding can be developed through problem solving, reasoning, and argumentation" (NCTM, 2000, p. 21). Many students lack the fluency needed to be successful in mathematical problem solving. If students struggle with basic facts, then how can they begin to focus on complex problems in mathematical situations? A study by Mauro, LeFevre and Morris (2003) found that before students can be successful problem solvers, they must be able to recall and understand basic facts. McCallum,

Skinner, Turner and Saecker's (2006) also agreed that the development of fact fluency is important to higher-level mathematics.

Students who struggle or have not mastered their basic facts, often times tend to struggle even more with problem solving in mathematics. According to the NCTM (2000), "understanding without fluency can inhibit the problem solving process" (p. 35). Struggling students, when given a word problem or complex mathematics problem situation, often times spend the majority of the time trying to work out the basic computation and do not successfully solve the problem. When this occurs, students can often loose self-confidence, tend to give up, and are put under stress. When students are put under stress, especially in mathematics, they often times are unable to successfully solve problems because the stress impedes their working memory-the area of the brain where we hold mathematics facts (Boaler, 2012). It has also been found that "mathematics anxiety has an impact on those with high, rather than low amounts of working memory-the students who have the potential to take mathematics to higher levels" (Boaler, 2012, p. 470).

Memorization or Automaticity

Memorization and automaticity are not the same. Fosnot and Dolk's (2001) do a thorough job of explaining the difference between teaching for memorization and teaching for automaticity. When teaching for memorization, one is committing the results of unrelated operations to memory so thinking is unnecessary; when one is teaching for automaticity, then answering facts automatically, one is thinking about the relationships between numbers.

Kilpatrick and colleagues found (2001):

> The role of practice in mathematics, as in sports or music, is to be able to execute procedures automatically without conscious thought. That is, a procedure is practiced over and over until so-called automaticity is attained. There are cognitive benefits to automatization. The more automatically a procedure can be executed, the less mental effort is required. Because each person has a limited amount of mental effort that he or she can expend at any one time, more complex tasks can be done well only when some of the subtasks are automatic. Hence, the automatization of mathematical procedures is justifiable when those procedures are regularly required to complete other tasks. (p. 351)

"Information-processing theory supports the view that automaticity in mathematics facts is fundamental to success in many areas of higher mathematics" (Woodward, 2006, p. 269). Contemporary approaches to mathematics, where more emphasis is placed on conceptual understanding and problem solving compared to computational skills, see the importance for automaticity in mathematics facts. According to Nelson, Burns, Kanive and Ysseldyke (2013), "students who demonstrated proficiency in mathematics should possess an understanding of key mathematical concepts and automatically retrieve arithmetic facts" (p. 659). Students who successfully recall basic mathematics facts from memory and are capable of automatically retrieving the facts, develop skills needed to be problem solvers. According to Godfrey and Stone (2013) "children gain automaticity along with number sense when they are given time and opportunities to explore number relationships" (p. 98). Teachers have to provide their students with

daily practice in order for students to become fluent in their mathematics facts.

A focus on memorization minimizes the importance of conceptual understanding and emphasizes rote learning. Students who struggled to commit basic facts to memory often believe there are hundreds to be memorized because they have little or no understanding of the relationships among them (Fosnot & Dolk, 2001). Results from Burns (2000), indicated "…it is not wise to focus on learning basic facts at the same time children initially study an operation, because a premature focus gives weight to rote memorization, instead of keeping the emphasis on developing understanding of a new idea" (p. 191). When learning basic mathematics facts, students should build on their prior knowledge and focus on the strategies that help them successfully compute (Burns, 2000). Hyde (2006) found, "Most kids are required to memorize "facts" that they do not fully understand. They are trying to use brute-force memory that connects nothing" (p. 115). Students must understand the mathematics facts, not memorize them, in order to apply them successfully.

Algorithms and Timed Test Versus Strategies

Numerous studies focus on helping students develop fact mastery, and it has little to do with the magnitude of drill or drill techniques that should be avoided. According to Van de Walle and Lovin (2006) if appropriate development was undertaken in the primary grades, there would be no reason that all students could not master their facts by the end of third grade. Seeley (2009) felt, "asking students to demonstrate basic multiplication fact knowledge within an arbitrary time limit may actually interfere with their learning" (p. 93). She goes on to say that "measuring one aspect of mathematics—

fact recall—using timed tests is both flawed as an assessment approach and damaging to many students' confidence and willingness to tackle new problems" (Seeley, 2009, p. 93). Timed tests can be seen as a punishment to students who need more time to process.

All too often teachers believe that repeated practice leads to fact fluency. Godfrey and Stone (2013) claimed that some teachers have a belief that through the use of flash cards and timed tests, students will be able to recall facts from memory and in turn become successful with fluently recalling their facts. Students who perform well under time pressure display their expertise, while students who have difficulty with skills, or who work more slowly, run the risk of reinforcing wrong learning. Results from a study by, Ramirez, Gunderson, Levine and Beilock (2013), "highlighted the potential of mathematics anxiety to negatively impact children's mathematics achievement as early as first and second grade" (p. 199). The findings from their study were worrisome because the children who suffer from mathematics anxiety are the very students that often times struggle with fast recall of facts using timed tests. Students who suffer from mathematics anxiety will continue to be unsuccessful at timed tests and fact recall if they do not understand the conceptual level.

By understanding the conceptual level of fact fluency, students will gain an understanding where they can later apply the skills successfully in problem solving. Even Burns (2000) said, "overemphasizing fast fact recall at the expense of problem solving and conceptual experiences gives students a distorted idea of the nature of mathematics and of their ability to do mathematics" (p. 191). Students who do not

understand the conceptual level are unable to apply to problem solving situations. The students are just recalling numbers without understanding the meaning of the operation. Burns (2000), also discussed "how timed tests do not measure students' understanding, but place an instructional emphasis on memorizing, which does not guarantee the needed consideration to understanding the concept" (p. 191).

Timed tests, in the classroom, do not ensure students will be able to effectively use the memorized facts in problem-solving situations. Kling and Bay-Williams (2014) discussed how timed tests offer little insight about how flexible students are in their use of strategies, and evidence suggests that efficiency and accuracy may actually be negatively influenced. "Timed tests can convey to students that memorizing is the way to mathematical power, rather than learning to think and reason to figure out answers" (Burns, 2000, p. 192). When timed tests are used as an assessment tool, minimal feedback can be given, an "assessment should support the learning of important mathematics and furnish useful information for both teachers and students" (Kling & Bay-Williams, 2014, p. 496).

There must be meaningful practice to develop fluency with basic facts. "Do not subject any student to fact drills unless the student has developed an efficient strategy for the facts included in the drill" (Van de Walle & Lovin, 2006, p. 82). NCTM, (2000) supported, "practice should be purposeful and should focus on developing thinking strategies and a knowledge of number relationships rather than drill isolated facts" (p. 87). According to Van de Walle and Lovin (2006):

> Drill can strengthen strategies with which students feel comfortable—ones they "own"—and will help to make these strategies increasingly automatic. Therefore, drill of strategies will allow students to use them with increased efficiency, even to the point of recalling the fact without being conscious of using a strategy. Drill without an efficient strategy present offers no assistance. (p. 117)

The goal in today's mathematics classrooms is to implement procedures that increase understanding of mathematics skills and concepts rather than encouraging memorization. According to O'Connell and SanGiovanni (2011), "students develop deeper understanding of operations through problem posing, hands-on explorations, real-world examples, classroom discussions, and exploring situations from children's literature" (p. 5). Students need to successfully do mathematics, and understand the mathematics they are doing. "Strategies help students find an answer even if they forget what was memorized" (O'Connell & SanGiovanni, 2011, p. 5). According to Fuson and Beckman (2012), the word "strategy" emphasized that computation was being approached thoughtfully with an emphasis on student sense making. When we discuss mathematical fact strategies students are focusing on number sense, operations, patterns and properties. O'Connell and SanGiovanni (2011) found:

> These big ideas related to numbers provide a strong foundation for the strategic reasoning that supports mastering basic mathematics facts. For multiplication and division, strategic reasoning related to doubling and halving, the commutative property, zero and ones properties, recognizing patterns, and breaking numbers apart to find related products provides students with a solid foundation for

mastery of mathematics facts. (p. 5-6)

Children progress through mathematical skills in different phases. Baroody (2006) claimed that fact fluency in mathematics is developmental and believes there are three phases through which children progress through when mastering basic mathematical facts. The three phases identified were: Counting strategies, reasoning strategies, and mastery. In the counting strategy phase, children use objects or verbal counting to find a solution or answer. From there children move to the reasoning strategy phase where they use relationships to solve problems. The last phase, through which students progress through, is mastery. In the mastery phase students reach automaticity with basic facts. Once students have developed an understanding of operations and they have explored strategies to find solutions to basic facts, it is time for students to begin practicing the facts to aid in committing the mathematics facts to memory. Students who successfully used strategies they had invented before they mastered the standard algorithm were able to demonstrate a better understanding and could apply their learning to future problems. "When students compute with strategies they invent or choose because they are meaningful, their learning tends to be robust—they are able to remember and apply their knowledge" (NCTM, 2000, p. 152). Number Talks is a thinking strategy that provides students with the opportunity to discuss their reasoning when solving problems. "The introduction of number talks is a pivotal vehicle for developing efficient, flexible, and accurate computation strategies that build upon key foundational ideas of mathematics such as composition and decomposition of numbers, our system of tens, and the application of properties" (Parrish, 2010, p. 5).

According to Parrish (2010), students developed computational fluency using classroom conversations during a Number Talk.

Professional Development Increasing Teacher Content Knowledge in Mathematics

In order for mathematics teachers to help their students become fluent with their facts, they must first have an understanding of the content in which they teach. "Professional development for teachers is often recommended as a strategy for school improvement" (Newmann, King, & Youngs, 2000, p. 259). According to Hill, Schilling and Ball, 2004, teachers' content knowledge of mathematics has become a concern because there is a difference between "a knowledge of mathematics and knowledge about mathematics" (p.14). In the U.S., mathematics achievement is a huge concern because the country continues to fall behind other countries in achievement (Lewis, Fischman, &Riggs, 2015). "Teacher learning has garnered renewed attention since teacher quality is the most important school-level factor to student learning" (Lewis et al., 2015, p. 448).

Professional development is an essential component in teaching. According to Polly (2013) professional development in mathematics has been viewed as one of the components in education reform. "Scholars and policymakers see improving teacher quality as a key way to improve student learning. Quality can be improved through professional development" (Foster, Toma, & Troske, 2013, p. 255). Teachers who continue their own personal learning through professional development sessions will in turn continue to improve their teaching quality. Polly (2013) claimed:

Syntheses and meta-analyses of professional development research have

> concluded that effective professional development includes: active learning experiences, focus on content and pedagogy, comprehensive and sufficient duration, collaborative activities with teachers and project staff, and teacher ownership of professional learning activities. (p. 565-566)

"Teaching and learning mathematics are complex tasks. The effect on student learning of changing a single teaching practice may be difficult to discern because of simultaneous effects of both the other teaching activities that surround it and the context in which the teaching takes place" (Grouws & Cebulla, 2000, p.8). The evidence suggests that teachers lack content knowledge that is essential when teaching mathematics. In order for student achievement to increase in mathematics, teachers have to understand the content in which they teach. By providing teachers with opportunities to increase their content knowledge, not only is that beneficial for the teacher but also for their students.

Research studies have found that teachers' mathematical content knowledge along with their beliefs about mathematics impact and influence their pedagogy (Polly, Neale, & Pugalee, 2014). "Mathematical knowledge for teaching goes beyond what has been captured in measures of mathematics courses taken or basic mathematics skills, there has to be on-going professional development" (Hill, Rowan, & Ball, 2008, p. 327). Despite widespread interest and concern, previous research is limited in the area of teacher content knowledge and its' effects on student achievement (Hill et al., 2008). The amount of content knowledge a mathematics teachers has influences their students' achievement according to (Hill et al., 2008), and there are certain teaching strategies that

teachers should consider in order to increase not only student achievement but their teaching practices as well (Grouws & Cebulla, 2000).

Teacher content knowledge can directly impact student achievement and it is vital that teachers continue to grow professionally not only for themselves, but for their students. "Ongoing research on teaching, on students' learning, and on the mathematical demands of high-quality instruction can contribute to content knowledge in teaching" (Hill et al., 2005, p. 401). Miriam Met (2004) wrote in her chapter on foreign languages in the Handbook of Research on Improving Student Achievement:

> Research cannot and does not identify the right or best way to teach […] But research can illuminate which instructional practices are more likely to achieve desired results, with which kinds of learners, and under that what conditions […] While research may provide direction in many areas, it provides few clear-cut answers in most. Teachers continue to be faced daily with critical decisions about how best to achieve the instructional goals embedded in professional or voluntary state or national standards. A combination of research-suggested instructional practices and professional judgment and experience is most likely to produce [high student achievement]. (p. 31).

Professional development can assist teachers in growing professionally. Grows and Cebella (2000) claimed that there were teaching strategies and methods that helped to improve mathematics teaching practices. One of the goals was to ensure teacher preparation and professional development programs were helping teachers develop their content knowledge in mathematics. According to Kilpatrick et al. (2001), "professional

development can create contexts for teacher collaboration, provide a focus for the collaboration, and provide a common frame for interacting with other teachers around common problems" (p. 397). "When teachers have opportunities to continue to participate in communities of practice that support their inquiry, instructional practices that foster the development of mathematical proficiency can more easily be sustained. Professional development beyond initial preparation is critical for developing proficiency in teaching mathematics" (Kilpatrick et al., 2011, p. 398).

Conclusion

In order for teachers to understand fact fluency and provide students with opportunities to practice, professional development opportunities must be provided. Teachers need to develop a true understanding of what fact fluency is, along with effective strategies to ensure their students are successful, and an understand that teaching mastery of facts means making connections between conceptual and computational understanding (Wallace & Gurganus, 2005).

CHAPTER III

METHODOLOGY

The purpose of this mixed method study was to address teachers' lack of understanding about fact fluency. Though act fluency is considered important in mathematical problem solving, it is seldom found in mathematics instruction in elementary/middle/high school classrooms. Actually, mathematics teachers in my own school do not provide opportunities for students to develop fact fluency from their mathematics learning experiences. The research design I selected for this study was an embedded mixed methods-intervention design that involved collecting qualitative data before and during the intervention phases of the study. In the first phase of the study, I collected qualitative data using structured interviews with participants to explore their understanding of fact fluency before intervention. During the second phase of the study, I gathered and quantitatively analyzed, observational data to understand the teachers' experiences with the intervention. The third phase of the study involved collecting qualitative data using structured interviews to determine if the professional development sessions were beneficial.

Participants

The participants were six mathematics teachers. The sample consisted of two mathematics teachers from grade 3, two mathematics teachers from grade 4 and two mathematics teachers from grade 5. Out of the six teachers, three teachers had five or more years of teaching experience and three had less than five years of teaching experience. The teachers were identified because students in these grade levels are

taught multiplication facts, which is what this study was focused on. Table 1 shows the demographic information of the six participating teachers: ethnicity, gender and the number of years each participant has been in education.

Table 1 *Participant Demographic Information*

Participant	Ethnicity	Gender	Years of Experience in Teaching
A	White	Female	16
B	Hispanic	Male	12
C	White	Female	2
D	Hispanic	Male	20
E	African American	Female	5
F	White	Female	2

Participant A

Participant A has been teaching for sixteen years. Prior to teaching, she was an interior decorator and a stay at home mom to her one son. She began her teaching career once her son entered middle school. When her son entered middle school she saw her son struggle in school as well his teachers struggling to meet his needs, which led her to go back to college to become a teacher. She attended Sam Houston State University and received a Bachelor's degree in Interdisciplinary Studies. After graduation she taught first grade for one year in Huntsville, Texas before moving to Bryan, Texas. Once in Bryan she began teaching fifth-grade at an elementary campus for one year and then taught third-grade for two years. After that she moved down a grade level to teach second grade for one year at this same campus. She then transferred to another elementary campus within Bryan ISD and taught third grade for four years where she

was departmentalized, teaching mathematics. After those four years passed, she then transferred to Neal Elementary where she has currently taught at for the passed six years. At Neal Elementary she has taught first, second and third grades. This past year she taught third grade where she was departmentalized teaching mathematics and science.

Participant B

Participant B has been teaching for 12 years. Prior to teaching he was an engineer in Mexico. As an engineer, he had a second job where he was teaching, some thing he has always enjoyed doing since he was in high school, helping others. Then for one year he just focused on engineering but wasn't fully satisfied with what he was doing. At the end of that year, the opportunity arose for him to come to the United States and become a teacher through an alternative certification program. He and his family relocated to the United States where he began doing what he loved, teaching students. He has taught in Bryan for the past 12 years, all 12 years being at Neal Elementary as a third-grade bilingual teacher. He has taught self-contained third-grade as well as been departmentalized teaching mathematics and science. This past year he taught third grade bilingual where he was departmentalized teaching mathematics.

Participant C

Participant C has been teaching for three years. She began her experience in public education as a library assistant for five years at an elementary school in Bryan. While working in this position she discovered her love for learning and working with kids, teaching them new things. Once her children were in school, she made the

decision to go back to school to become a teacher. Working full-time while also enrolled as a full-time student, she earned her Bachelor's degree in interdisciplinary studies. After receiving her degree, she was hired as a certified teacher in Bryan and began her teaching career at Neal Elementary. She has taught third grade science and social studies and this past year completed her second year in fourth grade where she was departmentalized teaching mathematics and science.

Participant D

Participant D has been teaching bilingual education for 20 years. He received his degree from Texas A&M University with a Bachelor's degree in agriculture. After graduation, he was unable to locate a job in his field but heard about an opening at an elementary school in Bryan. He went to an interview and the principal told him she needed a bilingual teacher with a science background and because of his degree he was a match. That day he was offered a fifth-grade bilingual science teaching position, a position he thought would be temporary, but he fell in love with teaching students. He completed an alternative certification program and began his teaching career at Neal Elementary. After two years, the need for a fifth-grade bilingual teacher diminished so he transferred to another elementary campus where he taught fifth-grade, self-contained, for seven years. During this time, he also received his Master's degree in Education Administration. He then transferred back to Neal Elementary, where he taught bilingual fifth-grade self-contained for eight years. This past year he completed his first-year teaching fourth grade bilingual where he was departmentalized teaching mathematics and science.

Participant E

Participant E has been teaching for five years. While working on her undergraduate degree at Texas A&M University in the medical field, she found her passion to be teaching and working with kids. It was at that time in her life that she realized what a positive impact her teachers had on her life and so she changed her major to education with a focus on mathematics and science, grades 4-8. While pursuing her dream of becoming a teacher, she worked as a reading and mathematics tutor at elementary schools in Bryan. After graduation, she was hired as a mathematics tutor at Neal Elementary for one semester. When the new school year began, she was hired as a third-grade, self-contained teacher. She taught third-grade for two years before moving to fifth-grade. In fifth-grade she was part of a departmentalized team where she taught mathematics for two years. This past year she taught fifth-grade reading and mathematics.

Participant F

Participant F has been teaching for two years. She had always enjoyed working with children and learning about different cultures. She attended college at the University of Texas San Antonio where she received her undergraduate degree in Interdisciplinary Studies. After graduating, she traveled overseas for eleven months where she worked with diverse groups of students teaching them English. Once she returned from overseas, she relocated to Bryan, and at that time, she was hired at Neal Elementary as a second-grade English as a Second Language (ESL) teacher that taught science and social studies. During her first month at Neal Elementary, she was moved to

fourth-grade as a mathematics and science ESL teacher. This past year she taught fifth-grade where she was departmentalized where she taught mathematics and science to ESL students.

Setting

The research site, R.C. Neal Elementary, which is located in Bryan, a city in central Texas. It is one of fifteen elementary schools in the largest district in Brazos County. The school district serves 23 campuses that consist of four high schools, four middle schools and 15 elementary schools that educate a diverse population. R.C. Neal Elementary serves 488 students in grades Kindergarten through 5th grade. Table 2 shows the distribution of students at R.C. Neal Elementary.

Table 2 *Student Demographics (Texas Education Agency)*

	Campus	**District**	**State**
African American	25.6%	18.9%	12.6%
Hispanic	71.3%	55.0%	52.0%
White	1.8%	23.9%	28.9%
American Indian	0.4%	0.2%	0.4%
Asian	0.0%	0.4%	3.9%
Pacific Islander	0.0%	0.1%	0.1%
Two or More Races	0.8%	1.5%	2.0%
Economically Disadvantaged	97.1%	73.6%	58.8%
English Language Learners	47.3%	22.3%%	18.2%
Special Education	4.7%	8.1%	16.9%

During the 2016-2017 school year, there were 28 teachers at R. C. Neal Elementary. Of the 28 teachers, one was a special education teacher while the other 27 were general education teachers. All the teachers worked together to ensure that all

students were successful. Table 3 shows the distribution of the teachers by degrees attained.

Table 3 *Teacher Degrees Attained (Texas Education Agency)*

	Campus	District	State
No Degree	0.0%	0.0%	0.9%
Bachelors	17.1%	59.3%	75.1%
Masters	11.7%	40.7%	23.54%
Doctorate	0.0%	0.0%	0.6%

Neal Elementary received a rating of met standard for the 2015-2016 school year based on their results from the standardized test, STAAR, State of Texas Assessments of Academic Readiness. Table 4 shows student performance at the campus, district, and state levels.

Table 4 *Student Performance on STAAR*

Grade Level	Campus	District	State
3rd grade	84.7%	70.1%	76%
4th grade	60.7%	66.5%	74%
5th grade	78.9%	81.3%	75%

Methods

The paradigm grounding the method of data collection in this study was a mixed design. "As a method, it focuses on collecting, analyzing, and mixing both quantitative and qualitative data in a single study or series of studies" (Creswell & Clark, 2011, p. 5). In this study, both qualitative (QUAL) and quantitative (QUAN) data were used in an embedded mixed methods design. See the research diagram (Figure 2), which was

drawn in PowerPoint to illustrate how I used the embedded design. This design illustrates how data was collected during this study. The data from this study was used (1) to determine teachers' understanding of fact fluency; and (2) to determine the effectiveness of the professional development delivered to teachers to increase opportunities for students to practice facts.

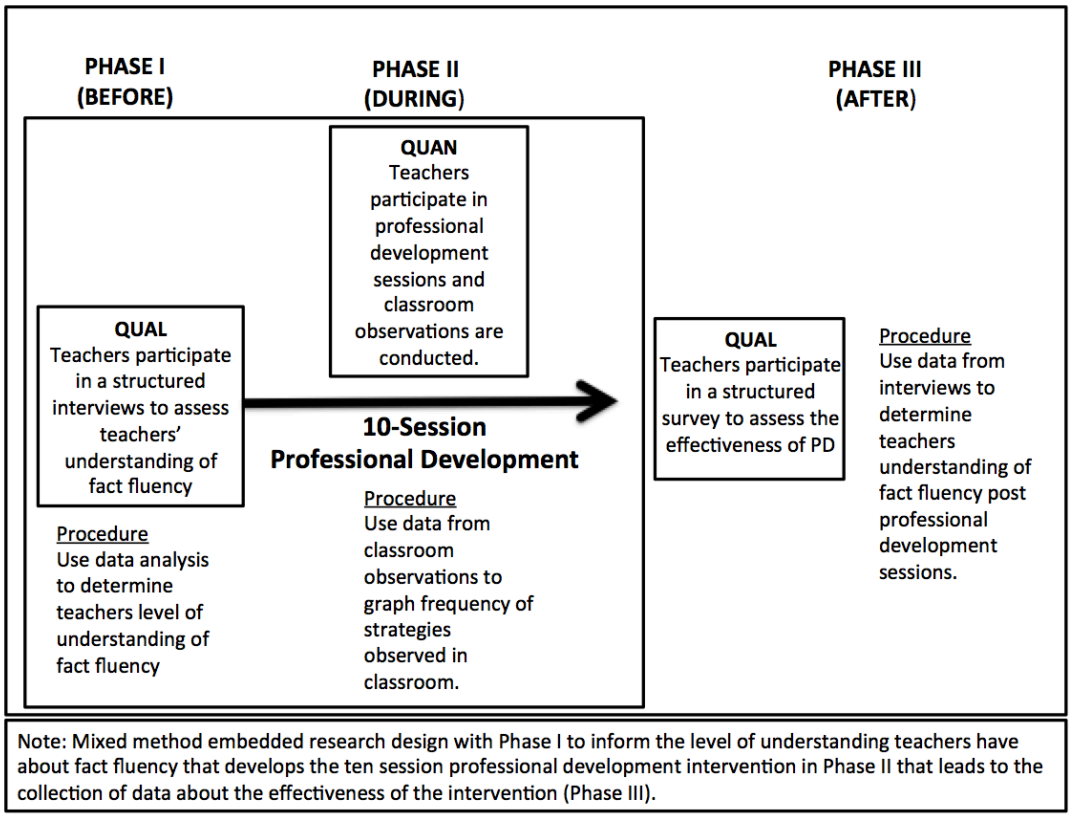

Figure 2. Research diagram

According to Stake (2010), one of the main purposes of interviewing is to "obtain unique information or interpretation held by the persons interviewed" (p. 95). The first phase of the study involved a structured interview of each participant, individually (see Appendix A). Interviewing the participants individually allowed

participants to "speak in their own voice and express their own thoughts and feelings" (Berg, 2007, p. 96) and by using a structured interview, closed questions will be used and Corbetta (2003) states all of the participants are to be asked the same questions in the same order. The participants were interviewed in their own classrooms during their conference period or after school. Each interview lasted approximately 15-20 minutes and were recorded using a handheld recording device. Once all interviews were completed, the researcher transcribed all interviews. There were two purposes for using structured interviews. The teachers were interviewed to assess their knowledge of fact fluency and to understand what professional development would benefit them to increase their knowledge of fact fluency.

The second phase of the study was the delivery of professional development sessions. Each session lasted approximately 60-mintues after school one day a week over a ten-week period. The professional development sessions all had the same procedures, introduction of strategy, modeling the use of the strategy (see Appendix B for strategies that were covered) and development time of the presented strategy. The sessions were held after school so that all six-teachers could collaborate with each other, develop and prepare the strategies for implementation in their own classrooms. If a teacher missed a professional development session, the plan was for the teacher to meet with the researcher individually, either during their conference period or after school, to receive the information that was missed. The participating teachers were not be paid to attend the professional development sessions.

During this second phase, I also collected observational data from the six teachers classrooms (see Appendix C for the observational tool that was used). The researcher developed an observational tool based on the ten mathematical fact strategies that were modeled during the professional development sessions. This tool was used to monitor implementation of the strategies by collecting observational data daily over the ten-week period. During each observation, the researcher looked for students' use of each strategy over a five to ten-minute walk-through. The researcher marked next to each strategy observed during the time they are in the classroom. This was completed for each of the six classrooms over the ten-week period.

The third phase of the study involved a structured interview of the participants. The open-ended questions (see Appendix D) used were determined before the study began. Data collected from the interviews "illustrate what information was obtained from participants" (Creswell & Clark, 2011, p. 177).

Data Analysis

This mixed methods design stated with analyzing the qualitative data and then considering the quantitative data. The reason for starting with the qualitative data was to determine the teachers' understanding of fact fluency and their knowledge of fact strategies.

Qualitative Analysis

The coding process went through several avenues to determine the themes from the six participants interviews. Ryan and Bernard (2003) wrote about how researchers know they have found a theme when they are able to link expressions found in text.

Themes were used to help reduce the data and the types of questions that were asked during the structured interviews helped with this process. As the researcher, dependability was ensured because I described any changes that occurred in the setting and may have affected the study. A member check was also conducted after the interviews were completed. The results were shared with the participating teachers to check the viability of the interpretation.

Qualitative data were collected during the first and third phase of the study from the interviews and were interpreted by the use of coding in which I assigned labels to the codes and then grouped the codes into categories. "Coding (classifying, sorting) is a common feature of microresearch and all qualitative analysis and synthesis. Coding is sorting all data sets according to topics, themes, and issues important to the study" (Stake, 2010, p. 151).

Quantitative Analysis

Descriptive statistics played a role in the analysis of the observational data of implementation of the fact strategies over the ten-week period. The observation was a nonparticipant observation, where the observer only watches and records and is not involved in the study. Burns (1999) focuses on the researcher remaining aloof and have little to no contact with the subjects while Fraenkel and Wallen (2003) write that "researchers do not participate in the activity being observed but rather sit on the sidelines and watch" (p. 451). The researcher not being an active participant helps increase reliability. To increase validity, observations were conducted over a ten-week period.

During the second phase of the study, quantitative data was collected from observations in each of the six teachers classrooms and was analyzed. The observational tool was a systematic instrument that was used during daily walk-throughs of the six teachers classrooms (see Appendix C for the observational tool that was used). A researcher collecting observational data, in quantitative research, can gather data where response categories are determined before the collection of data begins (Creswell & Clark, 2011, p. 177). During the observation, that occurred daily in all six classrooms, lasted between five and eight minutes. The observer noted which fact strategies that were being implemented at the time of the walk-through, minute by minute and the frequency was represented in a bar graph rather than inferential test of significance because of the small sample size.

Mixed Methods Analysis

In research, both qualitative and quantitative research are important and for a study to be considered a mixed methods study, the findings must be mixed or integrated. "The goal of mixed methods research is not to replace either of these approaches but rather to draw from the strengths and minimize the weaknesses of both in single research studies and across studies" (Johnson & Onwuegbuzie, 2004, pp. 14-15). For this study, a qualitative research objective was used, then quantitative data were collected and then the researcher performed a qualitative analysis of the quantitative data. The researcher collected quantitative data using the observational tool during phase two of the study and then analyze the collected data using descriptive statistics.

Qualifications of Researcher

Throughout my fourteen years as an educator, I have had many educational and work-related experiences that have fostered my passion for understanding mathematical concepts within the elementary school setting. My content knowledge spans from kindergarten through fifth grade, in addition to my ability to teach a diverse population of students. Furthermore, I have worked with teachers in planning and professional development sessions for five years. Through leadership positions and other educational experiences, I have gained the skillset of an effective communicator and collaborator. I have created professional development sessions and have trained teachers at the campus and district levels. I am a stakeholder invested in improving mathematics at the elementary level to ensure students are not just ready for high school, but ready for post-secondary success. I previously taught fourth and fifth grade mathematics and held the role as Master Teacher and Mathematics Instructional Coach at both campus and district levels. Currently, I am the Assistant Principal at R. C. Neal Elementary. As an instructional leader, it is my goal to equip teachers with the skills to reach and teach all students. I work directly with teachers in planning sessions and help them grow professionally so, in the end, their students are successful. As a result of my experiences, I was able to identify the problem and put a plan in place to help teachers gain a better understanding of a mathematics concept.

CHAPTER IV

RESULTS

The purpose of conducting this record of study (ROS) was to increase mathematics teachers' knowledge about fact fluency and develop effective strategies to increase the opportunities for students to practice their facts. The first part of the research study was focused on determining teachers' knowledge of fact fluency and strategies. During the second part I concentrated on determining the strategies that teachers were able to implement in their classrooms. The final part was dedicated on determining the overall effectiveness of the professional development on increasing teachers understanding of fact fluency.

Research Findings

In order to provide a complete picture of the results, the outcomes and results from this ROS was presented in two ways. First, the findings were presented grouped by each of the research questions. The theme was represented under the context of the research questions and will be described through selected quotes from the transcriptions. Secondly, to provide support, the observational data were discussed. This ROS was guided by the following research questions:

1. How do teachers understand fact fluency and in what ways do they provide opportunities for students to practice their facts?
2. What strategies are teachers able to implement in their classrooms that are focused on fact fluency?

3. How do teachers perceive the overall effectiveness of the professional development on increasing their understanding of fact fluency?

Finding for Research Question 1

Data from the structured interviews revealed the level of knowledge teachers possess about fact fluency and level of knowledge of strategies used to teach students. The results from the interviews also allowed insight to the kind of opportunities teachers provide for their students to practice their facts in their classrooms. Each of the six participants answered all the interview questions.

When asked about participants' experiences in learning basic mathematics facts, five of the six participants recalled having to memorize their mathematics facts when they were in elementary school. Participant C stated, "I was not good at mathematics because I never learned the basic facts. My teachers never stressed the importance, so I never learned them." Participant E said, "We played games but I mostly remember rote memorization of the algorithms for all four operations, addition, subtraction, multiplication and division." Participant B said, "In Mexico it was different. In grades 1-3 the most important thing we focused on was aromatics and by third I remember being an expert in all operations." Thus, their past experiences influenced their current thinking.

Next, participants described what fact fluency meant to them. Participant A, D, E and F all mentioned that fact fluency is not memorizing basic facts. Participant A said, "As a teacher it means having a basic understanding, a concrete understanding of whole numbers, and not memorizing." Participant E said, "It is a good grasp and foundation of

numeracy that can be recalled quickly." Participant F stated, "Fact fluency is when students have a good, proficient understanding of number sense of the four operations and can apply to problem solving." Participant B responded, "It is when you can solve operations accurately in a timely manner, correctly." Thus, descriptions of what fact fluency meant to the participant teachers varied.

Participants then rated their level understanding of fact fluency. These ratings were based on a scale of 1 to 5, 5 being high and 1 being low. Table 5 shows the participants responses to their level of understanding.

Table 5 *Understanding of Fact Fluency*

Participants	Level of Understanding
A	5
B	4
C	4
D	4
E	3
F	4

The next question focused on what would be needed to make a participant's rating a 5. Four of the six participants, Participants B, D, E, F, stated that in order to increase their knowledge of fact fluency they would need some type of professional development or training. Participant D said, "Professional development after school would help me." Participant B stated, "I would need to learn more about how to help students understand the concept to help them connect to the operations." Participants E and F both said they needed to learn more creative ways to teach fact fluency in their

classrooms. Two participants, Participant A and C, spoke about needing just repetition to help them develop a better understanding but did not elaborate on how or what that would look like. Overall, responses from the majority of the participant teachers focused on a need for professional development.

The next question was designed to gather information about the opportunities the teachers provide their students to increase fact fluency. Participants answered about what they usually do to provide students with the opportunity to practice their facts in class, a rating for opportunities for students practice facts in their classroom on a daily basis and what would be needed to make their rating a 5 if it was not already. Participants C, Participant D, Participant E, and Participant F all spoke about their students playing games of some sort to practice their facts. Table 6 displays all participant responses.

Table 6 *Student Opportunities to Practice Facts*

Participant	Ways students practice facts	Rating for opportunities to practice daily	What needed to make rating a 5
A	Daily station work	5	N/A
B	Fact practice handouts	3	More time needed during the day in class; student behavior under control
C	Games, cards, dominoes, stations	4	Consistently practice facts in class; student behavior
D	Around the world fact practice	3	Practice more; make part of daily routine
E	Games, dice, FASST Mathematics	3.5	Find activities that work; provide more exposure
F	Card games, competition, around the world	5	N/A

Two of the participants shared during their interviews that their rating for students opportunity to practice facts daily was a 5, while the other four participants rated between 3 and 4. The reason for not being a 5 was due to lack of time, student misbehavior interfering with instruction, consistently practicing and unable to find ways to provide more exposure to the mathematics facts.

The participants then were asked to rate the level of fact fluency their students exhibited in their class and what was needed to make their rating a 5. Table 7 illustrates each participant's rating and response.

Table 7 *Students Level of Fact Fluency (Low=1, High=5)*

Participant	Student Level of Fact Fluency	What needed to make rating a 5
A	3	More time to work with kids
B	3	More practice; students develop sooner in earlier grades
C	4	All students consistently know facts
D	3	Practice with the students
E	3.5	More time to practice
F	5	N/A

During the structured interviews, participants overwhelming shared that the reason their ratings were not a 5 was due to a lack of time to work with kids and/or a lack of time for students to practice.

Participants were asked to rate their knowledge and understanding of the ten different fact strategies. Table 8 shows each participants' response.

Table 8 *Understanding of Fact Fluency Strategies (Low=1, High=5)*

Strategy	Participant A	Participant B	Participant C	Participant D	Participant E	Participant F
Doubles	3	5	5	5	5	3
Halving then Double	5	5	5	5	5	4
Nearby Squares	0	5	1	4	4	2
Add a Group	5	5	2	5	4	5
Subtract a Group	5	5	2	5	4	5
Double +1 Group	2	5	5	5	5	5
Double and Double Again	2	5	5	5	5	5
Turnaround Facts	5	5	5	4	5	1
Related Equations	5	5	2	5	5	5
Decomposing a Factor	5	5	5	4	4	5

Participants were then asked what it would take to make their rating a 5 for all of the strategies. Participant C stated, "I need more time to understand the strategies before teaching them to my students." Participant F shared the same need as Participant C saying, "I need to have an understanding of each strategy before I teach it to my students." Participant E shared that, "I need to find activities that I could use to

implement the strategies. I also need to be consistent with implementation in my classroom." Participants A and D said they both needed professional development. Thus, the responses from the participant teachers varied.

At the conclusion of the interviews, each of the participants' responses were coded. It was evident that the participants had a basic understanding of fact fluency. The participants provided some type of practice in their classrooms, but it was not always consistent. It was also evident that the participants did not have an understanding of all of the fact strategies. The information collected from these interviews helped participants develop the focus for each of the ten professional development sessions.

Finding for Research Question 2

Phase two of the study focused on fact fluency professional development sessions and classroom observations that were used to help gather data on what strategies teachers implemented in their classrooms that were focused on fact fluency. Ten professional development sessions were conducted, see Appendix B for the strategy focus of each session. Because there is no hierarchy of the fact strategies, the order developed for each session was random because according to Hansen (2008), most children use a variety of strategies when recalling number facts because not all children learn in the same way. A description of each of the professional development sessions is provided in the subsequent paragraphs.

Session 1

The first introduction 30-minute session, was an overview of fact fluency and strategies. The session began by providing Baroody's (2006) definition of fact fluency

"the efficient, appropriate, and flexible application of single-digit calculation skills and . . . an essential aspect of mathematical proficiency" (p. 22) to the participants. Participants then discussed how their initial definition compared to the one given. Participant E talked about how she thought fluency was centered around how quickly a student could solve a problem, but after seeing this definition she realized it is more about efficiency and flexibility of solving a problem. Participant E also shared that now she feels like she has a better understanding of what fact fluency is, but still needs to know more about strategies to help her students become fluent. Next, we began to discuss the ten strategies that would be covered during the next nine professional development sessions. I shared the ratings collected from the interview that each participant provided based on their knowledge of the ten strategies, with identifiers removed. Two strategies, doubles and doubles +1, would be together because based on the interviews these strategies were ranked the highest overall. I shared the order the strategies would be delivered and explained that the next nine sessions would be about 60-minutes and all sessions would have same structure of: 1) Introduction of Strategy: 2) Modeling of Strategy: 3) Development of Strategy. Session 1 was then concluded.

Session 2

The second session was conducted in a 60-minute session. This session addressed two strategies, doubles and doubles +1 group. The session began by discussing what doubles was and how it can help students with their basic facts when two is a factor. I then modeled a game called Doubling Up! that focused on using doubles. I used a deck of cards, all face cards were removed, and a game board, see

Appendix E for the game board. I drew a card and then doubled it and covered that number on the game board. I explained that the first person to cover all of their numbers before time was called wins. After that I had the participants match up with a partner and play the game. Once the participants completed playing, they discussed how they could implement this game into their classrooms. Participant E shared that she planned on modeling it the next day and then put it in a station for the remainder of the week. Participant C shared that she would model it for her students and they would play it during their fact practice time. Participant B then asked, "How can we help students relate this to multiplication facts?" The participants discussed possible ways but the one that kept occurring was for the students to write out their doubles using addition and multiplication so they could see the relationship between the two operations. We then moved to the next strategy, doubles + 1 group. For this strategy, I began by discussing how it can assist students with multiplication when three is a factor. The participants agreed that students do better with their two's but often times struggle with three's. I then modeled a strategy for working with doubles + 1 group that the participants could use in their classrooms. I began by using a piece of graph or grid paper that I cut out in an array to represent 3 x 7. I then drew a line where doubles array would be (2 x 7 = 14) and pointed out that the additional set needed to be added on for one more set of 7 which would then equal 21. I then modeled an activity using a deck of cards with all face cards and 10's removed. I drew one card and multiplied it by 3 and used the doubles + 1 group strategy. I did a *think aloud* to model the thinking involved in the process, "The card I drew was a six so I think 6 x 2 = 12 and if I add one more group of 6 so that I am

adding 12 + 6 = 18 so therefore 6 x 3 =18." Following this, the participants worked with a partner on this same activity. Once they worked for about five minutes, I had the participants discuss what this activity would look like in their classrooms. Four out of the five participants agreed that this strategy would take more modeling than the doubles strategy. Participant D said he would model it on the first day and have the students watch and then on the second day have the students work through it with him and then hopefully by the third day his students could play with a partner and he could facilitate and monitor the activity. Each of the participants committed to trying both activities with their students during the upcoming week.

Session 3

During session 3, I focused on double and double again. This session lasted 40 minutes. I began the session explaining that this strategy builds upon the doubles strategy and how it would help students with multiplication facts where four is a factor. Next, I began by showing how double and double again works. I showed the multiplication fact 4 x 6 and how you double 6 to get 12 and then double 12 to get 24, so 4 x 6 = 24. Then I modeled an activity that the participants could take back to implement in their own classrooms. I took a sentence strip and folded it in half and then folded in half again, so there were four parts. Next, I rolled a six-sided di to find the number I would be working with. I rolled a 3 and drew three dots in each of the four sections. I then folded up the paper again to show one set of three dots and to double it I opened the paper up to show two sets of three that equal 6. To model doubling it again, I unfolded the other two sets to now show four sets of three or two sets of six. The

participants each took a sentence strip and folded it into fourths. They each rolled a six-sided di to find the number they would be working with and drew the dots to represent the number in each of the parts. After each participant completed drawing the dots in their four sections, they got with a partner to explain double and double again with their strip. After five minutes of sharing, I had the participants think about how they would apply this in their own particular classroom. Participant B shared that he would have to do this whole group with his students because he felt they would get either lost during the enactment of the activity or the students would not be able to make the connection between the strategy and the multiplication facts. Participant C shared that she immediately thought of three students who were struggling with their facts that this strategy would help. She said that she planned on implementing it during her intervention time with these three students in a small group setting. Each of the participants committed to trying the activity with their students during the upcoming week.

Session 4

During session 4, I focused on halving then double and lasted 45 minutes. I began the session by explaining to the participants what halving then double meant in multiplication and how it could specifically help students with their 6's and 8's. I also explained that when working with an even factor, you can use this strategy. I then modeled how to use the halving then double strategy using an array. On graph or grid paper I drew the array that represented the multiplication fact 6 x 7. When I counted the squares within the array there were 42 squares, so 6 x 7 = 42. I explained for students

who struggle with their 6's and 8's they can half the even factor and then double to help them solve. On my array, I drew a line to cut the six in half so that there were three columns in each half, demonstrating how to visually half an even factor. My array then showed 3 x 7 which equaled 21 thus I could double 21 to equal 42, showing that 6 x 7 = 42. Based on some of the facial expressions I determined that some of the participants did not fully understanding, so I pulled out color tiles to build the array that represented 6 x 7. I then split the array in half, three columns on each side to represent halving. Then I put the two halves together to represent the doubling which then equaled 42. Once I finished modeling, I had the participants take color tiles to represent 6 x 8 as an array. After each participant had created their array, Participant F asked which factor should they half. I explained that it was up to each individual because not everyone knows their 6's or their 8's, so it is what works for you. After I said that four participants halved the eight while the other two halved the six. What they discovered was that no matter which number they halved they still had the same amount in their halves. Then the participants pushed their tiles back together to represent doubling. They then counted their tiles to see that their products were the same, so even though some chose a different factor to half it had no effect on the product. The participants then rolled a six-sided di to obtain a factor to multiply by 6 and use the strategy halving then double. Then with a partner they had to explain their process aloud. Participant E shared how she did not think it would work halving a different factor than her partner but after working through it both ways she saw visually how it worked. She then mentioned how this would really benefit her students because so many of her students

struggle with their 8's, and if they had a strategy to help them break it down, they may begin to understand. The participants discussed how they would implement this strategy in their class and all agreed to try it out with their students.

Session 5

For session 5 which lasted 30 minutes, I focused on the strategy of adding a group. I began the session by explaining what adding a group was and how it related to friendly numbers. I wrote the multiplication fact, 8 x 6 on the board. I did a *think aloud* to demonstrate visually the thinking in using this strategy to solve this fact. "I do not know what 8 x 6 equals, but what do I know? I know that 8 x 5 is 40 so if I add one more group of 8, 40 + 8= 48, so 8 x 6 = 48." Participant D asked what to do when students do not know many facts they can relate back to? I suggested starting with smaller factors at first to help scaffold for students who are struggling, but the most important thing is to allow students to practice. The participants then paired up to solve three facts listed on the board using the strategy, adding a group. The facts listed were 7 x 6, 3 x 9, and 9 x 6. After five minutes passed, I had each pair explain how they solved one of the facts. The partner pair shared one fact, so when all three groups had finished sharing, all three facts had been explained. The participants then discussed how they could implement this strategy into their classroom. Participant D shared that he would introduce this strategy with his whole group and then possibly implement into a learning station for students to practice. Participant F said that she would pull a few students that seemed to struggle with their facts to model this strategy and then allow them time to

practice at her teacher table during intervention time. All of the participants committed to trying this strategy with their students during the upcoming week.

Session 6

During session 6, I focused on the strategy subtract a group and like session 5 lasted 30 minutes. The format of this session was similar to the previous session 5. I began the session by explaining what subtracting a group was and how it related to adding a group just like we had discussed during the previous week. I wrote the multiplication fact, 8 x 4 on the board. I did a *think aloud* to demonstrate the thinking in using this strategy to solve this fact. "I do not know what 8 x 4 equals, but what do I know? I know that 8 x 5 is 40 so if I subtract one group of 8, 40 - 8= 32, so 8 x 4 = 32." Like last week, the participants then paired up to solve three facts listed on the board using the strategy, adding a group. The facts listed were 7 x 4, 4 x 9, and 6 x 4. After five minutes passed, I had each pair explain how they solved one of the facts. The partner pair shared one fact, so when all three groups had finished sharing, all three facts had been shared, demonstrated, and explained. The participants then discussed how they could implement this strategy into their classroom. Participant D shared that he would introduce this strategy like he did this past week in a whole group setting and then relate it to the previous strategy, adding a group. All of the participants committed to trying this strategy with their students during the upcoming week.

Session 7

The focus of the 45-minute session 7 was nearby squares. I began this session by explaining the strategy of nearby squares and how it related to the strategies of adding a

group and subtracting a group. I explained how nearby squares can be a helper fact for a hard to solve multiplication fact. I went through a *think aloud* to model how to use the strategy of nearby squares by displaying the fact 4 x 3. I began by saying aloud, "I see that I am having to solve 4 x 3 and I do not know the product, but I do know the square helper fact of 3 x 3 = 9. Thus, I know I need one more group of 3 to solve the problem, so I add a group of 3 to find 4 x 3 = 12." I then modeled another fact, 8 x 6. I went through the same process but when it was time to add I modeled that I had to add two groups instead of just one like before. Then it was time for the participants to develop the strategy on their own. I posted the fact 6 x 7 on the board and had the participants solve it using the strategy of nearby squares. After three minutes passed, I had the participants share out and justify their solution and the process involved. Participant A explained that she felt that explaining the process would be the most difficult for her students and Participant C agreed. Participant E shared that she felt that justifying solutions in general is difficult for students, but if it is expected daily then students will hopefully become accustomed to justifying and explaining their solutions and processes. I then posted another fact, 6 x 4 for the participants to work through and then share their processes and solutions. After that I shared an idea for the participants to take back to their classroom for students to practice this strategy. Students could work in partners and roll two six-sided dice, record the two factors, and use the strategy of nearby squares to solve. The students could then explain their process with their partner and compare their processes. The participants then discussed that this strategy would be a good idea to implement in one of their mathematics learning stations. However, everyone felt

they would first need to be model the process. Participants A and B said they would probably need to model it for a couple of days and then have students work with them a few more times before putting it in a station. All of the participants were committed to attempting to enact this strategy with their students during the following week.

Session 8

During session 8, I focused on turnaround facts and lasted 30 minutes. I began this session by discussing what turnaround facts were and how they were related to inverse operations. I provided the example of 6 x 3 = 18 and 18 ÷ 3 = 6. The participants discussed how this strategy was apart of the state standards in third grade so it should not be difficult for students to understand and apply. I modeled using an array to help students visually use turnaround facts when solving basic mathematics facts. I used grid paper to represent 4 x 7 by creating an array. After the array was created I was able to identify that the product was 28 and I could turnaround the facts into a division problem, 28 ÷ 4 = 7. Participant C mentioned that this strategy may not help students with a multiplication fact necessarily, but it could help students if they understand the connection between the operations. By understanding this strategy, students can find a way to solve a problem they are struggling with using a turnaround fact for any operation. The participants practiced different facts using grid paper to represent using arrays and then identifying the turnaround fact. After five minutes the participants discussed how they would implement this strategy into their own classroom. Participant D said he would use this strategy at his teacher table with students who were struggling

not only with multiplication but with division. Each of the participants agreed to implement this strategy with their students during the forthcoming week.

Session 9

This session lasted 45 minutes and I focused on related equations. During this session, I began by explaining what related equations are in regards to multiplication. I explained that a turnaround fact is a multiplication fact where you can turnaround the factors and still get the same product (thus essentially the commutative property. I provided the example, 4 x 3 = 12 and if we turnaround the 4 and the 3, 3 x 4 = 12. Participant E shared that if students understood turnaround facts there would essentially be a lot less mathematics facts for them to actually learn. Participant B agreed and discussed how students are not fluent with their facts and lack an understanding of multiplication in general and because of that they struggle with related equations and are so focused on memorizing facts. I then modeled how to use arrays to help students understand related equations. I posted the fact 6 x 7 and represented it with an array horizontally on grid paper. I then labeled the rows and columns to identify the factors and wrote down the fact, 6 x 7 = 42. I then turned the array vertically to represent the turnaround fact, 7 x 6 = 42. Next, I had the participants take a piece of grid paper and two dice. The participants rolled the dice and represented the fact using an array, labeling the rows and columns. I then had the participants turn their array to represent the related equation. The participants then shared their related equations with the group and then discussed how they could implement this strategy in their classroom. All of the participants agreed that after the strategy was modeled by the teacher, it would be placed

it in a mathematics learning station within their rotations. They all decided that they could definitely implement this a related operation activity into their own particular classrooms sometime during the next week.

Session 10

During the final session, I focused on decomposing a factor and lasted for 45 minutes. I began this session by explaining what decomposing a factor means and how multiplication can be decomposed into simpler facts using the distributive property. I then provided an example for the participants, 9 x 8. I modeled how you can choose one of the factors to decompose, or break apart. I decomposed 9 into 5 and 4 and then multiplied 5 x 8 = 40 and 4 x 8 = 32. I then added the two products, 40 + 32 = 72, so 9 x 8 = 72. I then handed the participants a mathematics fact, 7 x 8 and requested that they decompose one of the factors to solve. After three minutes, I had each participant share out how they decomposed a factor to solve. I then handed the participants another mathematics fact, 12 x 6 and asked them to decompose one of the factors to solve. After three minutes, I had each participant share out how they decomposed a factor to solve. Participant C shared that she wished she had known this strategy in school because it would have helped her with her own with multiplication facts. Participant E discussed that if students understood decomposing numbers, which begins in earlier grades, students would have an easier time decomposing factors.

Classroom Observations

Additionally, during the next phase (or phase 2) of the study classroom observations were conducted during the ten-week period. The teachers in the majority

of the classrooms in this study implemented some type of daily fact practice with their students. Observational data were collected for 44 out of 50 days during a walk-through that took between five and seven minutes during the already scheduled in time for fact practice. The data from the six days were unable to be collected due to a school holiday, Good Friday, and five days of state standardized testing that occurred on the campus. The data I was able to collect from each observation documented students working with facts and using a variety of the strategies presented during the professional development sessions (See Appendix C for the observational tool). During observations of the six classrooms, the doubles strategy was observed most frequently, while nearby squares was observed the least amount of times. Figure 3 illustrates the number of times a strategy was observed over the ten-week period in the six classrooms during daily walk-throughs.

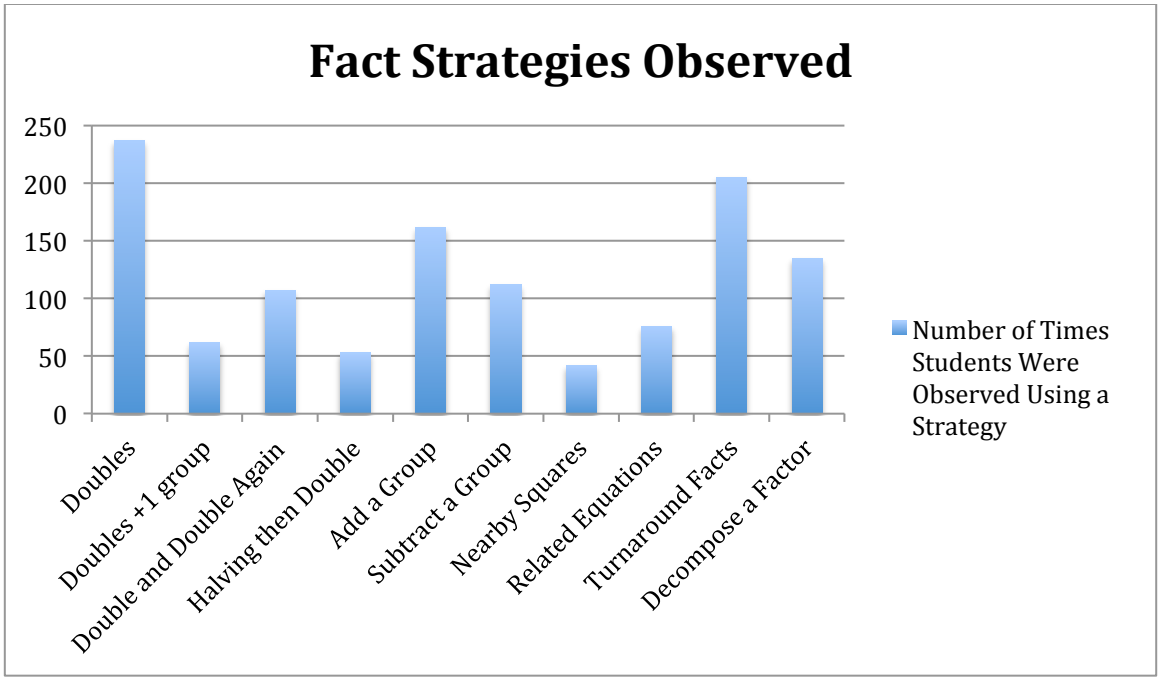

Figure 3. Fact strategies observed

During observations of the six classrooms, the doubles strategy was observed most frequently. From classroom observations during weeks 2, 5 and 8 there is a noticeable decrease in the use of the strategy. This decrease is due to standardized testing during weeks 2 and 8 and a school holiday during week 5. The vertical line on the graph indicates the week in which the strategy was presented during the weekly professional development sessions. Figure 4 illustrates the number of times a the doubles strategy was observed over the ten-week period in the six classrooms, as well as the which week the doubles strategy was presented during the professional development session.

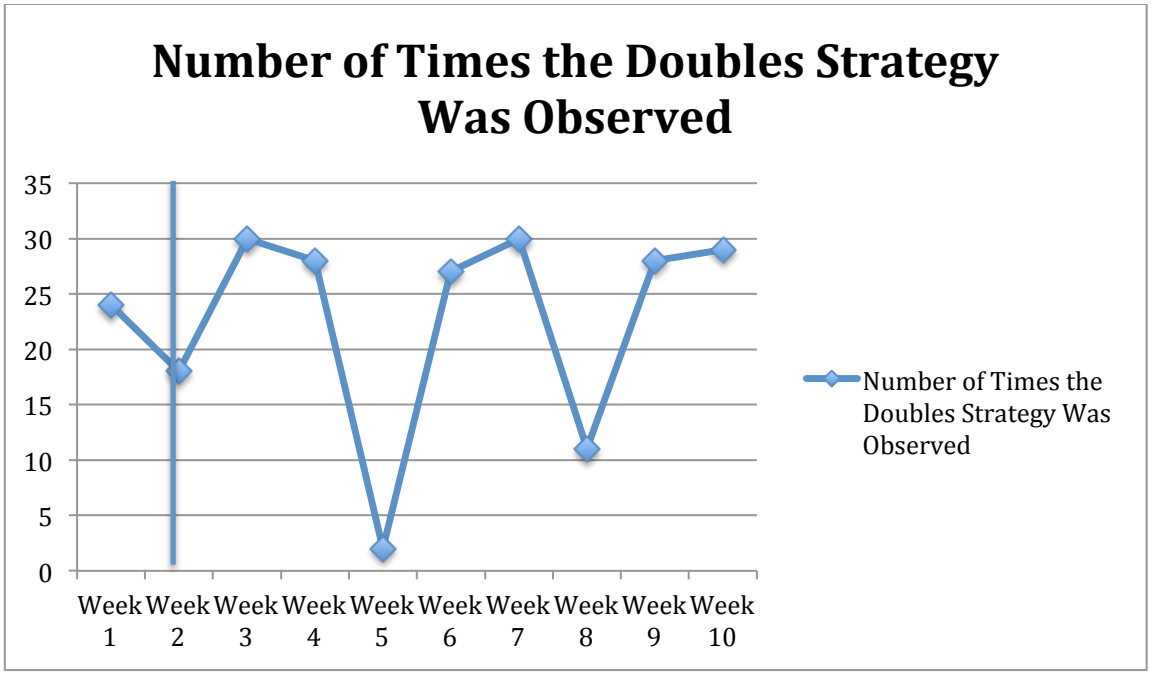

Figure 4. Doubles strategy observed

During observations of the six classrooms, the nearby squares strategy was observed the least frequently. From classroom observations during weeks 1 through 5 the nearby squares strategy was not observed at all. Based on the teacher's ratings during the structured interviews, this was not a surprise. There is a noticeable increase in the use of the strategy during week 6 because this was the week that the strategy was presented during the professional development session. The vertical line on the graph indicates the week in which the strategy was presented during the weekly professional development sessions. Figure 5 illustrates the number of times the nearby squares strategy was observed over the ten-week period in the six classrooms, as well when the strategy was presented during the professional development session.

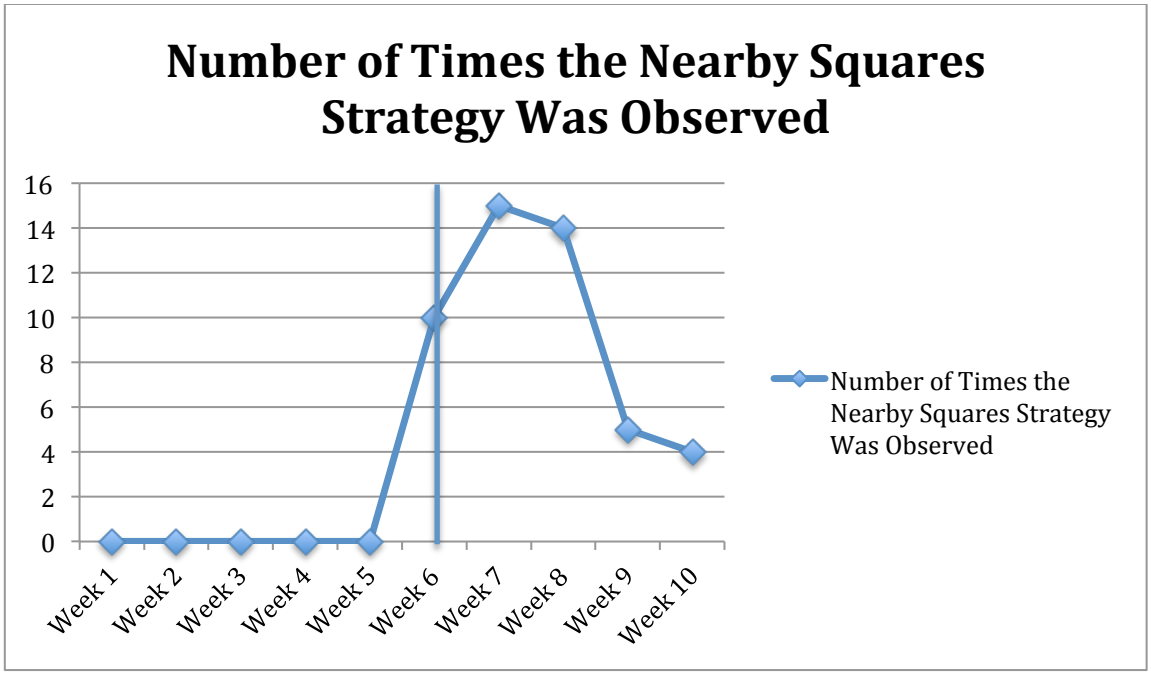

Figure 5. Nearby squares strategy observed

Finding for Research Question 3

The structured interviews conducted during phase three of the study helped to determine the overall effectiveness of the professional development on increasing teachers' understanding of fact fluency. Each of the six participants answered all questions from the interview providing a rating from 1-5, 1 being low and 5 being high. Appendix D contains the interview questions.

As I conducted each interview, I began by asking the participants how they would now rate their understanding of fact fluency now that they have completed ten professional development sessions focused on fact fluency. All six participants indicated a rating of a 5. Because all participants provided this rating of a 5, I did not ask the follow-up question about what would be needed to make their rating a 5. Each of the participants were then asked how they would rate the opportunities for students to

practice facts in their classroom on a daily basis now that they had completed the professional development sessions. Table 9 shows the responses from all participants' responses.

Table 9 *Student Opportunities to Practice Facts After Intervention*

Participant	Rating for opportunities to practice daily	What needed to make rating a 5
A	5	N/A
B	4	Need extra time in the day; set a time for practice or it doesn't occur
C	5	N/A
D	5	N/A
E	4	Need to set a scheduled time and don't stray from it
F	5	N/A

The participants shared during their interviews that the opportunities for students to practice did increase, even though it was a part of their daily schedule. Participant B shared that he felt he needed more time scheduled during the day for students to effectively practice. He shared that the 5-7 minutes that is allotted in the schedule was not enough time for students to gain a deep understanding of the fact strategies. Participant E shared that he need to consistently adhere to his daily schedule and not stray from it because he saw how important that practice time was for his students, so they do need daily practice in order to become fluent with their mathematics facts.

The participants were asked to describe what fact fluency means to them. Participants A, B, D and F all used the words "flexible and efficiently" when describing

fact fluency. Participant C stated, "I feel that I have a better understanding of fact fluency now and understand that it is not how fast a student can solve a problem, but how students understand numbers in a way that helps them solve problems." Participant E said, "Fact fluency not only has to do with having a good grasp of numeracy but students have to be able to efficiently work with numbers in order to be fluent." When responding to this question, not one participant responded with memorization as part of their answer.

Next, the participants were asked what they did to provide students with the opportunities to practice their facts in their classrooms over the past ten-week period. Participant A shared that "students practiced daily in stations and I tried to give them time every day for fluency practice before our lesson began." Participant B said, "I tried to make sure that my students practiced their facts daily by using dominoes, cards, dice and some of the activities that were shared during the professional development." Participant C and D both shared that every morning right after their problem solving they provided their students with five minutes of fact practice. Students played games to practice their facts and they also had a station where they continued practicing. Participant E said, "I tried to provide daily opportunities to practice as a whole group but sometimes it would go longer than the allotted five-minutes, so I ended up putting it in a station, so most students had the opportunity to practice daily." Participant F shared that her students "practiced in stations and also during intervention time using dice and card games." All participants were able to share at least one new way in which their students practiced their facts.

The participants were then asked how they would rate the level of fact fluency their students exhibited in class now that they completed the professional development sessions and what it would take to make the rating a 5 if it was not already a 5. Participants who were unable to provide a rating of 5 had a common response of their students needed more time to practice their facts. Table 10 lists the particular responses from each of the participants.

Table 10 *Student Level of Fact Fluency After Intervention*

Participant	Student Level of Fact Fluency	What needed to make rating a 5
A	4	More time to practice
B	4	More time needed
C	5	N/A
D	5	N/A
E	4.5	More time needed
F	5	N/A

After the intervention, the participants shared during the interviews that overall they felt their students' level of fact fluency had increased but not all participants rated it a 5. Participants A, B and E all shared that their students just needed more time to practice in order to become fluent with their mathematics facts.

Next, participants were asked to rate their knowledge and understanding of the ten different fact strategies after the professional development sessions, using a scale of 1 to 5, 1 being low and 5 being high. Table 11 displays each participant's response.

Table 11 *Understanding of Fact Fluency Strategies After Intervention*

Strategy	Participant A	Participant B	Participant C	Participant D	Participant E	Participant F
Doubles	5	5	5	5	5	4
Halving then Double	5	5	5	5	5	5
Nearby Squares	3	5	3	5	5	4
Add a Group	5	5	4	5	5	5
Subtract a Group	5	5	4	5	5	5
Double +1 Group	4	5	5	5	5	5
Double and Double Again	4	5	5	5	5	5
Turnaround Facts	5	5	5	5	5	4
Related Equations	5	5	4	5	5	5
Decompos-ing a Factor	5	5	5	5	5	5

During the interviews, participants rated the ten fact strategies after the intervention. All strategies were now rated a 5 except, nearby squares, add a group, subtract a group, double +1 group, double and double again, turnaround facts, and related equations. Out of the strategies that were not rated a 5 by all participants, 6 strategies were rated a 5 by all participants, except one. Nearby squares was a strategy

that several participants did not rate a 5 after the intervention. When comparing ratings from before the intervention to after the intervention, all strategies that were not rated a 5 before, at least increased one rating level if not more.

Participants were then asked what it would take to make their rating a 5 for all of the strategies. Five out of the six participants shared that more time was needed for not only students to practice the strategies, but for them to as well. Participant C shared that she would like to have additional professional development sessions on the strategies that she still struggles with because if she does not fully understand them then how can she teach them to her students correctly. Participant A said, "I need more training on these strategies and would like to have more ideas on activities to help my students grasp these strategies. I feel like some of the strategies were hard for me to relate to so I know that my students struggled relating too." Thus, most participants needed more time and training to truly understand all the fact strategies that were presented.

The final two questions asked about the effectiveness of the professional development on improving the teachers' understanding of fact fluency and on the improvement the students overall opportunities to practice their facts. Table 12 displays all of the participants' responses to both questions.

Table 12 *Overall Effectiveness of the Professional Development*

Participant	Improved Understanding of Fact Fluency	Improved Students Overall Opportunities to Practice Facts
A	Yes	No
B	Yes	No

Table 12 *Continued*

Participant	Improved Understanding of Fact Fluency	Improved Students Overall Opportunities to Practice Facts
C	Yes	Yes
D	Yes	Yes
E	Yes	No
F	Yes	Yes

When asked about the overall effectiveness of the professional development sessions, participants shared that they all felt that the sessions helped to improve their understanding of fact fluency. Three out of six participants shared that believed that the professional development sessions positively impacted students' opportunities to practice their facts. The participants felt that the overall study had a greater impact on teachers than on students.

After the interviews were concluded I coded each of the participants' responses, it was evident that the professional development sessions were effective for both students and teachers. Based on the participants' responses, the professional development fact fluency sessions were more effective for the teachers than the students. However, the participants did informally speak about the improvement in students' level of fluency that was exhibited in their classrooms. It is evident that teachers need to understand what fact fluency is in order to help their students become fluent in their facts. By focusing on specific strategies, one at a time in most cases, teachers were able to gain a deeper understanding and apply it in their own classroom. The on-going professional development sessions allowed teachers to increase their mathematics

content knowledge, specifically with fact fluency, while developing strategies to help their students practice their facts.

CHAPTER V

SUMMARY AND CONCLUSIONS

In this chapter I summarized my record of study, and provided an analysis of the procedures that were utilized to explore the three research questions while explaining the findings from the data analysis performed, and the conclusion. The last section in this chapter includes possible implications and recommendations for further study.

Summary

The purpose of the research conducted through this record of study was to address teachers' lack of understanding about fact fluency and increase students' opportunities to practice their facts in two each third, fourth and fifth-grade classes at R. C. Neal Elementary School. A mixed-methods embedded approach was used to determine the effects of a ten-session fact fluency professional development, and its impact on teachers' understanding about the topic. The researcher also ultimately examined students' opportunities to practice their facts using the newly acquired pedagogical fact fluency strategies learned by their teachers in the professional development fact fluency series. This record of study using a mixed-methods approach to help inform teachers about fact fluency and effective classroom strategies as well as provide students with opportunities to practice their facts using the strategies provided during the professional development sessions. This approach could potentially increase teachers' knowledge of fact fluency on our campus and within our district.

A mixed-methods approach was selected for this study as it involved collecting qualitative data from structured interviews and explaining the data using coding. The

research conducted during this study also involved collecting data from classroom observations and quantifying the data collected and then explaining the data using descriptive statistics.

The participants in this study consisted of six teachers who all taught at Neal Elementary, two in grade 3, two in grade 4, and two in grade 5. The research questions included were as follows:

1. How do teachers understand fact fluency and in what ways do they provide opportunities for students to practice their facts?
2. What are the strategies teachers are able to implement in their classrooms that are focused on fact fluency?
3. How did teachers perceive the overall effectiveness of the professional development on increasing their understanding of fact fluency?

These research questions were addressed through the analysis of data using qualitative techniques from structured interviews and quantitative data gathered from observations in classrooms. The results from the qualitative data indicated that teachers have developed a better understanding of fact fluency and fact strategies. The classroom observations indicated that the opportunities for students to practice their facts and the use of fact strategies in the classrooms increased.

Implications

The implications of this record of study show that the mathematics teachers at the participant school may need to continue to focus on practicing and implementing strategies to increase the fact fluency of their students. Continued professional

development sessions will help to ensure that teachers continue to provide students with numerous opportunities to practice facts daily. It is recommended that refresher sessions be offered for teachers so they may continue to learn about effective fluency strategies and have opportunities to practice these effective fact fluency strategies and find ways to help their students become fluent with their facts. So with that, refreshers professional development sessions will be offered throughout the school year. For teachers new to the campus, professional development will be provided during their lesson design times by the instructional coach or a team member who has already received the professional development. The professional development sessions need to focus on one strategy every two to three weeks to allow for teachers to gain a deeper understanding of the strategy. Also, the sessions need to focus on only 5 or 6 strategies rather than 10.

In addition to continued professional development sessions, campus administrators may want to work with teachers when developing daily schedules to help build in a specific time for daily fact fluency practice. By providing a set time in their daily schedule, teachers will be more likely to provide specific opportunities for students to practice their facts fluently.

Furthermore, the data imply a need for students to become fluent in other operations such as addition and subtraction in earlier grades, such as first and second grades. To assist students in becoming fluent in multiplication, they must have a conceptual understanding of addition. By focusing on numeracy and fluency in the early

elementary grades, students will be able to gain a more solid conceptual understanding of multiplication, which leads to fact fluency.

Recommendations for Further Study

Researchers, such as Polly (2012), Ball (2005), and Hill (2005), suggests that in order for students to become fluent with their facts, teachers must have to have an understanding of fact fluency as well as provide daily opportunities for students to practice their facts. The research conducted through this record of study supports this idea, but there is still work to be done to improve fact fluency. Recommendations for further study related to this topic are as follows:

1. Additional research on effective fact fluency strategies for teachers to use to help students become more fluid in their facts is needed.
2. Further research is needed to study a larger sample size across multiple elementary schools. While this record of study involved three different grade levels, including other schools would provide additional data on the impact of the professional development sessions.
3. According to the results from this record of study, multiplication fact strategies were the focus. Further study of fact strategies for addition and subtraction is recommended.
4. A longitudinal study approach to measure if the fact strategies improved students mathematical problem solving on standardized tests, STAAR, should be conducted over time.

5. A focus on one strategy for a longer period of time would be beneficial. For example, one strategy focused on for two-three weeks rather than one strategy every week.
6. A study that lasted longer than a ten-week period so that more time is allowed for each strategy to be developed.
7. When choosing strategies to focus on, only select 5-6 strategies so that the participants can develop and implement in their classrooms.

Conclusions

After examining the results from this record of study, data has revealed that the teachers who that participated in the ten professional development sessions gained a better understanding of fact fluency because the participants responses mirrored what NCTM, *Principles and Standards for School Mathematics* (2000) document, the writers refer to computational fluency as one having an effective and accurate method for computing numbers. The results from this study also revealed that the teachers' knowledge of the ten fact strategies presented during these sessions increased as measured by the qualitative data collected from the interviews after the intervention. The opportunity for students to practice their facts on a daily basis increased along with the use of effective fact strategies was also revealed after examining results of this study. However, the data indicates that students use some strategies more often than other strategies.

From an examination of the data one can determine that the ten professional development sessions had a positive impact on teachers' understanding of fact fluency as

well as on their understanding of fact strategies. When observing at the ratings before the ten-professional development sessions and the ratings after, there was at least a one rating increase on all fact strategies that were rated less than 5, which showed a significant difference. All teachers also improved their level of understanding of fact fluency to a rating of 5 after the professional development sessions. According to Sparks & Loucks-Horsley (1989)," demonstration or modeling of a skill, practice of the skill under simulated conditions, feedback about performance, and coaching" (p. 43) are components of effective professional development. The participant teachers indicated that their students increased their level of fact fluency assuming that it was because the opportunities for students to practice their facts daily also increased for all teachers as measured through the quantitative results from the observations.

The data also suggest that the strategy that was most frequently observed was doubling. In both interviews, this strategy was one of the highest rated strategies. This strategy was also one of the first strategies presented at the first professional development session. One would assume that because teachers had a better understanding of the strategy, they felt more confident when presenting it to their students in the classroom. Unlike doubling, the strategy of nearby squares was observed the least amount of times. From examining the data from the interviews, it was obvious that this strategy was one of the lowest rated strategies. One would assume that because teachers did not possess a strong understanding of this strategy, they felt reluctant to choose it when presenting fact fluency strategies to their students.

Furthermore, the data indicate that there is still a need for more professional development for teachers to gain a better understanding of some of the fact strategies presented as well as time for students to practice their facts. While the data suggest that there was an increased opportunity for students to practice, there is still a need for some teachers to find the time to make this part of their daily routine.

As a result of my research, I have worked to make sense of the data and have attempted to construct meaning from it for myself. My goal was to increase teachers' understanding of fact fluency and increase students' opportunities to practice their facts. Although I realize, not all participant teachers were able to rate their own understanding of all fact strategies a 5, nor provide the opportunities for students to practice their facts, I hope that I was able to make a contribution to their knowledge.

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APPENDIX A

Teacher Name _____

Grade Currently Teaching _____

1. Describe your educational background and experiences that lead to you becoming a teacher.

2. What were your experiences in school with learning basic mathematics facts?

3. Describe what fact fluency means to you.

4. On a scale of 1 to 5, 5 being high and 1 being low, how would you rate your level of understanding in fact fluency?

What would it take to make your rating a 5?

5. What do you usually do to provide students with the opportunity to practice their facts in class?

6. On a scale of 1 to 5, 5 being high and 1 being low, how would you rate the opportunities for students to practice facts in your classroom on a daily basis?

What would it take to make your rating a 5?

7. On a scale of 1 to 5, 5 being high and 1 being low, how would you rate the level of fact fluency your students exhibit in your class?

What would it take to make your rating a 5?

8. On a scale of 1 to 5, 5 being high and 1 being low, how would you rate your knowledge and understanding of the following fact strategies?

Strategy	Rating 1-5 (1 is low; 5 is high)	Comments
Doubles		
Halving then Double		
Nearby Squares		
Add a Group		
Subtract a Group		
Double + 1 Group		
Double and Double Again		
Turnaround Facts		
Related Equations		
Decomposing a Factor		

What would it take to make your rating a 5 for all strategies?

APPENDIX B

10 Strategies to Help Students Develop Fact Fluency

PD Session	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10
Strategies	Introduction What is fact fluency? What are strategies to support students in developing fact fluency?	*Doubles *Doubles +1 Group	*Double and Double Again	*Halving then Double	*Add a Group	*Subtract a Group	*Nearby Squares	*Turnaround Facts	*Related Equations	*Decomposing a Factor

APPENDIX C

Fact Strategies Observation Tool

Strategy	Minute 1	Minute 2	Minute 3	Minute 4	Minute 5	Minute 6	Minute 7	Minute 8	Minute 9	Minute 10
Doubles										
Halving then Double										
Nearby Squares										
Add a Group										
Subtract a Group										
Double +1										
Double and Double Again										
Turn-around Facts										
Related Equations										
Decompose a Factor										
Student Behaviors: Attentive, Active Participation, Disruptive, Off Task etc.						Setting Conditions: Building Level Disruptions (announcements, fire drill, knocks on the door, etc.)				

APPENDIX D

1. On a scale of 1 to 5, 5 being high and 1 being low, how would you rate your level of understanding in fact fluency now that you have completed the professional development sessions?

What would it take to make your rating a 5?

2. On a scale of 1 to 5, 5 being high and 1 being low, how would you rate the opportunities for students to practice facts in your classroom on a daily basis now that you have completed the professional development sessions?

What would it take to make your rating a 5?

3. Describe what fact fluency means to you.

4. What did you do to provide students with the opportunity to practice their facts in class?

5. On a scale of 1 to 5, 5 being high and 1 being low, how would you rate the level of fact fluency your students exhibit in your class now that you have completed the professional development sessions?

What would it take to make your rating a 5?

6. On a scale of 1 to 5, 5 being high and 1 being low, how would you rate your knowledge and understanding of the following fact strategies now that you have completed the professional development sessions?

Strategy	Rating 1-5 (1 is low; 5 is high)	Comments
Doubles		
Halving then Double		
Nearby Squares		
Add a Group		
Subtract a Group		
Double + 1 Group		
Double and Double Again		
Turnaround Facts		
Related Equations		
Decomposing a Factor		

What would it take to make your rating a 5 for all strategies?

5. Do you believe that the professional development sessions improved your overall understanding of fact fluency?

6. Do you believe that the professional development session improved the students overall opportunities to practice their facts?

APPENDIX E

DOUBLING UP!

2	8	18
10	16	20
4	12	14