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Solving Dynamic Addition Math Word Problems Using The Start-Change-Result Strategy

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SOLVING DYNAMIC ADDITION MATH WORD PROBLEMS USING THE START-CHANGE-RESULT STRATEGY

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DEDICATION

I dedicate this work to my husband who never doubted my ability and took care of things at home so that I could have the time to complete my assignments. He was also the best proofreader ever. I also want to include each of my four children: Brittany, Anna, Eli, and Molly in this dedication. Though they may be the reason it took so long for me to accomplish this task, without them the work would not have been worth doing. I hope that by finishing at my age, I show them that if you really want something it is never too late to try. Finally, I want to honor my parents, my Mom who valued education more than anything and my Dad for always asking when I was going to be Dr. Smith. Though they are not here to express their thoughts, I know they would be proud and telling all their friends, "My daughter earned her doctorate."

ABSTRACT

The purpose of this action research study was to examine the impact the *Start-Change-Result* strategy had on the ability level of first-grade students working to solve dynamic addition math word problems. During an eight-week period, a class of 15 first-grade students from a high poverty setting participated in this study. These students struggled with correctly answering dynamic addition math word problems in which the unknown could be in any of three positions: the start, the change, or the result even though they had the computational skills to answer these questions accurately. All of these students had mastered solving basic addition facts and missing addend problems. The problem was these students were lacking in the ability to determine what was the unknown in the problem and apply an appropriate strategy for finding a solution. Data was collected through pre- and posttest results, as well as, student responses to a simple interview and teacher recorded observations. Results of a nationally normed Measures of Academic Progress (MAP) math test were also examined to see if teaching this strategy had any effect on these test results. The researcher analyzed the collected data and found that the implementation of the *Start-Change-Result* strategy increased the ability of these first-grade students to solve dynamic addition math word problems.

Key words: dynamic addition, *Start-Change-Result* strategy, math word problems, semantics, poverty, and schema

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LIST OF ABBREVIATIONS

AMES .... Advanced Math Engineering and Science

CEP .... Community Eligibility Provision

ELL .... English Language Learner

HMA .... High Math Anxiety

LMA.. Low Math Anxiety

MAP .... Measures of Academic Progress

SBI .... Schema Based Instruction

STEM .... Science, Technology, Engineering, and Math

WM .... Working Memory

WMC... Working Memory Capacity

CHAPTER 1

RESEARCH OVERVIEW

Introduction

One would imagine that with all the years of students working on solving math word problems, this skill would be mastered. However, this seems to be just as difficult a task today as it was nearly a hundred years ago. As Newcomb (1922) asserts,

> Practically all pupils have more or less difficulty in solving problems. Even those who have gained a comparatively high rate of speed and accuracy in the fundamental operations do not always succeed equally well in problem-solving. Psychological experimentation has shown that many of the difficulties encountered by pupils in problem-solving are due to wrong methods of attack. (p. 183)

Currently much research is being conducted to see what can be done to help students efficiently solve math word problems in the twenty-first century. The National Council of Teachers of Mathematics (2000) emphasizes, "Being able to reason is essential to understanding mathematics" (p. 56). A student's ability to reason what is being asked in a word problem is the key to accurately solving the problem. To address the challenge of first-grade students struggling with math word problems, this action research focused on developing reasoning ability through the use of the *Start-Change-Result* strategy to build specific schema for the various problem types and reduce the load on the working memory.

Research has shown that teaching students using Schema Based Instruction (SBI) for solving word problems has been successful. Morin (2017) found that explicit teaching using schematic-based instruction and cognitive-strategy instruction was effective in teaching the math skills related to solving word problems. Development of schema provides students with a plan for solving math word problems. According to Smith (2015), "Schema theory explains how learning occurs when learners integrate new knowledge with prior knowledge stored in long-term memory" (p. 6). Students learn to recognize various problem types and can pull up a strategy for solving them. If students are taught specific strategies for solving various types of word-problems, they will be able to retrieve this information when exposed to a problem and use the stored process information or schema to arrive at an accurate solution. Jitendra (2013) states, "With SBI, students learn to first categorize word problems into a few different types and then apply a tailor-made plan to figure out the solution" (para. 2).

Mathematical join, or addition, problems come in two types: dynamic and static. According to Carpenter, Fennema, Peterson, and Carey (1988), dynamic problems can generate several different types of problems by varying the quantity that is unknown. They iterate that even though most of the same words appear in the problem, a number of distinct problems can be generated just by varying the structure of the problem. Their most recent research focuses on the analysis of verbal problem types that distinguish between different categories of problems based on their semantic characteristics. This type of word problem where students are looking for various unknown components depending on how the question is worded is what was studied in this particular action research. Even though most of the same words are being used in a problem, students needed to look at the problems in different ways in order to arrive at the correct answer. Based on the research of Carpenter, Fennema, Peterson, and Carey (1988), teachers were unaware of the difficulties the different types of problems would cause for their students. The majority of the students could solve the result-unknown problems, but had a harder time with the start-unknown and change-unknown problems. These teachers did not seem to recognize the change in difficulty for their students nor did they model appropriate strategies for the students to use. Therefore, in this action research study, there was modeling of a strategy for solving the three different types of problems, *result unknown*, *change unknown*, and *start unknown* to determine if this type of direct teaching would help students to be more successful. This instructional practice of modeling strategies is supported by Modeling Word Problems (n.d):

> By learning to use simple models to represent key mathematical relationships in a word problem, students can more easily make sense of word problems, recognize both the number relationships in a given problem and connections among types of problems, and successfully solve problems with the assurance that their solutions are reasonable. (para. 1)

Making the students more aware of the various types of problems being presented will better prepare them to solve these word problems accurately.

Griffin and Jitendra (2009) emphasized that students who developed strategies to solve the three-different types of problems do better on math tests. They describe how students build schema, or framework for solving problems, based on the semantic differences of the word problems. Their findings suggest that high-quality word problem-solving instruction may help to improve students' understanding of what the problem is asking, thus improving their computational accuracy. Therefore, it is essential that teachers provide students with the tools to recognize various word problem scenarios and provide them with a structure to solve them. As Sutton and Krueger (2002), put it, “Teachers who model building mathematical knowledge and design learning environments that support it are honoring their students as emerging mathematicians” (p. 79).

The importance of being able to solve word problems is undeniable in the twenty-first century world. Students must not only be able to complete the computations; they also need to be able to analyze what specifically needs to be done in order to set up the problem. Silver and Thompson (1984) emphasize, “Despite the generally accepted importance of problem-solving…many students are not capable of solving relatively straightforward mathematics problems, and most students fail to solve somewhat complex problems” (p. 529). Therefore, it is essential to provide young children with strategies that allow them to dissect what particular part of a dynamic addition problem one needs to find to compute an answer accurately.

Also, the way that word problems are presented to students plays a large role in the reason why students find them difficult. Often, the location of word problems is at the end of the mathematics unit and teachers who are uncomfortable teaching word problems will just skip them. As Fiore (1999) points out, “A high percent of elementary teachers say they avoid mathematics and have been found to be math anxious” (p. 403). As a numeracy coach, the researcher has repeatedly worked with teachers who do not have confidence in teaching their students how to solve math word problems. They do not know how to present specific strategies to their students that will provide them with a basis to begin the task. Math word problems are often just assigned and the students arrive at the correct answer because they take the numbers and just apply whatever principle they have been learning in the chapter. They do not truly analyze what is being asked in the problem. Then when they encounter word problems that are worded differently or that are mixed by what type of operation needs to be performed; they do not arrive at accurate answers. This failure of students to analyze what is being asked in a math word problem must be addressed. Research shows that countries that outscore the United States in mathematics put a stronger emphasis on the placement, difficulty, and semantics of math word problems. According to Angateeah (2017), "The sources of difficulties with word problems are well documented. For instance, many studies observed ineffective instruction as one of these sources, while others suggested a lack of linguistic knowledge" (p.46). It is necessary to provide teachers with specific strategies for teaching students to solve word problems in order to improve the problem-solving ability of all students so they will have the skills needed to compete in a twenty-first century environment. As Desilver (2015) states, "But one thing both groups agree on is that science and math education in the U.S. leaves much to be desired" (para. 1). Our teachers need to be able to provide students with a specific way to enhance the direct teaching of how to solve math word problems.

Problem of Practice Statement

The researcher's role at Sammy Seagull Elementary School is that of numeracy coach. The expectations of the job include conducting classroom observations, analyzing data, modeling lessons, and coaching teachers as they implement the math curriculum. If any areas of weakness are noticed in classroom observations or based on analysis of data by the researcher, then it is expected that coaching will take place with the teachers to address these issues. An area of weakness that has been noticed at this school is solving math word problems with accuracy. At the first-grade level, the researcher noticed a major issue with students meaninglessly shouting out answers without taking any time to think about what the math word problem was actually asking. It came to the point where the students had to be told that the answer to the problem was not wanted, but instead they needed to give some facts about how to get the answer. Questions such as the following were posed to students: "Will the answer be larger or smaller? What operation will you use to get the answer? What do you want to find?". Students actually began to apply some mathematical reasoning as they were answering these questions.

Therefore, the Problem of Practice (PoP) in this school, based on numerous classroom observations, is that the students struggle with reasoning relative to solving math word problems. Students rarely analyze what the problem is asking for, but aimlessly combine numbers and often arrive at inaccurate answers. It is not that the students are unable to complete correctly the necessary calculations, but rather that they appear not to take the time to do any reasoning concerning what is being asked prior to attempting to solve the math word problem. Unfortunately, as discussed by Yeap and Kaur (2001), students frequently do not receive instruction on how to use a specific strategy to help them complete this task of reasoning to find out what the question is asking prior to deriving an answer. They feel that students need to focus on what the question is asking them to find prior to attempting any computation. As Yeap and Kaur (2001) put it, "In other words, students solving math word problems should engage more in making sense of the semantics of the problem and less in doing tedious computations" (p. 555).

Recently, the researcher attended a series of workshops for Numeracy Leader certification. At one of the workshops a strategy for students to use to analyze word problems was presented. This strategy referred to as the *Start-Change-Result* strategy had the students analyze word problems for their unknown prior to performing any computation. This allowed the students the opportunity to make sense of the problem and correctly solve the problem rather than just aimlessly combining numbers. As stated by Cross, Woods, and Schweingruber (2009), "Story problems and situations that can be formulated with addition or subtraction occur in a wider variety than just the simplest and most common "add to" and "take away" story problems" (p.32). This situation in the training, correlated directly to the issues presented in the classroom with the students always combining the given numbers as if the unknown in every problem was the result. At that time, the researcher decided that teaching the students the *Start-Change-Result* strategy might give them a basis for analyzing simple word problems and developing their mathematical reasoning abilities.

The *Start-Change-Result* strategy can be applied to any of the four mathematical operations. Since the problem had been observed many times in the first-grade classroom and the students are just beginning to solve word problems and only use one operation, addition, it was decided this would be a great place to try to implement this strategy. Cross, Woods, and Schweingruber (2009), suggest that first grade is a good starting point.

> Change situations have three quantitative steps over time: start, change, result. Most children before first-grade solve only problems in which the result is

the unknown quantity. In first-grade, any quantity can be the unknown number. Unknown start problems are more difficult than unknown change problems, which are more difficult than unknown result problems. (p. 32)

If students are given strategies to be successful solving various word problems at a young age, perhaps as they proceed through the years there will be less of an achievement gap between those who come to school with different levels of mathematical reasoning.

Addition problems known as *dynamic* or *joining* can have three missing parts: the start, the change, or the result. *The South Carolina College and Career Readiness Standards Support Document for Mathematics* (2016) defines them as, "Joining action - involves three quantities; an initial amount, a change amount (the part being added or joined), and the resulting amount (the amount after the action is over)" (p. 6). This action research consisted of teaching first-grade students to determine which part is missing in a dynamic addition math word problem, to make a model to solve, and to solve the problem accurately. The students then translated the model into a number equation. Again, this process is referred to as the *Start-Change-Result* strategy. While researching this topic, one of the repeated theories about difficulties solving word problems was the semantics of the text, which appears to be what the student participants in this study struggle to understand. Carey (1991) found that, when the order of the numbers did not match the semantic structure, the majority of students wrote a number sentence with a plus sign, but it was the wrong one in which they added the two given numbers to find a result rather than the change. Many experiences working with these young students solving dynamic addition math word problems reinforces this is often the case.

Teachers of younger children in self-contained classrooms often consider themselves “reading teachers” and do not have a strong math background, making them feel uncomfortable when presenting strategies for how to solve math word problems. Green (2014) supports this idea of weak math skills, “As graduates of American schools, they are no more likely to display numeracy than the rest of us. ‘I’m just not a math person,’ Lambert says her education students would say with an apologetic shrug” (para. 29). Also, teachers usually present addition problems for which the students are expected to combine numbers and find the result, but in real-world situations problems arise for which students might also need to know how to find the starting number or the amount of change to a number. This action research provided students with a strategy to analyze and solve these dynamic addition problems. As explained by Yeap and Kaur (2001), these problems have three different parts for which students can be expected to solve. These include the magnitude of the physical quantity at the initial state (referred to in this paper as the start), the magnitude of the change (referred to in this paper as the change), and the magnitude of the physical quantity at the final state (referred to in this paper as the result).

Sammy Seagull Elementary School (SSES) (pseudonym), where this action research took place, has a population of 521 students located in a coastal town in South Carolina. This is a high poverty public school setting in which many of the students come to school with limited school readiness, impacting their ability to solve correctly math word problems. With respect to children from poverty, Jensen (2016) puts it this way, “Before these kids even get to school, they have been subjected to years of ‘doing without.’ Poor children are half as likely to be taken to museums, theaters, or to the library and are less likely to go on culturally enriching outings" (para. 1). This sentiment is also expressed by Lahey (2014) when saying many of the students come to school lacking skills and experience, which means that they start out behind their more advantaged peers. The lack of opportunity to participate in varied experiences greatly influences the reasoning skills that students have to draw from when solving math word problems. Classroom experiences have shown that indeed using reasoning skills to analyze math word problems is a skill these first graders have not had experience implementing. According to Kent and Carson (2008), innovative approaches to mathematics teaching and learning with an emphasis on math word problem solving has shown an increase in performance of elementary students on mathematics standardized tests. Therefore, this action research took place in a first-grade classroom with a large percentage of high-poverty students to determine if the skills needed to reason through these problems could be taught using the *Start-Change-Result* strategy.

Research Question

What impact will the *Start-Change-Result* strategy have on the ability level of first-grade students working to solve dynamic addition math word problems?

Purpose of Study

The purpose of this study was to examine the impact the *Start-Change-Result* strategy had on the ability level of first-grade students working to solve dynamic addition math word problems. See Appendix A for an explanation of the *Start-Change-Result* strategy format.

In this strategy, students were taught to think about the relationship between the numbers presented prior to solving the word problem. When the strategy was first introduced, the actual numbers were not included in the problems so that students could focus on what the question was actually asking instead of trying to compute an answer. Students were taught the vocabulary terms: start, change, result, and unknown. They learned to identify the start in the problem, the change in the problem, and the result in the problem. Then they used a graphic organizer to look for the particular unknown that was being asked for rather than just randomly combining numbers. This strategy can be applied across all four mathematical operations. However, with this action research the focus was on first grade and the operation of addition. When reading an addition word problem there are three components that a student could be asked to find. The most common type of problem to which students are exposed, is finding the result but this frequently leads to students aimlessly combining all numbers to get an answer when the question might actually want to know what was the starting number or how much of a change occurred. As defined by Shannon (2007), these types of addition problems where change occurs are known as dynamic problems.

Examples of word problems asking this type of questions are as follows:

(Result) There were 3 rabbits sitting in a field eating carrots, 5 more rabbits joined them. How many rabbits are in the field?

(Start) Some rabbits were sitting in a field eating carrots. They were joined by 5 more rabbits. Now, there are 8 rabbits in the field. How many rabbits were in the field at first?

(Change) There were 3 rabbits sitting in the field eating carrots. Some more rabbits joined them. Now there are 8 rabbits in the field. How many rabbits joined them?

If students are taught to recognize the possible scenarios and to reason the size of the needed answer compared to given numbers, accuracy in solving word problems should increase.

Methodology

Consistent with Mertler (2014), the action research method that was used for this DiP is a one group pretest-posttest design. It was a mixed-methods approach because there was a use of both qualitative and quantitative data during this action research study. Several data collection methods were used that included prerequisite addition fact skill quizzes, a pretest, a posttest, nationally-normed standardized test scores from both pre and post treatment, structured and semi-structured interview questions, observations with field notes, and student work artifacts.

The group of first-grade participants were given a pretest on dynamic addition math word problems. The results of this pretest showed the areas of strengths and weaknesses of individual students solving start, change, and result problems. Based on the results, the researcher provided an appropriate treatment through the explicit teaching and modeling of how to determine which part of the problem was missing, how to set up a graphic organizer to solve the problem, how to answer accurately, and how to write the problem as an equation. Through this modeling, the researcher demonstrated the use of this metacognitive process for the students to use as they solve dynamic addition math word problems. As the modeling occurred for how to solve each of these three different types of problems, it was accompanied by a "think aloud" (i.e., a classroom instructional technique where teachers verbalize what they were thinking) so that the students knew the thought process being used while analyzing the problem. Then the students were able to apply the same methods as they worked independently on their problems.

The students solved daily practice problems using the specific *Start-Change-Result* strategy for a period of six weeks before they were given a posttest. These problems were presented each day in random sequence. This kept the students from figuring out a pattern as they solved the problem. Some days they might have had one of each type to solve (start, change, and result), another day they might have solved two starts and a result, sometimes all three problems might have been looking for the change. The goal was to have the students actually analyze each problem to figure out what is the unknown rather than just thinking "we have done a result and change so this problem must be a start."

After implementation of the *Start-Change-Result* strategy was completed and students had ample time to practice applying the strategy, the same test was again administered as a posttest following the original protocol. The growth value was measured from the pretest to the posttest since this action research was quantitative in nature. Descriptive statistics were used to analyze the data to see what type of effect implementing the *Start-Change-Result* strategy for solving dynamic addition problems had with the treatment group of students. As data was collected from this one class, the researcher who is also the school numeracy coach had a basis to make an informed decision if the use of the *Start-Change-Result* strategy was a strategy that should be replicated throughout the school.

Significance of Study

Getting students to critically analyze what a math word problem is asking prior to finding a solution is an essential skill to develop if students are to solve problems accurately. According to Gojak (2012), regardless of whether one teaches preschool, elementary school, or high school one must consider steps that can be made to transform the mathematics classroom into an environment that promotes reasoning and sense making for all students. As outlined by Mertler (2014), an action research topic will be significant if it has the potential to improve the practice of teaching and learning. Providing a method for students to become better math word problem solvers would meet these criteria.

As the school numeracy coach, a specific need was noticed and this study examined finding a way to meet this need by implementing the direct instruction of a specific schema-based strategy. The Problem of Practice that first-grade students frequently do not use mathematical reasoning to determine what is being asked of them in dynamic addition math word problems was addressed. Students needed a simple strategy to encourage them to read math word problems carefully and to make a plan for finding a solution. The researcher had been presented with the idea of the *Start-Change-Result* strategy, but no previous research based studies were located to see if implementation would have an impact. Therefore, the researcher determined this to be an area of need and explored if this strategy helped students take the time to think about math word problems and solve them accurately. The information provided by this action research showed the researcher a method to meet the word-problem-solving needs first graders from poverty often lack in order to begin closing the school's achievement gap.

Limitations of Study

This study was limited by a small sample size, only one class of fifteen first-graders in one school participated in the study. An additional concern is that the best teaching practices implemented by the researcher and not the strategy itself may be the cause of growth. It could be that the students improved on their ability to solve dynamic addition math word problems due to the fact that the researcher motivated them to focus on this area rather than the use of the *Start-Change-Result* strategy. Therefore, generalizations cannot be made.

Summary of Findings

The findings of this study showed that the direct teaching of the *Start-Change-Result* strategy did have a positive impact on the ability of this group of first-grade students to solve dynamic addition math word problems. The students were able to determine the unknown in each problem, prior to attempting to compute an answer. Then, based on whether the unknown was the start, the change, or the result the students correctly completed a graphic organizer which they used to solve the problem. The data showed that all students increased their ability to solve accurately dynamic addition math word problems regardless of the unknown. Additionally, the action plan developed from the findings of this study will guide further research for the impact of teaching the *Start-Change-Result* strategy in different settings.

Dissertation in Practice Overview

Chapter One of this DiP is an introduction to the PoP, social concerns and background of the school, explanation of role of the researcher, purpose statement, research question, a summary of the action research method along with data collection methods that were used, and definitions of key terms. In addition, the researcher introduced the *Start-Change-Result* strategy for dynamic addition word problems. Chapter Two of this DiP is a thorough review of literature related to the topic. Chapter Three details the action research methodology used to answer the research question and describes data collection methods. Additionally, a review of the purpose of the study, a statement about action research validity, an explanation of the research context, and an outline of the specific design/instruction of the study. Chapter Four thoroughly reviews the findings of the action research along with an analysis of data compiled during this time. Chapter Five summarizes the conclusions of the action research and identifies future areas of research that relate to these results.

Definition of Key Terms

Action research: According to Mertler (2014), action research is a cyclical process in which the researcher implements an action to solve a problem that has been noticed in the classroom. The researcher collects and analyzes data to determine if the particular implemented action works. Based on this analysis the researcher decides what next steps should be taken.

Change: In this paper, the change as explained by Yeap and Kaur (2001), is the magnitude of the variance referred to in this paper as the change from the start to the result of a dynamic addition word problem. An example of a problem in which the unknown is the change is: *Mother had 4 cookies on the plate. She added some more cookies, now there are 7 cookies on the plate. How many cookies did she add to the plate?*

Dynamic Addition: The South Carolina College and Career Readiness Standards Support Document for Mathematics (2016) defines dynamic (joining) addition problems as follows: problems that have a "joining action -involves three quantities; an initial amount, a change amount (the part being added or joined), and the resulting amount (the amount after the action is over)."

Equation: As defined by Education Development Center, Inc. (2016),

> An equation is a mathematical sentence (also called a "statement") with an "=" (equals) sign. An equation represents an equality relationship between two expressions, one expression on the left side of the equals sign and the other expression on the right side of the equals sign. The expressions can include known quantities (represented by numbers) and/or unknown quantities (possibly represented by variables, a box, or a question mark). For an equation to be true, the two expressions are always equivalent (have the same total value) to each other, even if values for the unknown quantities change. (p. 2)

Math anxiety: Math anxiety is a real problem that has been shown on brain scans when students are working math problems. This anxiety can negatively impact the student's ability to be successful at math. According to Beilock and Willingham (2014), "People who feel tension, apprehension, and fear of situations involving math are said to have math anxiety" (p.29). They go on to explain that this math anxiety is related to poor performance throughout school and that its origins must be found and alleviated in order to improve student achievement.

Mathematical Reasoning: As defined by the New Jersey Mathematics Curriculum Framework (1996),

> Mathematical reasoning is the critical skill that enables a student to make use of all other mathematical skills. With the development of mathematical reasoning, students recognize that mathematics makes sense and can be understood. They learn how to evaluate situations, select problem-solving strategies, draw logical conclusions, develop and describe solutions, and recognize how those solutions can be applied. Mathematical reasoners are able to reflect on solutions to problems and determine whether or not they make sense. (para.1)

Number sense: Having number sense is one factor used to predict future ability to solve math word problems. For this action research, the researcher will consider number sense as the ability to count, compare, and manipulate sets of whole numbers.

Perseverance: As explained by Bass and Ball (2015), "Perseverance, an important psychological construct, matters for mathematics learning because solving challenging mathematics problems and reasoning about mathematical ideas often requires a kind of uncomfortable persistence" (p. 2). Too often students give up on finding an answer after only a few minutes of trying. Perseverance as related to word-problem solving is the student's ability to keep trying, even when it is difficult until they reach an accurate solution.

Poverty: According to Jensen (2009), "poverty is a chronic and debilitating condition that results from multiple adverse synergistic risk factors and affects the mind, body and soul" (para. 3) In this paper, it will be considered a condition in which students come to school lacking materials, experiences, and support to be successful.

Problem solving: According to McDougal and Takahashi (2014), problem solving is a task in which the answer is not known in advance.

Productive struggle: Pasquale (2015) states that productive struggle is the concept held by mathematics educators and researchers that when students struggle to make sense of a mathematics concept it is an essential component in developing mathematical understanding.

Result: As explained by Yeap and Kaur (2001), is the magnitude of the physical quantity at the final state referred to in this paper as the <u>result</u>. An example of a problem in which the unknown is the result is: *Mother had 4 cookies on the plate. She added 4 more cookies to the plate. How many cookies are there now?*

Schema: As referred to by Fuchs, Zumeta, Schumacher, Powell, Seethaler, Hamlett, and Fuchs (2010), schema as related to solving word problems is the transfer of novel ideas to categories that allow students to represent these problems with equations that can be solved. Fuchs et al. (2010) state, "Some psychologists view such transfer in terms of the development of schemas, by which students conceptualize word problems within categories or problem types that share structural, defining features and require similar solution methods" (para. 2).

Semantics: Semantics as related to word problems and this action research is the students' understanding of what a problem is asking. Griffin and Jitendra (2009) refer to semantic relations in mathematics as "conceptual knowledge about increases, decreases, combinations, and comparisons involving sets of objects" (p. 188). If students are to be able to solve a word problem accurately, they must understand the language of the question as related to mathematical processes.

Spatial relationships/processing: As explained by Dewar (2016), "Spatial thinking is what we do when we visualize shapes in our 'mind's eye'… the mode of thought we use to imagine different visual perspectives" (para. 1). Examples of this skill include recognizing shape nets, picking out rotation of objects, predicting paper-folding outcomes.

Start: As explained by Yeap and Kaur (2001), is the magnitude of the physical quantity at the initial state referred to in this paper as the start. An example of a problem in which the unknown is the start is: *There were some cookies on the plate, Mother added 3 more cookies to the plate and now there are 7 cookies. How many cookies were on the plate at first?*

Start-Change-Result Strategy: A mathematical strategy in which students must determine which portion of the addition problem (the starting amount, the amount of change that occurs, or the amount of the total) is missing prior to using computation to solve the dynamic addition word problem (see Appendix A). According to Kanthack (n.d. para. 1), "the objective of *Start-Change-Result* is: SWBAT (students will be able to) solve word problems by applying strategies that help them understand the meaning of the problem so that they can then set up and solve equations."

Unknown: For the purpose of this action research paper, the unknown will refer to the missing part of a dynamic addition problem. There are three possibilities for the unknown that include: a missing start, a missing change, or a missing result.

Visual representation: According to Griffin and Jitendra (2009), visual representation techniques such as drawing a picture or making a diagram are helpful scaffolds used to organize information in a problem and reduce the level of cognitive load needed for the problem-solving task.

Working memory capacity: As defined by MedicineNet (n.d.), working memory/short-term (recent) memory, is a system for temporarily storing and managing the information required to carry out complex cognitive tasks such as learning, reasoning, and comprehension. This type of memory is used in information-processing functions such as encoding, storing, and retrieving data which is essential to the ability to solve math word problems.

CHAPTER 2

LITERATURE REVIEW

Introduction

The review of literature section investigated what research says about helping students overcome their difficulties with solving math word problems. "It is the common knowledge of every teacher of arithmetic that the most difficult part of the subject is the securing of satisfactory results in the solution of problems" (Newcomb, 1922, p. 183). This literature section will first discuss the history of solving word problems. This will include the theories of the renowned mathematician George Polya. Additional theories such as schema and working memory as related to why solving word problems is difficult for students will also be discussed. Additionally, predominant factors affecting students' ability to solve problems will be established.

Then the literature discussion will address the teachers' influence on their students' ability to solve word problems. Teacher issues such as math ability, preservice training, math anxiety, and attitude toward problem solving will be presented. Next the discussion will explore student weaknesses that might affect their ability to solve word problems. These will include working memory, math anxiety, lacking perseverance, lack of strategies to implement, difficulty understanding the semantics of the problem, in addition to poor skills in counting, number sense, and spatial reasoning. Another area that will be presented is how living in an extreme poverty environment plays a role in the development of problem-solving skills. According to Poverty and Race Research Action

Council (n.d), high concentrations of poverty in schools indeed has a detrimental impact on student achievement.

Additionally, research suggestions for what can be implemented in today's classrooms to help students solve math word problems with accuracy will be presented. Ideas to increase math achievement in all students will be introduced. These ideas incorporate the use of early interventions, developing perseverance, decoding semantics of problems, and specific strategies for solving dynamic addition math word problems. Finally, there will be a focus on how the incorporation of the *Start-Change-Result* strategy is related to what has been learned about solving math word problems.

History of Teaching Mathematics and Word Problems

There is a long history of students having trouble learning math concepts. As Vigdor (2013) puts it, "Concern about our students' math achievement is nothing new, and debates about the mathematical training of our nation's youth date back a century or more" (para. 3). As long as children have been attending school, they have had to solve mathematical word problems sometimes referred to as story problems. Often students have had difficulty with this task. Gerofsky (1999) highlights this idea, "For many students, the transformation of word problems into arithmetic or algebra causes great difficulty, and a number of recent studies have addressed the linguistic and mathematical sources of that difficulty from a psychological point of view" (p. 2).

Schoenfeld (2016) provides a long and detailed history of the teaching of mathematics of which highlights will be shared. In the late 1800s and early 1900s, mass education was for elementary students and their mathematics instruction focused on learning the operations that would prepare them for the marketplace. Then in the late 19th and early 20th centuries there were the beginnings of professionalism in education and the formation of societies focused on math education in particular. The National Council of Teachers of Mathematics (NCTM), which is presently the world's largest mathematics education organization, was founded in 1920. The emergence of societies like this helped to bring order to an unstructured educational context. By 1926 an elementary curriculum was developed that shifted from the abstract to the concrete. During this time, educational research was being used to determine what and how children should be taught. More students were graduating high school and mathematics, that was once thought to be for the elite, was becoming more mainstreamed. Vigdor (2013) reinforces this saying that early in the 20th century, high schools were blatantly divided, with rigorous math courses limited to the college-bound elite. However, Vigdor (2013) further asserts that by midcentury the U.S. tried unsuccessfully to bring rigor to the masses.

Schoenfeld (2016) explains that midcentury, Sputnik took place and this caused a push for mathematics education. Therefore, students were taught "new math" which departs from the basics and included a great deal of instruction on set theories. According to Vigdor (2013), this push for "new math" to bring rigorous math to all students actually had the opposite effect of having fewer students majoring in math-related fields in college. Schoenfeld (2016) explains that during the 1980s math problem solving becomes a major focus of instruction and was mainly guided by the teachings of George Polya. His work introduced heuristic problem-solving strategies which are still the popular method of problem solving today.

In the 1990s math wars began and there was another look at what should be taught in math education. As stated by Schoenfeld (2004), the math wars were a heated controversy, between the traditionalists who respected core mathematical values and the reformers who cherished process orientation, over what should be taught in schools. Unlike research of the 1980s and 1990s, today's research is concerned with foundational knowledge and its use. Currently, classrooms are serving as research laboratories with projects such as TeachingWorks focusing on the core work of teaching. Their emphasis is on "high-leverage" practices for beginning teachers which include: recognizing common patterns of students' thinking, conducting a whole class discussion, building relationships with students, choosing representations and examples, and assessing students' learning. As stated by Schoenfeld (2016), "These projects represent just a small beginning in terms of addressing the major problems the nation faces in (re)building a teacher corps that is capable of supporting students equitably in the pursuit of meaningful mathematical knowledge" (p. 526). As one can see, the teaching of mathematics has undergone many changes over the last two centuries just as one would imagine it should. The problem is finding teachers who can guide students as they grow their mathematical understandings especially in the ability to solve word problems.

Theories on Solving Word Problems

Educators need to understand various theories about what influences students' ability to solve word problems. Based on current literature, solving math word problems can be difficult for students for several reasons, but these can be addressed by teachers who are aware of what the theories say. First, research shows that students need to develop problem-solving schema. Jitendra (2013) stresses, "Schema-based instruction (SBI) was developed to address the needs of students who have difficulty solving math word problems, despite having adequate computation skills" (para. 2). Next, teachers need to be aware of the effects that math anxiety has on strategy implementation and working memory capacity. According to Passolunghi, Caviola, De Agostini, Perin, and Mammarella (2016), "The processing efficiency and attentional control theories suggest that working memory (WM) also plays an important part in such anxious feelings" and has an effect on mathematical achievement" (para.1). Finally, students need to understand how to implement steps in Polya's problem-solving model so they have a format to use as they go about solving word problems.

Problem-solving schema. Developing schema is essential to being able to solve word problems. McLeod (2018) references Piaget's theory on development of schema as the storing of mental representations that are applied as needed. Students could pull on these stored representations of different problem types and apply them as they solve various math word problems. In a study conducted by Fuchs et al. (2010), 18 teachers (270 students) were randomly assigned to either a control group or a schema broadening group. After a 16-week intervention period, the students in the schema broadening group indicated superior word problem learning. Teachers usually just teach the total or result unknown type of problems, but this study broadened schema to teach students to recognize other types of problems such as start and change unknown and taught specific strategies to solve them (Fuchs et al., 2010).

Working memory capacity and math anxiety. Another consideration when teaching students problem solving is their working memory capacity. Math anxiety is factored into this mix because when students suffer math anxiety it decreases their working memory capacity. Passolunghi et al. (2016) conducted a research study to find how levels of math anxiety affected working memory and math achievement. Their findings showed, “Math anxiety seems to have a straightforward influence on cognitive processing, not only impairing WM (working memory), but also making children with HMA (high math anxiety) perform less well than children with LMA (low math anxiety) in mathematical tasks” (para. 36). There are two contradictory thoughts of using specific strategies for solving word problems and its effect on the working memory. One is that when students are trying to remember a strategy their anxiety goes up and their working memory capacity decreases and they have a more difficult time. Beilock and Willingham (2014) state, “The finding is rather counter intuitive: kids with the highest level of working memory show the most pronounced negative relation between math anxiety and math achievement” (p. 30). Their explanation is that students with a higher working memory capacity tend to use more complicated strategies which eats up their working memory capacity causing them more anxiety which reduces their achievement. The other point of view given by Ashcraft and Krause (2007) is if students are given a simple specific strategy to use, this decreases their stress level and they do not have as much anxiety, therefore they are better able to solve word problems.

In a study conducted by Swanson, Moran, Lussier, and Fung (2013), eighty-two third grade students who were identified to be at-risk for math difficulties were randomly assigned to two groups. One group received instruction on a specific strategy to use with solving math word problems. They found that the strategy was effective but only with students who had a higher level of working memory capacity. Swanson et al. (2013) assert, “At a relatively high WMC level, a clear advantage was found … to the control condition on measures of problem-solving accuracy and solution planning. No significant treatment advantages were found when pretest WMC was set to a low level”

(p. 121). Research has also shown that the biggest predictors of students having an inability to solve math word problems is poor skills in the areas of counting, number sense, and spatial reasoning. Jordan, Glutting, and Ramineni (2011) found, "Number sense, as assessed by our screening measure, is a powerful predictor of later mathematics outcomes" (p. 87). Therefore, it is essential to take the time to develop these skills early on in all students, but being particularly mindful of those students from poverty who lack experiences and resources.

Polya's problem-solving steps. George Polya, a famous Hungarian mathematician wrote a book entitled, *How to Solve It* in 1945. This book outlines the four basic steps of problem solving that are still the basis used today. "Polya's four-step problem-solving model includes the following stages: (a) understand the problem, (b) devise a plan, (c) carry out the plan, and (d) look back and reflect" (Polya's Problem-solving Techniques, n.d.). Griffin and Jitendra (2009), further detail Polya's work as asking a series of supporting questions for each step, "For example, to understand the problem, supporting questions include the following: Do you understand all the words used in stating the problem? and What are you asked to find or show?" (p.188). Additionally, they explained how Polya felt there were many ways to solve a problem and students should use appropriate strategies which include: drawing a picture, working backwards, using a formula, and looking for a pattern. Hoon, Kee, and Singh, (2013) reinforce the use of Polya's heuristic approaches to be used as tools to help students in solving mathematical problems.

Teachers' Influence on Solving Word Problems

Teachers play a major role in their students' ability to solve word problems, sometimes without even realizing their influence. Teachers wanting to help students will sometimes inadvertently take over their students' thinking. Jacobs, Martin, Ambrose, and Philipp (2014) conducted a study where they watched 129 videos of teachers working with students to solve math word problems. What they found was that teachers might undermine the process of developing math reasoning by taking over the thinking and having the students arrive at an answer without engaging them in the thinking which is a major goal in math problem solving. Phillip (2014) gives three warning signs that the teacher may be taking over: 1) interrupting the child's strategy, 2) manipulating the tools, and 3) asking a series of closed questions. These signs are not labeled as wrong just as warnings that they might be taking over the thinking process. Suggestions for stopping this were for the teachers to ask themselves questions prior to taking over that would guide them in whether they should proceed or not. Also, Phillip (2014) suggests that the teacher should slow down and let the student finish the task prior to taking over.

Teachers having math anxiety has been proven to be another factor influencing the problem-solving ability of their students. According to a study by Maloney and Beilock (2012), teachers who are anxious about their own abilities impart these negative attitudes to some of their students, interestingly, they say this transmission of negative math attitudes seems to fall along gender lines with female teachers imparting this to female students. This reinforces the idea of boys are good at math and girls are not. The research showed it was more important to do something to address the anxiety than the math skills themselves to show improvement in achievement. One suggestion given by

Maloney and Beilock (2012) for decreasing this anxiety in students was to have the students write about their negative feelings for 10-15 minutes prior to an important math activity. An additional suggestion by Maloney and Beilock, was for the teacher to convince the students that the anxious reactions they were having such as sweaty palms and rapid heartbeat were beneficial for thinking and reasoning and would actually give students an advantage and help improve test performance. When the students perceived these feelings as an advantage they actually did better on the tests.

Teachers having low confidence with their own math ability is another issue when it comes to supporting their students as they learn how to solve these word problems. Preservice training did not give the teachers strategies for how to teach students problem solving. In a study conducted by Hine (2015), preservice primary and secondary teachers that had completed part of their training were asked to reflect on their ability to teach math. A summary of this study showed that less than half of the participants declared that they felt confident in teaching mathematics, and almost all participants stressed that they needed to improve both their math content knowledge and pedagogical knowledge on teaching mathematics. A Hechinger report supported the findings of Hine's study. "Their content knowledge is less than what a specialist would have so they don't understand math in a broad way. Preparatory programs have to be more attentive and have a way to develop teacher expertise" (Ostashevsky, 2016, para. 7). In Ostashevsky (2016), Deborah Ball, dean of University of Michigan's education school states, "What's needed is a class geared specifically to guiding teachers through problem solving from various angles and making connections between number operations, just like students are expected to do" (para. 10). Teachers lack confidence in their own abilities so they will sometimes skip word problems or just give the students the answers because they do not know how to explain a procedure for solving. The Florida Department of Education (2010) published a paper on research-based strategies for problem solving to give their teachers. The introduction includes the statement that the chart illustrates several strategies to be used to facilitate the work related to problem solving, however, the approach is to be considered dynamic, non-linear and flexible. An excerpt from the Florida Department of Education (2010) states, "Learning these and other problem-solving strategies will enable students to deal more effectively and successfully with most types of mathematical problems" (p. 8). It goes on to provide the teacher with many specific strategies for problem solving they could incorporate into their classroom. This is showing they recognize that teachers are unprepared in this area and are providing support.

Students' Difficulties with Solving Word Problems

The causes of student difficulties with solving math word problems are numerous. These include working memory capacity, math anxiety, poor counting ability, weak number sense, deficient spatial processing, lack of perseverance, lack of strategies, and problems understanding the semantics of the word problem. In order to help students increase achievement in this area teachers will have to begin implementing instruction that specifically addresses developing these abilities,

Working memory capacity. One of the reasons students have a difficult time with solving word problems is their working memory capacity. As defined by Swanson and Beebe-Frankenberger (2004), "Temporary storage of material that has been read or heard is said to depend on working memory" (p. 471). Swanson and Beebe-

Frankenberger (2004) go on to say that in order to comprehend and solve mathematical word problems, students must be able to understand words, phrases, sentences, and propositions that, in turn, are necessary to construct a coherent and meaningful interpretation of word problems. Based on a study completed by Ashcraft & Krause (2007), even in early grades there is a strong relationship between a child's working memory capacity and performance on number-based tasks. The use of mathematical symbols adds to this difficulty when learning math specifically in storing and using working memory.

Ramirez, Chang, Maloney, Levine, and Beilock (2016) explain that individuals with a higher working memory could be more prone to poor performance as a result of math anxiety. Higher working memory students rely more on problem-solving strategies that use more working memory, so when their math anxiety uses up some of their working memory capacity, they tend not to work up to their potential. In contrast, students with a low working memory capacity rely on shortcuts or simpler strategies to solve math problems because they cannot hold demanding problem-solving strategies in their working memory. Therefore, Ramirez et al. (2016) expound that being math anxious has less of a negative impact on students with low working memory.

In direct correlation with this idea are the findings of Swanson et al. (2013) on using generative strategy training. In this study, "generative training strategies were requiring the student to paraphrase the text either orally and/or in writing prior to responding to questions about the text" (Swanson et al., 2013, p. 112). They found that in students with a higher working memory capacity, use of generative training strategies showed an increase in problem-solving ability. However, in students with lower working memory capacity the generative training strategies did not improve problem-solving ability. The generative training strategies were resource demanding (used a lot of working memory) so they could not use their working memory to both implement the generative training strategy and still work the problem so they ended up having poorer abilities to solve word problems trying to use the strategy. Therefore, the researcher must be mindful of using a strategy that does not put too much load on the working memory capacity if the low-achieving students are to improve in their word problem-solving ability.

Math anxiety. Maloney and Beilock (2012) explain that math anxiety is the feeling of apprehension and fear many people experience when dealing with numerical information. Math anxiety greatly affects working memory capacity and increases the inability of students to solve word problems. Studies have proven that students who have high math anxiety have a harder time learning math because this anxiety is taking over part of their working memory, as math anxiety increases, math achievement declines (Beilock & Willingham, 2014; Ashcraft & Krause, 2007). According to Beilock and Willingham (2014), "Math anxiety robs people of working memory, or the mental scratch pad, that allows you to keep several things in your mind simultaneously and to manipulate them in order to think and solve problems" (p.29). Ashcraft and Krause (2007), "argue that a math-anxious person's working memory resources are drained—that the individual suffers a compromised working memory—only when the actual math anxiety is aroused, as in span tasks that involve computations" (p.245). Based on a study by Maloney and Beilock (2012), until recently math anxiety was thought to begin at junior high age when math became more difficult. However, recent research shows this assumption to be incorrect and children as young as first-grade are reporting having varying levels of anxiety about math. Maloney and Beilock (2012) tell us that this anxiety "is inversely related to their math achievement, and this anxiety is also associated with a distinct pattern of neural activity in brain regions associated with negative emotions and numerical computations" (p. 404).

Poor number sense, counting, and spatial reasoning. Students who have not developed good counting, number sense, and spatial processing skills have a harder time solving word problems than their classmates who possess these skills. "Early number sense is a strong predictor of later success in school mathematics. Dyson, Jordan, and Glutting (2011) point out, "A disproportionate number of children from low-income families come to first-grade with weak number competencies, leaving them at risk for a cycle of failure" (p. 166). In their study, Dyson, Jordan, and Glutting examined the effects of an eight-week number sense intervention on 121 low-income kindergarteners who were randomly assigned to either a number sense intervention group or a business-as-usual control group. The intervention purposefully targeted whole number concepts related to counting, comparing, and manipulating sets. This intervention was conducted in 30-min sessions, three days per week, for a total of twenty-four sessions. The intervention group made significant gains compared to the control group on immediate and delayed posttests on a measure of early numeracy. Additionally, the intervention children performed better on a standardized test of mathematics calculation. In her study, Wilson (2014) found that "early mathematics skills more strongly predicted later math achievement than early reading skills predicted later reading achievement, and the mathematics skills were better predictors of total achievement and grades" (p.19).

Visual-perceptual skills showed consistently strong predictive relationships with later achievement, especially math. Another study by Jordan, Kaplan, Ramineni, and Locuniak, (2009) showed many mathematics difficulties in elementary school can be traced to weaknesses in basic whole number competencies or number sense. These weaknesses would include difficulties understanding the value of small quantities immediately, making judgments about numbers and their magnitudes, grasping counting principles, representing one less and one more than a given number, and joining and separating sets.

Failure to persevere. Another factor in ability to solve word problems is students lack of determination to persevere at a task until it is completed. ThinkMath! 2016 declares, "We must have enough stamina to continue even when progress is hard, but enough flexibility to try alternative approaches when progress seems too hard" (para. 2). According to Pasquale (2015), teachers feel that perseverance is a skill that only some students possess instead of a behavior that everyone can cultivate. Teachers need to develop this behavior in their students in order for them to keep working on a problem until it is solved.

According to ThinkMath! (2016), problems encountered in the real world are not about the topic we just studied nor do they tell us what prior knowledge to recall and use. In fact, the problems usually do not give us the exact question to answer or tell us where to begin-these problems just happen. To succeed at solving these problems, the relevant information must be figured out. Based on the Department of Education and Early Childhood Development (2009), "Encouraging students to work hard and not give up when faced with challenges is no simple matter. Skill development is incremental and is not something that can be reached rapidly" (p.10). The paper also points out that students need to realize that this process often involves initial failure and errors, but these should be regarded as a normal part of the learning process and a signal that the challenge is worth pursuing.

Lack of strategies. Not having specific strategies for how to solve different types of word problems is another contributing factor as to why students find them difficult to solve accurately. Huson (2017) points out students who struggle solving math word problems do so for various reasons which can be identified and corrected by teaching possible strategies for taking apart and working through word problems step-by-step. Frawley (2014) states "As a student in elementary school, I remember feeling unsure about how to solve math word problems. I did not know many problem-solving strategies, and I would often become confused" (para. 1). He goes on to say that many elementary students, experience similar frustrations when faced with a math word problem. Uncertainty about what the problem is asking and/or what the steps are in solving the problem make solving word problems difficult. Though if a student has explicit instruction on how to solve specific problem types they will be more successful with the increased rigor of state standards. Florida Department of Education (2010) states the following:

> Students should be encouraged to develop and discover their own problem-solving strategies and become adept at using them for problem solving. This will help them with their confidence in tackling problem-solving tasks in any situation, and enhance their reasoning skills. (p.2)

The writings of Dewolf, Van Dooren, Cimen and Verschaffel (2013) explain that after several years of schooling, the approach students use to solve math word problems is unrealistic and artificial. Dewolf et al. (2013) describe this approach as, "They execute arithmetic operations with the numbers given in the problem without making any serious realistic considerations" (p. 2). Based on these statements students need to have a method or strategy that establishes an approach that emphasizes reasoning prior to implementing arithmetic calculations.

Not understanding semantics. Finally, not understanding the semantics of the problem, or what the problem is asking plays a large role in why students often arrive at incorrect answers when working with number problems. Huson (2017) explains that one must make sure the student understands the problem. Reading comprehension can hinder skill in solving a word problem. Reading the problem aloud and talking about the process needed to find a solution can be helpful. Sometimes it is necessary to rephrase the problem in simpler language. In a study by Daroczy, Wolska, Meurers, and Nuerk (2015) they found that the semantic (understanding meaning) structure properties of a word problem are a more important factor contributing to difficulty than the syntactic (word order) structure. According to Boonen and Jolles (2015), students have more difficulty solving word problems in the first-grades of elementary school than their numerical counterparts. As summarized by Boonen and Jolles (2015), "This discrepancy between performance on verbal and numerical format problems strongly suggests that factors other than calculation ability contribute to children's word problem-solving success" (p. 1). Students need specific instruction on recognizing what a word problem is asking them to solve.

How Poverty Affects Solving Word Problems

Students growing up in extreme poverty face additional difficulties when it comes to solving word problems. In this context, poverty is defined as the extent to which students do without resources. Lacour and Tissington (2011) define these resources as "Financial, emotional, mental, spiritual, and physical resources as well as support systems, relationships, role models, and knowledge of hidden rules" (p. 522). Due to these lack of resources, students from poverty have a more difficult time achieving success, specifically in the area of solving math word problems. More than one-half of public school students are designated low-income (van der Valk, 2016). Knowing this information, it is essential that public school teachers develop strategies that will work with students from poverty so they can attain the necessary skills to solve math word problems that involve reasoning in order to be successful in today's society. Wilgoren (2001) interviewed Bob Moses, founder of the Algebra Project. During this interview, he expressed that we must provide our poor students the opportunity to develop math skills so they can be competitive in today's culture. In Wilgoren (2001), Moses is quoted saying "But the Algebra Project is as much about demanding rigorous education in low income communities where children are typically tracked into remedial classes, as it is about a particular teaching method" (para. 7). Low-income students frequently do not come with these reasoning skills and too many times teachers do not take the time to develop them. Possessing these simple skills will provide the basic building blocks for future mathematical learning. All too often, primary teachers spend a large proportion of time focusing on implementing specific reading strategies, but have a tendency to focus on just the basics of math through the use of worksheets and spend very little time teaching the necessary specific strategies to assist the students in solving word problems. Arrighi and Maume (2007) emphasize this focus on the basics in the following:

> The amount of time spent on activities with graphs, estimating quantities, and writing math equations to solve word problems-those activities which incorporate children's own thinking, engage children to think about mathematics and help them build reasoning skills-increases with family income. In essence children below poverty have the least exposure to these kinds of practices, which is contrary to the desire to increase low-income children's exposure to the practices that will help them develop skills in problem-solving and reasoning skills. (p. 441)

Teachers must expose all of their students to activities that will allow them to engage in mathematical thinking.

Van der Valk (2016, para. 5) states, "We understand children learn most effectively when educators know and support their unique strengths and validate the multiple aspects of their identities." According to Lacour and Tissington (2011), numerous studies have been done on the effects of poverty and academic achievement. The results are conclusive that students growing up in poverty settings, regardless of race or gender score significantly below level. Lacour and Tissington (2011) reinforce this notion, "Some families and communities, particularly in poverty stricken areas, do not value or understand formal education. This leads to students who are unprepared for the school environment" (p. 526). However, in their conclusion, Lacour and Tissington confirmed that instructional techniques and strategies could be implemented that would help close the achievement gap and change the picture for students from poverty.

Teachers could provide students with necessary assistance, such as encouraging active participation and supportive feedback, in order to achieve high performance in academics. One of their most powerful suggestions for building the home school relationships needed was to share positive comments about the students with parents. These comments helped the parents feel accepted in the school environment which is often a barrier for families of poverty. Hill, Rowan, and Ball (2005), conducted a three-year longitudinal study of 334 first and 365 third graders from 115 high poverty schools to see if the teacher's mathematical knowledge of teaching contributed to a gain in students' math achievement. Their findings showed there was a positive correlation between teachers' mathematical knowledge and student achievement, however, there was the possibility that it could be general knowledge and aptitude for teaching but they did not measure for these qualities. Though many variables could have affected these results, their main suggestion was that these neediest students should be taught by the highest quality teachers. The gap that poverty shows in academic achievement can only be addressed by having the highest quality teachers meeting the needs of these students.

In a study conducted by Dyson, Jordan, and Glutting (2011), they wanted to see if developing number sense in low-income kindergarteners would increase their mathematical achievement. They focused on number sense because it is one of the major factors in predicting success in solving word problems along with counting and spatial processing and a vast number of low-income students lack these competencies. The study showed that the intervention group made meaningful gains over the control group on the posttest and the delayed posttest. The students used more counting-on strategies to solve word problems than the control group. Results showed specific number sense activities could be taught in order to prevent these at-risk students from falling behind.

Another study by Siegler (2009) conducted with children from low-income settings, wanted to test the effect playing a number board game would have on developing number sense. Siegler randomly assigned thirty-six students to two groups, a number games group and a color games group. These students either played a board game by spinning a spinner and moving the required number of spaces (1 or 2) or the same game with colors and no numbers. After only four sessions lasting fifteen to twenty minutes the number game students showed significant improvement in their ability to estimate numbers. The number game group increased in their number task assessment from 15% to 61%. The color game group scored 18% before and after treatment. The control group of twenty-two higher income students without a treatment scored 60%.

Dewar (2016a) stressed that research emphasized the development of spatial processing in young children. If teachers could improve the spatial processing skills in young children, they would have less math anxiety, be better able to visualize number relationships, and become better problem solvers. In Dewar (2016b) and Dewar (2016c) there were several studies that showed that playing with construction toys would improve spatial processing. One study tested students on spatial processing skills and one group played Scrabble® and the other group participated in structured block play. Afterwards, they were retested on spatial processing and the block group made higher gains regardless of gender.

Dewar (2016c) gave suggestions on ways to improve spatial processing skills which include: practicing mental rotation, paper folding tasks (predicting the shape a paper net would fold into), playing certain action video games, structured block play, and using spatial vocabulary when talking with students. However, Dewar (2016b) stated that many of the construction toys that would really help build spatial processing such as Keva® and Legos® were expensive and inaccessible to children of poverty. Based on this information, it would be a great benefit to increase future word problem-solving ability if we could provide some specific activities that would develop counting, number sense, and spatial reasoning activities in our low-income students prior to their arrival in school.

Increasing Math Achievement on Word Problems

There are many suggestions for increasing math achievement in the area of solving word problems. These include building schema, developing perseverance, early intervention, reducing math anxiety, understanding the semantics, and instruction on specific strategies for dynamic addition word problems. Building on these skills should increase the ability of first-grade students to solve dynamic addition word problems.

Building schema. If instruction is used that builds schema for solving different types of problems the students will have a base of knowledge to draw from as they attempt to make sense of various word problems. According to Jitendra and DiPipi (2002), as a student develops knowledge in the mathematical domain, this knowledge eventually maps relationships in the brain known as schema. Schema is a way of organizing knowledge that allows students to sort strategies for solving problems into types. “In summary, the schema strategy is seen as a viable approach for teaching students with learning disabilities to solve addition and subtraction word problems" (Jitendra and DiPipi, 2002, p. 26). Building schema for word problem types is a way to allow students to categorize problems and use specific methods for solving each type. In a study conducted by Fuchs et al. (2010) research found that students who had instruction on building schema for word-problem types and trying to broaden this schema to cover many situations increased in their ability to solve word problems.

Developing perseverance. In the South Carolina College and Career Readiness Standards (2016) the first mathematical practice is to, "Make sense of problems and persevere in solving them" (p.7). This includes relating problems to prior knowledge; recognizing more than one way to solve; analyzing what is being asked, the given, ungiven, and strategies needed to make an attempt at finding a solution; and evaluating the success of an approach and continuing to refine attempts if necessary. Developing perseverance in problem solving is a skill that needs to be taught and valued. Teachers need to set up situations in which students have productive struggle in order to develop the ability to persevere. As defined by Pasquale (2015) productive struggle is, "When students labor and struggle but continue to try to make sense of a problem" (para. 6). Pasquale (2015) draws the analogy that a student will practice a free throw for hours, though it is a challenge, because it feels accessible. Students need to view the challenge of solving math word problems in this same way and persevere in their attempts.

However, Pasquale (2015) expresses that there are many factors standing in the way of allowing students the opportunity to develop productive struggle as they are learning math concepts and teachers need to encourage students to develop productive struggle in mathematics. Pasquale also explains that the kind of support teachers give and the type of questions they ask are critical to either facilitating or undermining the productive efforts of students' struggles. Pasquale (2015) offers four strategies to help teachers support their students in this form of learning in order to develop their perseverance in problem solving. These strategies are summarized as follows: 1) Teachers ask questions that help students focus on identifying the source of their struggle, then have them look for alternative ways to solve the problem; 2) Teachers inspire students to reflect on their work and reward effort not just getting correct answers; 3) Teachers allow students the time needed to try and fail and do not step in too soon to help, thus taking away the intellectual thinking from the student; and 4) Teachers recognize that struggling is a key component of learning mathematics.

In research conducted by Jacobs and Ambrose (2009), they watched videotaped student-teacher conversation interviews about problem solving. These interviews included 65 teachers, 231 children, and 1,108 word problems. They identified actions that helped students to develop their math reasoning skills. These actions included conversations before and after problem-solving activities. Before a student attempted to solve a problem the teacher would ensure the student understood the problem, change the mathematics to match a student's level of understanding, explore what the child has already done, or remind the student of other strategies. After a student had correctly solved a problem, there were another four moves the teacher could use to help students deepen their understanding and relate it to other mathematical ideas. They could promote reflection on the strategy used, encourage the student to think about other strategies, connect the child's thinking to symbolic notation, or generate follow up problems.

Teachers could choose to employ any of these actions to develop a student's perseverance in reaching the goal of correctly solving word problems.

Providing situations that promote productive struggle and valuing the effort students put into coming up with an accurate solution will develop perseverance in students. In a paper by the Department of Education and Early Childhood Development (2009) there is a list of ways to encourage students to develop perseverance. A summary of this list includes the following: feedback should encourage persistence and patience, avoid attributing performance to ability only when scoring, emphasize progress made so far, encourage students not to lose patience when success is not instant, assure vulnerable students that persistence (possibly with additional help) will eventually pay off, make students aware that learning may involve confusion or mistakes, support students to become risk takers in their learning and equip students with problem-solving strategies specific to different challenges, present difficult work not so much as requiring strenuous effort, encourage students to see that giving up means they will miss an opportunity to learn, and invite 'experts' from different fields such as the arts, sciences, sport and business to share their experiences.

Early interventions. As referenced earlier, it is known that developing number sense, counting, and spatial processing in students will help increase math achievement. Therefore, these skills need to be developed at the earliest opportunity. Research shows that students that have developed spatial relationships/processing skills are more likely to be successful at solving word problems. Dewar (2016), explains how these are skills that can be developed in children through construction play with items such as Legos® and blocks. This is something to keep in mind to help develop students who are problem solvers. Dewar (2016c) has explained the importance of getting construction-type toys into the hands of students who are at risk. Knowing this information, Head Starts and prekindergarten programs should make sure they have a plethora of building materials such as blocks and Legos® that students can use to develop spatial reasoning.

According to the study by Dyson, Jordan, and Glutting (2011), kindergarteners who received intervention on developing number sense scored higher on tests of mathematic calculations. It is imperative that kindergarten teachers incorporate lots of activities that develop number sense. Dyson, Jordan, and Glutting (2011) listed eleven different activities that they incorporated with their intervention group. These included the following simple tasks: verbal subitizing, sequencing number cards, playing counting games, before and after number recognition, number comparisons, and using counting to solve problems. All of these activities could be easily incorporated into any kindergarten classroom.

Decreasing math anxiety. In order for students to increase math achievement, math anxiety must be decreased. Blazer (2011) states, "Researchers believe that implementation of strategies to prevent or reduce math anxiety will improve the math achievement of many students" (p. 1). It has been discussed how math anxiety uses large portions of the working memory capacity thus decreasing a student's math achievement. Beilock and Willingham (2014), substantiated that if one can make students less anxious they will be able to do better completing math tasks.

According to Blazer (2011) math anxiety can be caused by both intellectual and environmental factors. The main intellectual contributor is the inability to understand math concepts. Environmental factors can include overly-demanding parents, negative classroom experiences, unintelligible textbooks, an emphasis on drill without understanding, and a poor math teacher. Balzer (2011) points out, "Researchers agree that math teachers who are unable to adequately explain concepts, lack patience with students, make intimidating comments, and/or have little enthusiasm for the subject matter frequently produce math-anxious students" (p. 2). As compiled by Blazer (2011) from multiple research studies there are a multitude of suggestions for things that teachers, parents, and students can do to reduce math anxiety. Teachers can do the following: develop strong skills and a positive attitude toward math, relate math to real life, encourage critical thinking, encourage active learning, accommodate students' varied learning styles, place less emphasis on correct answers and computational speed, organize students into cooperative learning groups, provide support and encouragement, avoid putting students in embarrassing situations, never use math as a punishment, use manipulatives, use technology in the classroom, dispel harmful but popular misconceptions, use a variety of assessments, and prepare students for high stakes testing sessions. Parents can reduce math anxiety in their students by implementing the following: do not express negative attitudes about math, have realistic expectations, provide support and encouragement, monitor children's math progress, and demonstrate positive uses for math. Students can reduce their own anxiety by practicing the following procedures: practice math every day, use good study techniques, study according to one's own learning style, don't rely solely on memory, focus on past successes, ask for help, and practice relaxation techniques. Placing these suggestions into practice can be the focus for reducing math anxiety and increasing student math achievement, especially when it comes to the anxiety-producing task of solving word problems.

Understanding semantics. To understand the semantics of the word problem is another essential part of arriving at an accurate solution. Griffin and Jitendra (2009), share that when learning how to solve word problems students not only need basic numerical skills and strategies they also must have knowledge about semantic structure and mathematical relations. The three types of change problems that students need to recognize the semantics of as shared by Griffin and Jitendra (2009) are the beginning, change, and ending which correlate to the start, change, and result of dynamic addition word problems.

Fuchs et al. (2010) express the necessity of students understanding the mathematical structure of problem types, recognizing problems as belonging to a particular type, and having developed a method for solving each type. In contrast to Jitendra (2008), Fuchs et al. (2010) incorporate an additional instructional layer by teaching students to broaden their schema for recognizing problem types. As stated in Fuchs et al. (2010) teachers explained how the format or vocabulary of certain problems can make them seem unfamiliar even though they are the same type and require the same solution steps, therefore, teachers need to emphasize structural features of the problem type rather than superficial features such as format or vocabulary used. Goldenberg, Mark, Kang, Fries, Carter, and Cordner (2015) point out that at first one should start out with visual and experimental situations that use a minimum of text that give students the chance to learn the mathematical ideas without the added burden of decoding complex word problems. However, they state that eventually students must learn the language of mathematics and the teacher is the native speaker of mathematics from whom the students will learn. In order for students to be successful with solving word problems they need to develop the mathematical vocabulary that will allow them to decode problems and this is most easily accomplished through teacher modeling and practice.

Strategies instruction. Strategies for solving dynamic addition need to be explicitly taught to students. In the article by Hill, Rowan, and Ball (2005), strategies are defined as mathematical content knowledge that combined with the ability to interpret mathematical semantics allows the learner to successfully comprehend and solve math word problems. Dewolf, Van Dooren, Cimen, and Verschaffel, (2013) state that students approach word problems in an artificial way; they execute arithmetic operations with the numbers given in a problem without making any serious considerations about what they are trying to solve. Students need to be moved from this type of blind applying of an operation to the point where they are giving thoughtful consideration to what a problem is asking them to find. Based on the New York State Common Core Mathematics Curriculum (2013), students are presented problems and it says they might solve these problems using both the Level 2 counting on strategy and Level 3 subtraction strategies depending on their mathematical understanding. The curriculum includes multiple strategies that have been specifically taught that students may use to solve a variety of problems.

One of the most successful strategies for increasing student ability to solve word problems has been the use of visual representation. In a study conducted by Boonen, van Wesel, and va der Schoot (2014), the researchers wanted to see if using an accurate visual representation would help students accurately solve word problems. One hundred twenty-eight students in sixth grade that represented a balance of low, average, and high scores based on the CITO Mathematics test participated in the study answering a total of

625 questions. The researchers scored each problem individually and coded them as using a pictorial representation, an inaccurate visual representation, or an accurate visual representation. When the subjects used an accurate visual representation they were six times as likely to get the problem correct. The researchers felt that pictorial representations were just details about what the word problem is talking about not actually a visual about what is being done in the problem so they were not considered helpful. In the study all problems were read to the students to control for variances in reading levels. Based on these results, if the researcher gets the students to create accurate visual representations of what is happening in a dynamic addition word problem they will be more likely to arrive at a correct solution.

Start-Change-Result Strategy Relationship

Using the *Start-Change-Result* strategy met many of the research-based suggestions for increasing the ability of first-graders to solve dynamic addition math word problems. Griffin and Jitendra (2009) share, "A growing body of evidence suggests that strategy instruction in mathematics is a powerful approach to helping students learn and retain not only basic facts but also higher order skills, like problem solving" (p.188). The *Start-Change-Result* strategy sorts dynamic addition math word problems into three types depending on the unknown in the problem. According to Powell (2011), most word problems in the elementary grades can be sorted into a few types. If students are able to classify problems as a certain type and know a schema to apply for solving each type of recognized problem, then the student should be able to solve most word problems based on the ability to apply the solution method for each schema.

Thus, if students are taught to recognize the differences in the three types of dynamic addition problems based on the unknown in each problem and then learn to develop a schema for each of the three types they should be able to apply the schema and accurately solve for the start, change, or result. Based on the writings of Van de Walle, Karp, Lovin, and Bay-Williams (2014), there are basic structures for addition story problems and each has three numbers and any of the three could be the unknown. In the join structure, the unknown could be the start, the change, or the result. Van de Wall et al. (2014) reinforces the need to teach students to solve for these structures, "These categories help students develop a schema to identify important information and to structure their thinking" (p. 101).

Also, the *Start-Change-Result* strategy emphasizes the use of visual representation. It was demonstrated that the production of accurate visual representations was more frequently associated with a correct than with an incorrect answer to a word problem (Boonen, van Wesel, and va der Schoot, 2014). Also, the practices outlined to encourage students to persevere without developing math anxiety will be implemented in the lessons. The strategy is simple and will not overload the working memory capacity of students so it should not affect their ability to accurately come to a solution. Additionally, this procedure can easily be replicated by other teachers. New York State Common Core Mathematics Curriculum (2013) has a step-by-step unit plan that can be followed as teachers implement this strategy into classrooms.

Conclusion

Based on the information gleaned from the literature review, students need to be provided several things in order to increase their abilities to solve dynamic addition math word problems. Math problems are usually presented using words instead of numerical format and students as young as first grade have been shown to experience more difficulties with solving these word problems (Boonen & Jolles, 2015). Students need to be able to understand the semantics of the question so that they can reason what the problem is asking them to find. According to Daroczy et al. (2015), “word problems belong to the most difficult and complex problem types that pupils encounter during their elementary-level mathematical development” (para.1). Though they are considered to just be arithmetic tasks, research shows that these problems contain a number of linguistic verbal components not directly related to arithmetic that contribute greatly to their difficulty (Daroczy et al. 2015). Next they need to decide what type of problem are they going to be solving, is the unknown the start, the change, or the result. After they have classified the problem by type, they can activate the proper schema to use to find an appropriate strategy.

Students should have developed a strategy to answer each type of problem that is simple and does not need a large working memory capacity. Knowledge of the mathematical structure of problems, in turn, can facilitate activation of the relevant schemata or patterns that would guide problem representation, which is necessary for solving problems. Jitendra and DiPipi (2002) emphasize that when students are solving problems, they need to access problem-relevant knowledge which has been organized in memory by a cognitive structure called problem schemata. They continue to say that knowledge of the mathematical structure of problems can facilitate activation of the relevant schemata that would guide students to using accurate problem representation, which is necessary for solving problems. Having schema for problem-solving strategies available will be especially useful if the students happen to have math anxiety. Maloney and Beilock (2012) state that lacking mathematical capabilities may predispose students to becoming math anxious, therefore providing them with tools to boost their basic mathematical competencies may help to prevent children from developing math anxiety in the first place.

Students need a way to visually represent this information that allows them to accurately answer the question. Boonen and Jolles (2015) explain this representation, "More specifically, the verbal and numerical information that is relevant for the solution of the word problem should be connected and included in a visual representation, in order to clarify the problem situation described in the word problem" (p.1). All of this should be presented to the student by a teacher who has confidence in his or her ability to show the student a problem-solving strategy, values the time needed to be spent on problem solving, and teaches the student how to persevere at problem solving. By instructing students on the use of the *Start-Change-Result* strategy, these specific needs were met and students obtained the ability to solve dynamic addition math word problems with accuracy.

CHAPTER 3

METHODOLOGY

Problem of Practice

Looking at high-stake-testing data the growth among the students at Sammy Seagull Elementary School was not at the level one would like. When conducting classroom observations and modeling lessons it had been noticed that the students often just did some sort of computation with the numbers presented rather than reason what a math word problem was asking them to find. Students must increase their reasoning and problem-solving skills if they are going to be able to apply their learned mathematical skills in real-world situations.

If students first analyzed the math word problem to see what they are really being asked to find they would have more success. The purpose of this action research was to determine if children from this high poverty setting could be taught a specific strategy to develop mathematical reasoning in order to answer dynamic addition math word problems accurately. As Johnson (2013) points out, educators who are effective with children who live in poverty know they face challenges often not experienced with other groups such as struggling with mathematical skills. Therefore, the goal was to explicitly teach the *Start-Change-Result* strategy so these students could determine the unknown in any given dynamic addition math word problem prior to attempting a solution. After students figured out if the unknown was the start, change, or result; they employed various addition strategies (i.e. number lines, drawing pictures, manipulatives, counting on, making tallies…) that they typically use to solve computational addition problems. By analyzing what part is missing prior to doing the computation, they should arrive at accurate answers regardless if the start, change, or result is the unknown in the problem. Based on the writings of Johnson (2013), one of the ways to succeed with children who live in poverty is to incorporate strategies and practices that lead to achievement. An action research study was the most appropriate method to use to answer this question with this set of students.

Research Question

What impact will the *Start-Change-Result* strategy have on the ability level of first-grade students working to solve dynamic addition math word problems?

Purpose of Study

The purpose of this study was to examine the impact the *Start-Change-Result* strategy had on the ability level of first-grade students working to solve dynamic addition math word problems. Two factors that contributed to these specific students' inability to solve these type of word problems were that they receive little direct instruction on strategies to guide on the proper approach and that coming from their environment of extreme poverty they have had very little opportunity to develop math reasoning skills. Both of these issues can be counteracted by providing teachers a very specific way to help students understand the problem and purposefully developing their mathematical reasoning skills. Jensen (2013) discusses the importance of recognizing the differences encountered in teaching students of low-income and having teachers purposefully mitigate some of the negative effects of poverty. "Focus on the core academic skills that students need the most. Begin with the basics, such as how to organize, study, take notes, prioritize, and remember key ideas. Then teach problem-solving, processing, and working-memory skills" (Jensen, 2013, p.26). Using the *Start-Change-Result* strategy provided the students with needed academic skills to successfully solve dynamic addition math word problems that can be built upon for later learning. The results of this action research will guide future decisions about math instruction made by the researcher.

Action Research Method Design

The researcher planned an action research study to see if the direct instruction of a strategy would help first-grade students reason what a math word problem was asking prior to attempting to find a solution. This study focused on implementing the *Start-Change-Result* strategy, a schema-based strategy to facilitate a process in which students can better learn how to focus on a plan for solving math word problems. According to Middle School Matters (2017), "Schema-based instruction teaches students to focus on the underlying structure of word problems to determine the best procedure for solving the problem. Students learn common characteristics of different types of word problems focusing on the structure of the problem" (p. 1). After students have learned to recognize the structure of various math word problems, they can apply strategies learned in class such as *Start-Change-Result* to solve them.

The researcher, who is also the school's numeracy coach, outlined a specific plan for how to implement this strategy in the classroom. The researcher modeled the strategy in a first-grade classroom every day for the six-week treatment period of this study. After collecting baseline pretest data, direct instruction on the *Start-Change-Result* strategy was implemented for twenty minutes three times per week. Students in this class were given practice problems that they were asked to solve by implementing the *Start-Change-Result* strategy as it had been modeled. For students who needed differentiated assistance it was given in the form of small group or one-on-one instruction. At the end of the study time frame, an identical posttest was given to the students and the results were analyzed.

Research Context

A description of the school where this research took place is provided, along with the demographics. In addition, the timeline of the research structure is outlined. Finally, ethical considerations are explained.

Setting. Sammy Seagull Elementary is a Title I school which serves grades pre-kindergarten through fifth grade. Due to the high number of low socio-economic status students, this school has been named as a Community Eligibility Provision (CEP) school; this means that 100% of the students receive free lunch and breakfast. This school is unique because it has multiple special programs. There are two programs of choice that students throughout the district can apply to attend, which include the Montessori program and the AMES (Advanced Math, Engineering, and Science) Academy. The Montessori is grouped by lower (grades first-third) and upper (grades fourth and fifth). AMES is a program for which one must qualify that serves gifted and talented students in third, fourth, and fifth grades.

In addition, there are multiple self-contained special education programs housed in the school that serve students from three years to twelve years old. These seven different special education classes group students by age and severity of classification. The school is also home to two Head Start classes. Finally, the school serves all students in the attendance zone, which includes multiple low-income housing areas. These students are referred to as the Community School.

All students in the different programs interact with one another on a daily basis. Though everyone receives free lunch because of the extreme poverty of most students, due to the varying populations in the different programs that are housed within this school, there is still a huge disparity in the socio-economic level of the students that attend. This school is labeled by the state of South Carolina as a Focus School because there is a large achievement gap. Therefore, how to teach children of low socio-economic status in order to level the educational playing field is an essential topic to address.

Also, the school recently received STEM accreditation from AdvancedED® based on the AMES Academy programs. The school would like to expand this accreditation to the entire population. Thus, there is a focus on developing STEM learning throughout the entire school population. In order to reach this goal, as a school, the Community School children must be provided with the same opportunities to develop in the areas of science, technology, engineering, and mathematics that the AMES Academy students receive. Part of this is providing the students with the skills needed to develop mathematical reasoning, which is part of this action research project. This year, the engineering teacher began including the Community School children in her schedule. She has noticed that they are having a very difficult time applying reasoning skills and become easily frustrated as they attempt to complete builds. Therefore, it is essential that the school work toward developing these reasoning skills at a young age even if it is as simple as deciphering what a basic addition problem is asking.

Participants. The first-grade students in this study are part of the Community School. There are fifteen students in this class. There is a total of eight girls; five are

African American, one is Caucasian, and two are Hispanic. There is a total of seven boys; four are African American, two are Caucasian, and one is Hispanic. Currently six students are receiving reading intervention because they are significantly below grade level. Two of these students receive ELL services.

The majority, 12 out of 15, of the participants who are part of this action research study fall into the low achievement end of the spectrum. Most of the participants come from extreme poverty environments, therefore they arrive at school without the necessities for learning which range from materials to educational support. However, it is thought that if these students receive the right type of instruction they will be able to achieve at a level similar to their more advantaged peers. Johnson (2013) explains that for children of poverty to go from a culture of despair to one of hope they need, "Effective educators who will not settle for mediocrity, who will not accept excuses for why these children can't learn, who are willing to do whatever it takes to help each child succeed" (para. 1). With the implementation of the *Start-Change-Result* strategy to develop the mathematical reasoning of the students in this class, success should take place.

These students took the Measures of Academic Progress (MAP) test created by the Northwest Evaluation Association (NWEA) at the beginning of the school year. As related to the action research study on solving dynamic addition problems, the researcher reviewed their scores to show their general math ability. National percentile scores for these fifteen students based on the previous spring's scores are as follows: 4, 5, 5, 6, 12, 14, 16, 18, 20, 25, 30, 33, 38, 81, and 90. This puts nine students or 60% of the class in the LO range, four students or 27% of the class in the LOAvg range, and two students or

13% of the class in the HI range as defined by NWEA. A quadrant grid showing their math growth from fall of kindergarten testing to spring of kindergarten testing shows that 13 of the students fall in the low achievement, low growth quadrant; one student falls in the high achievement, low growth quadrant; one student falls in the high achievement, high growth quadrant, and there are no students in the low achievement, high growth quadrant. This data shows that these children are not only low ability, but that 93% of the class is not getting a year's growth in a year's time (see Appendices B-C). In first-grade, the achievement gap is already forming. Therefore, the teacher must provide these students with some specific math instruction, which will help them to show growth.

Timeline. This is an overview of the timeline for activities implemented to complete this action research. The researcher implemented the treatment on random days and at random times so that other activities taking place in the school day did not influence the results. Details on how each session was conducted will be explained in the Modeling of *Start-Change-Result* Strategy section of this chapter.

Week 1 (two times a day, for five days, for 10 minutes each session)

- Administered pretests to all students. Protocol followed was to give three questions in the morning and another three in the afternoon Monday through Friday.
- Friday, when all tests were completed, conduct student interviews.

Weeks 2 (once a day, at random times, for five days, for twenty minutes each session)

- Explicitly taught the *Start-Change-Result* strategy for problem solving. Introduced students to the idea of dynamic addition problems and the three unknowns that could be in each problem working five problems each day. During this time, the researcher had the students always name the missing unknown prior to attempting to solve any problems. They did this in a variety of ways: hand signals of letter signs for S-start, C-change- or R-result, circling S, C, or R on a paper, and oral answering.

Weeks 3-6 (three random days a week, for twenty minutes each session)

- Each day the researcher reviewed the use of the *Start-Change-Result* graphic organizer as they solved dynamic addition word problems as a group.
- Each session after a short review, the students independently worked three mixed variety dynamic addition problems that included the *Start-Change-Result* graphic organizer already drawn on the paper.

Week 7 (five days Monday-Friday, at random times, for twenty minutes each session)

- Give students three problems each day with no *Start-Change-Result* organizer included for them to use when solving the problem. Prior to doing this, the teacher always modeled completing a sample problem with a think aloud and the drawing of a graphic organizer like they had been using.

Week 8 (five days a week, two times a day, for ten minutes each session)

- Administered posttests to all students. Protocol was to give three questions in the morning and another three in the afternoon.
- When all posttests were completed, the researcher interviewed each student again to see if there was a change in how they went about solving the dynamic addition word problems.

Ethical Considerations. The researcher completed the district's permission to conduct research form and obtained IRB permission in order to conduct the study. According to Dana and Yendol-Hoppey (2014), good and ethical teaching involves looking carefully at student work, making observations, assessing, and asking questions and is a normal part of teaching. These were the types of things that happened as this action research was being carried out in the classroom.

Building administration was notified of the action research idea because that is the process that is utilized for planning for professional development opportunities. It is school policy to field test a strategy and look at the results to determine if it will be presented to a larger audience. The basis for the field test or action research project was determined by observations, student test results, and new learning received from the state department. The researcher obtained parental permission due to the fact that work samples and quotes from the students were used in the published dissertation (see Appendix F). Also, all identifying information was removed prior to writing about the action research study in order to ensure anonymity of the students. However, this action research is not fundamentally different than the day-to-day operations of our school, and posed no harm.

Action Research Validity

Mertler (2014) describes action research as a cyclical process incorporating various stages. The first stage is the planning stage where one picks a topic, gathers information, reviews literature, and makes a plan. Then there is the acting stage where the researcher collects and analyzes data. Next is the developing stage in which an action plan is developed. Finally, there is a reflecting stage in which the researcher shares results and reflects on the process. This action research study has been approached using Mertler's steps. After observing the students, an area of need to address was chosen. Then information was gathered on how best to meet this need. Current literature related to the topic and the strategy selected was reviewed. This information assisted with the development of the research question.

Then a plan for implementation of the strategy that was to be tested was created. Implementation of the treatment had to control for extraneous variables. For example, word problems were read to all students regardless of their reading ability so that this was not a factor in whether or not they could accurately solve the dynamic addition math word problems that were presented to them. Prior to, during, and after the treatment; data was collected and analyzed. Based on the information gathered during this study, it was determined to what extent the implementation of the *Start-Change-Result* strategy affected the ability of these first-grade students to answer dynamic addition math word problems accurately.

In the end, reflection on the information gathered was used to determine how the results of the action research study would be shared. This action research method was the most appropriate way scientifically to go about finding out if implementing the *Start-*

Change-Result strategy helped this specific group of students. This method allowed the researcher to address a real problem in the context of the classroom. Changes to instructional procedures were made based on the everyday findings of the classroom. Action research is a continuous improvement method that does not end when the treatment is finished. The researcher can decide to try something new. The goal is to find something that will work with the group of students that the teacher has on a day-to day-basis. Reaching the goal of finding a way to develop mathematical reasoning in these first-grade students was the objective of employing the *Start-Change-Result* strategy.

However, after implementing the *Start-Change-Result* strategy, rather than just state that there was success and walk away as a traditional researcher would, this researcher reflected on the process. As explained by Dyke (n.d.), there are several advantages to using action research. These advantages include the following: teachers use data rather than hunches as they try to make improvements, teachers reflect about what is happening in their classroom and develop ideas on which way to go, it leads to actions that will change the learning environment, and it leads to implementation of practices of improved pedagogy. The use of the action research process was advantageous to the school as they sought ways to make improvements in student achievement. "Action research is an ongoing process of reflection and action to produce the most effective learning environment possible…action research is an essential process for education to evolve to meet the needs of the students of today and tomorrow" (Dyke, n.d. para. 5).

Research Design

A mixed method, pretest-posttest design was used to conduct this action research study. One of the major benefits of collecting both qualitative and quantitative data when conducting an action research study is that one can potentially gather the strengths from both types of data expressed in one's discussion of the results of the research. As explained by Creswell (2014), "This 'mixing' or blending of data, it can be argued, provides a stronger understanding of the problem or question than either by itself" (p.264). The qualitative data provided clarity to what the quantitative results showed. For example, if one did a pretest-posttest study and the students showed growth, that would provide support for treatment. However, if one took the opportunity to interview the students and take field notes about the observations one would have deeper insight into what he/she did that allowed them to grow thus allowing one to provide even more explanation for what made the strategy work.

Both types of data were used for this action research study on using the *Start-Change-Result* method to provide first-grade students with a specific strategy to solve dynamic addition math word problems and there was no perceived notion this posed any type of problem. Based on Creswell (2014), it would be an ideal approach for a researcher to have access to both quantitative and qualitative data because it allows for a more complete understanding of the research. A pretest was given prior to teaching the strategy and posttest afterwards to see if the students showed growth in their ability to solve the problems, which would be a quantitative form of data. Qualitative data collected during this study included a structured interview and field notes of observations to see how the implementation of the strategy influenced the participant's approach to solving dynamic addition math word problems.

Analyzing both types of data helped the researcher to reflect on the action research project and guide the direction of future cycles. According to Mertler (2014), decisions are made about future plans of action, based on the information gleaned from the analysis of the results of the action research data. By understanding what the students did with what they learned, it helped to explain better the results and to improve implementation with other classes since the results of the research turned out to be positive.

Collected artifacts used for analysis included work samples from students completed throughout the study. Field notes were taken of what was observed by the researcher as students progressed through the treatment period. Also, each students' answers to the interview questions of "How did you solve these problems?" and "Was there anything else that helped you?" were recorded prior to and immediately after the treatment period. An initial pretest was given that was also administered at the end of the study as a summative posttest to gauge student growth. Additionally, formative assessments were given once a week during weeks three through seven of the study. The results were used to guide the researcher on the students' strengths and weaknesses in developing the strategy-specific schema as appropriate instruction was planned.

Data Collection Procedures

The background data on these participants' mathematical levels that were collected was their results on the nationally normed MAP test. Also, prior to the treatment being implemented, participants took weekly addition facts and missing addends tests with answers within twenty to determine the needs of this group of students in mastering the operation of basic addition (see Appendix Q-R). Since the students must have the prerequisite skill of being able to correctly answer basic addition facts prior to the implementation of the *Start-Change-Result* strategy, those participants who needed help were worked with on a regular basis until they obtained a rate of mastery which was stated as being a score of 80%.

Prior to the start of the treatment a series of pretests was given. These pretests were spread out over a period of five days (one test administered in the morning and one test administered in the afternoon-6 questions per day) with a total of thirty questions. These questions were presented in random order, and included ten each of problems with the start unknown, change unknown, and result unknown (see Appendices G-P). Not only did this provide the baseline data needed to determine if students showed growth, it also provided data about which type of problem the students have the most trouble answering. This information helped guide instruction as the treatment was implemented. The results of this data were recorded on the color coded sheet so that it could easily be determined what type of problem the students were having the most difficulty solving (see Appendix S).

Additionally, the researcher conducted an interview with the participants when the pretests were completed to see what strategies they relied on as they answered the word problems. During this interview process, the participants were asked these two questions: 1) "How did you solve these problems?" and 2) "Anything else that helped you?" All answers were clarified and responses recorded. This information was used for comparison to their answers after the treatment. Finally, the researcher made observations and took field notes about what was noticed as students were solving the problems.

After six weeks of implementing the *Start-Change-Result* strategy, the researcher administered an identical posttest (see Appendices G-P). This allowed the researcher to see if the students improved in their ability to solve these dynamic addition math word problems. In addition, the researcher conducted a posttest interview with the participants to find out what strategies or processes they implemented as they answered the problems. The researcher noted if any of the participants implemented the steps in the *Start-Change-Result* strategy. As the participants took the posttests, the researcher again made observations about what was noticed as the students were solving the problems and compared them to the original observations to see if there were changes as a result of the treatment.

Data collection method 1. The first data that was collected from the participants was their Measures of Academic Progress (MAP) math test scores which was given during the first two weeks of the school year (see Appendix C). From this test, each student was given a RIT score. This score was used to determine the basic math level of individual students as a nationally normed percentile ranking prior to the implementation of the action research. In addition, data was provided that showed a past history of growth on MAP for these students (see Appendix B). This growth was divided into four areas or quadrants, distinguishing a student as low achieving with either low or high growth; or high achieving with either low or high growth. This pretreatment growth data was compared to post treatment growth data (see Appendix D-E).

Data collection method 2. The second type of data that was collected were results of weekly basic addition facts and missing addends tests which were administered to all participants (see Appendix Q-R). This information was used to determine when the participants had the necessary prerequisite computation skills necessary to solve the dynamic addition math word problems. In order to answer the stated research question appropriately, the researcher ensured that basic computation ability was not hindering the students arriving at accurate answers.

Data collection method 3. These participants were given a pretest created by the researcher that contained dynamic addition math word problems. The researcher read this test to them so that everyone knew what the problem said regardless of their individual reading level. This test was a mixture of the three types of dynamic addition problems in which the question might ask for the start, change, or result. This pretest was spread out over five days with three questions in the morning and three questions in the afternoon. This was done so that enough data could be collected without the students tiring or losing their focus. There were an equal number of start, change, and result problems mixed randomly throughout the test to ascertain where participants were struggling. The information gathered from this pretest guided the researcher in the presentation of the strategy.

Data collection method 4. The researcher asked participants from the group about what strategies they used in solving the word problems to establish a base line of what type of strategies they employed to come up with an answer. The student answers were compiled into a table to determine the frequency of use of the various strategies that they shared with the researcher. This qualitative data was compared to the same type of data collected at the end of the implementation of the action research to see if using *Start-Change-Result* strategy changed their responses.

Data collection method 5. After implementing the *Start-Change-Result* strategy in an action research setting for a period of seven weeks, the student-participants were given a posttest which was exactly the same as the pretest. The results from the posttest were compared to the pretest to determine growth of the student-participants. This analysis of individual growth using descriptive statistics classified this action research as a quantitative study.

Data collection method 6. A post interview was administered to participants by the researcher to see what strategies for solving the dynamic addition problems were used. The researcher wanted to determine if the participants who were taught the specific strategy of *Start-Change-Result* gave any new information on the strategies that were used to solve the word problems than they did at the start of the action research prior to direct instruction of the *Start-Change-Result* strategy.

Modeling of Start-Change-Result Strategy

At the start of the treatment portion of this action research study, the researcher modeled by thinking aloud while solving dynamic addition math word problems that had one of three unknown components: the start, change or result. Students were taught how to decide what was the unknown in each problem prior to solving for an answer. Based on the three possible unknowns and the information given in the problem, students were shown how to determine what is missing; the starting amount, the amount of change, or the amount that there was in the end. The set-up that was used is a graphic organizer including three boxes labeled start, change, and result with an addition sign and an equal sign included as shown (see Figure 3.1.). These boxes had space for the student to draw, make representations, or use manipulatives as they arrived at an answer. They also included an addition sign and an equals sign to reinforce the concept of the start added to the change equals the result. This assisted them when they started writing corresponding equations.

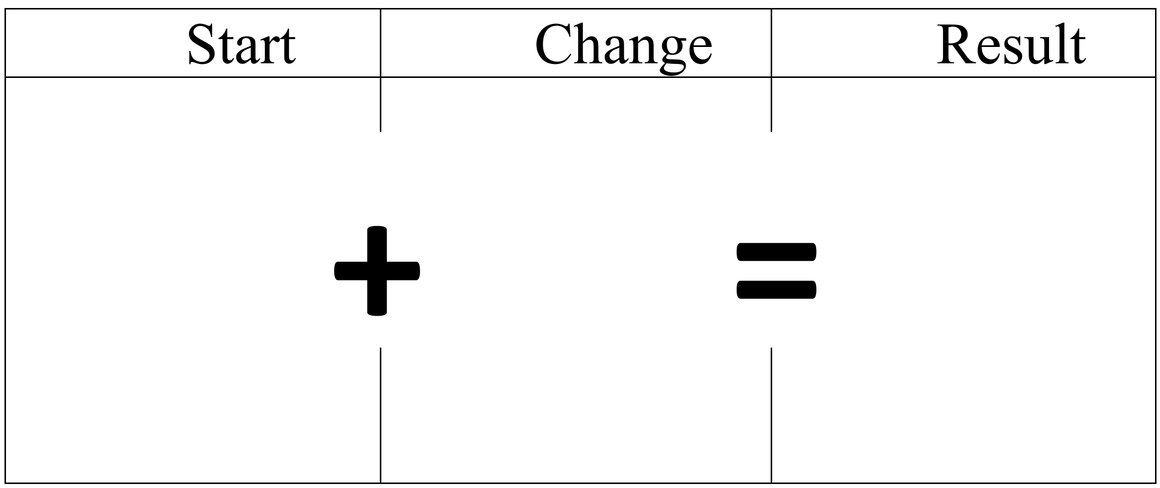


Figure 3.1. Graphic organizer for *Start-Change-Result* strategy. This figure illustrates how students will organize data prior to solving problems.

Students needed to realize that if they were finding the start or the change the answer had to be smaller than the result. Every time that modeling took place on how to solve a dynamic addition word problem, the researcher used this graphic organizer. Students were encouraged to replicate the graphic organizer on their own when they were given problems to solve independently. The participants were taught how to visually represent the numbers with tallies, circles or drawings as they went about solving for the unknown. The researcher modeled counting up or combining the numbers to find the correct answer and the students were expected to replicate the process. Every time dynamic addition math word problems were presented, the researcher talked about how there were three parts to each problem, the amount that one starts with, the amount of change that occurred, and the result or the amount one ends up having. The students were expected to use this same vocabulary as they analyzed the problems.

As suggested by Jessica (n.d.), when the students began using the *Start-Change Result* strategy independently, the researcher presented dynamic addition word problems without numbers so that students developed an understanding about the relationship of the words in the problem without the pressure of trying to get the correct answer. Samples of the three types of problems are shown (see Figures 3.2, 3.3, and 3.4). After the students became proficient at recognizing what the unknown was in each problem type then numbers were placed in the problem and they began to find solutions.

Eli put _____ pieces of turtle food in the pond before school, and _____ more when he got home. How many pieces did he put in the pond?

Figure 3.2. Result unknown problem without numbers. This figure illustrates a sample of a problem with the result unknown that can be completed using any numbers.

Molly was serving in the volleyball game. She scored _____ points. Then she got some more points. Now she has _____ points. How many more points did she get?

Figure 3.3. Change unknown problem without numbers. This figure illustrates a sample of a problem with the change unknown that can be completed using any numbers.

Brittany had some toy horses. She bought _____ more toy horses at the store. Then she had ____ toy horses. How many toy horses did Brittany have before she went shopping?

Figure 3.4. Start unknown problem without numbers. This figure illustrates a sample of a problem with the start unknown that can be completed using any numbers.

When numbers were added to the problems, the first step was to write down in each box the given quantities in the problem. For example, in this problem: Anna had some puppies in a box, she put 2 more puppies in the box. Now there are 6 puppies. How many were in the box at first? (Typically, students would say 8 puppies prior to the implementation of this strategy, because they just add the two numbers in the problem without any regard to what the question is actually asking.)

When modeling, the researcher stated, "I know that at the end there were 6 puppies so I would put that number in the result box. The change that occurred in the problem is that 2 more puppies were put in the box, so I will write 2 in the change box. Now, I know that I have to solve for the start. That means that I will need a number that is smaller than 6 and when I add it to 2 it will equal 6." Then the researcher modeled getting this answer using various methods that the students already incorporate when adding such as counting on, using the number line, using manipulatives, drawing pictures, etc. Practice using the *Start-Change-Result* strategy with these students took place three times a week during the six-week treatment period. Additionally, participants were given three problems each week to solve independently that included the *Start-*

Change-Result graphic organizer to see where they were in applying the strategy. This helped to guide instruction and determine the need to differentiate for certain students. If it was decided that individual students needed extra help, the researcher worked with them in small groups or one-on-one until they were able to apply the *Start-Change-Result* strategy independently.

Data Analysis

There are two methods for analyzing quantitative data. These include descriptive statistics and inferential statistics. Mertler (2014) states that descriptive statistics is the numeric measures of a particular study while inferential statistics determines the accuracy of generalizing the results to a larger population. The goal of the researcher determined which type of statistics was used, this decision was based on what best meets the needs of the study. According to Trochim (2006), "Researchers use inferential statistics to make inferences from our data to more general conditions; we use descriptive statistics simply to describe what's going on in our data" (para. 1). The typical action research project will likely use descriptive statistics.

Descriptive statistics are used to analyze data for general trends and look for patterns that might arise. Crossman (2016) explains, "Descriptive statistics are the basic statistics that describe what is going on in a population or data set" (para. 1). According to Crossman (2016), it is important to realize that this type of data can only be used to describe the population that is being studied. The two types of descriptive data that he describes being used are measures of central tendency and measures of spread. The various types of central tendency measures include mean, mode, and median while the measures of spread are range, frequency distribution, variance, and standard deviation.

As explained by Crossman (2016), inferential statistics are based on more complex mathematical formulas and allow us to infer trends to a larger population. Since this action research is not trying to be generalized to larger populations there was no need to calculate the results using inferential statistics. Rather, this was an action research involving a class of students and the results are not trying to be generalized to a larger population, so descriptive statistics were the basis for analysis of data. As Mertler (2009) asserts, "In most cases, descriptive statistics will suffice for the analysis of action research data" (p. 36). When the action research was completed, mean growth and the range of growth on pre-post assessments were calculated in order to determine what type of effect using the *Start-Change-Result* strategy had with first-graders solving dynamic addition problems

Additionally, the qualitative data that was gathered from observations and interviews was analyzed for trends to see how implementing the *Start-Change-Result* strategy affected these first-grade students' mathematical reasoning ability. According to Mertler (2014), when looking at qualitative data one should notice patterns and consider how they relate to the research question. The researcher related these patterns or trends to the changes that occurred in students' mathematical reasoning ability as they used the *Start-Change-Result* strategy to solve dynamic addition math word problems.

Summary and Conclusion

During this action research study, the *Start-Change-Result* strategy was implemented with a group of first-grade students to see if it improved their mathematical reasoning ability as they solved dynamic addition math word problems. The researcher wanted to determine if the direct teaching of this specific strategy had an effect on the students' ability to understand how to interpret the semantics of dynamic addition math word problems and answer accurately. Did applying the *Start-Change-Result* strategy help students to make sense of what unknown (start, change, or result) they were being asked to solve for in each math word problem? The researcher wanted the students to have a subject-specific strategy that would help them to develop their math reasoning skills as they looked at the relationship among the words and numbers prior to attempting to solve various word problems. Ultimately, the goal was to be able to provide teachers with a strategy to implement to start these children developing the skills they need to participate in a world where science, engineering, technology, and mathematics are prevalent.

CHAPTER 4

FINDINGS FROM THE DATA ANALYSIS

Introduction

This action research study aimed to examine the impact of the direct teaching of the *Start-Change-Result* strategy on the ability level of first graders to solve dynamic addition math word problems accurately. A class of first-grade students (n=15) voluntarily participated in this study with the school numeracy coach acting as the researcher. All activities and data collection occurred in the students' regular classroom setting. The researcher made sure to visit this class frequently prior to the study beginning to both become familiar with the students and to get them used to the fact that the researcher would sometimes teach them math lessons. Since the researcher is the school numeracy coach this is a typical practice.

The study lasted for a total of eight weeks with the first and last week being devoted to administering a pretest and posttest. The other six weeks consisted of the researcher applying explicit instruction of the *Start-Change-Result* strategy three random times per week for twenty minute sessions. Times and days were random so that the researcher would catch the students at different times in case some did better in the morning versus the afternoon, or not always on a day when they had physical education to avoid these variables influencing results. Frawley (2014) shares that an effective strategy for teaching students with math difficulties is to use explicit instruction. According to Archibald and Hughes (2003), explicit instruction is a method for a teacher to guide students through a learning process "that involves introducing and explaining a new concept/skill, modeling/thinking aloud, providing opportunities for guided and independent practice, and giving corrective feedback on the student's performance" (as cited in Frawley 2016, para. 4). In conjunction with the researcher teaching the *Start-Change-Result* strategy, the classroom teacher also referenced the *Start-Change-Result* strategy during daily math word problem-solving opportunities during the six-week period to reinforce student use of the strategy.

The problem being addressed is that when presented with information in the form of a math word problem, first-graders frequently just apply an operation to the given numbers, taking very little time to analyze what a problem is asking. With dynamic addition math word problems, rather than determining if the unknown is the start, change or result, these first-grade students just automatically combine the numbers and find the result. As Frawley (2014) discusses, "Solving word problems can be a challenge for elementary students. Sometimes they read a problem and use the operation the class has just been practicing (e.g., addition), or they simply guess which operation to use" (para. 2). The researcher was concerned about this lack of applying thinking skills to solving math word problems and wanted to determine if the direct instruction of a specific schema-based strategy such as the *Start-Change-Result* strategy would address this concern within this first-grade classroom.

Research Question

What impact will the *Start-Change-Result* strategy have on the ability level of first-grade students working to solve dynamic addition math word problems?

Purpose of Study

The purpose of this study was to examine the impact the *Start-Change-Result* strategy had on the ability level of first-grade students working to solve dynamic addition math word problems.

Findings of Study

When the study was completed, the researcher carefully analyzed the collected data to determine if the *Start-Change-Result* strategy had an impact on the success of first-grade students to solve dynamic addition math word problems accurately. First, there was quantitative data garnered from analyzing pretests compared to posttests. Next, the researcher reviewed MAP scores from prior to implementation of the strategy to those scores obtained after the conclusion of the action research. Then the researcher considered student responses to interview questions. Finally, the researcher made note of information gained from observations made before, during, and after the study.

Quantitative Data Analysis

A thorough analysis of all the quantitative data was conducted. The researcher compared the results of the pretest and posttest which dealt only with the implementation of the *Start-Change-Result* strategy to solve dynamic addition word problems (see Appendices T-U). Additionally, the researcher looked at overall changes the students had on the MAP math test comparing scores prior to treatment to those obtained after the treatment to see if there was any type of impact.

Pretest to posttest analysis. There were fifteen students who worked to solve ten of each type of unknown: *start*, *change*, or *result* for a possible score of 150 answers per question type. A comparison of the number of questions answered accurately out of the

150 possible on both the pretest and posttest for each type of unknown was made (see Table 4.1). The difference in the number of *start* problems solved accurately after the study was completed was an increase of 129 problems, which is equal to an increase of 86%. The difference in the number of *change* problems solved accurately was an increase of 104 problems which is equal to an increase of 69%. Finally, there was an increase of 52 problems in which the result was unknown which is an increase of 35%. The increase for result problems is not as large due to the fact that more of them were solved accurately prior to the treatment being implemented.

Table 4.1. Number of correct answers for each unknown. This table depicts the number of questions answered correctly on pretest compared to posttest for each of the problem types start, change, and result.

Start		**Change**		**Result**	
Pretest # questions correct out of 150	Posttest # questions correct out of 150	Pretest # questions correct out of 150	Posttest # questions correct out of 150	Pretest # questions correct out of 150	Posttest # questions correct out of 150
8	**137**	**23**	**127**	**82**	**134**

Typically, the *result* problems have the highest rate of being accurately solved because students usually just combine the two given numbers without considering what is the unknown and this gives the *result*. However, what is truly substantial about this data is that the number of *start* problems solved correctly in the posttest was higher than the number of *result* problems. Research has shown that students usually have the most trouble with solving *start* unknown problems. According to Powell, Fuchs, and Fuchs (2008), “Students had the greatest difficulty when the missing information was in the first position (start); second-position (change) problems were easier than first-position problems, and third-position (result) problems were the easiest" (p. 103). Therefore, the data supports that explicit teaching of the *Start-Change-Result* strategy to develop a schema to apply to different types of unknowns did have a large positive impact on the ability of this class of first-grade students to solve dynamic addition word problems.

Table 4.2. Percent of change. This table depicts the % of change from pretest to posttest for start unknown, change unknown, and result unknown.

Start		**Change**		**Result**	
Pretest %	Posttest %	Pretest %	Posttest %	Pretest %	Posttest %
5	91	15	85	55	89
Gain of 86%		Gain of 70%		Gain of 34%	

Additionally, a comparison of class mean percentages from the pretest to the posttest was made for all three question types, start unknown, change unknown, and result unknown. (see Table 4.2). Percentage score data for the three different dynamic addition question types posttest mean scores show the following results: start equals 91%, unknown equals 85%, and result equals 89%. All three types of questions had a mean score above the 80th percentile, which would indicate mastery of the skill. The percentage of increase for start unknown questions was 86%. Change unknown questions increased by 70%. An increase of 34% was demonstrated for result questions, but this area was initially higher than the other two due to the fact that this is the type of problem that correlates to what children usually do by combining the two given numbers in a problem. Overall, the inclusive mean scores for solving all three types of dynamic addition math word problems went from 25% on the pretest to 88% on the posttest, which is significant. Students did indeed apply the *Start-Change-Result* strategy to determine what type of unknown was in the problem so that they could apply the correct schema for solving that problem type.

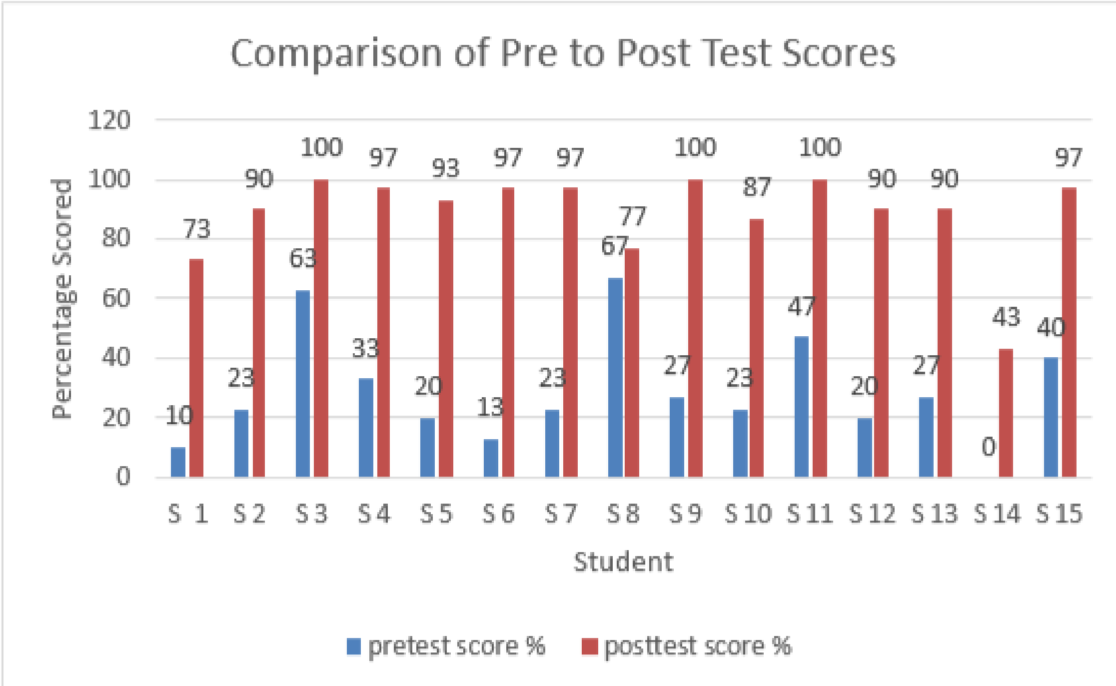


Figure 4.1. Comparison of individual student growth. This figure depicts the % of change from the pretest to posttest for each individual student.

Table 4.3. Calculated student growth % from pretest to posttest. This table calculates the percentage of change for each student from pretest to posttest and class average growth.

Calculated Student Growth % from Pretest to Posttest			
Student #	Gains	Student #	Gains
S1	63%	S9	73%
S2	67%	S10	64%
S3	37%	S11	53%
S4	64%	S12	70%
S5	73%	S13	63%
S6	84%	S14	43%
S7	74%	S15	57%
S8	10%	Class Average Growth	60%

Original scores of each student on the pretest were compared to their score on the posttest (see Figure 4.1). This bar graph shows that all 15 students increased their ability to solve accurately dynamic addition math word problems during the research study period. It was interesting to note that the student who scored the highest on the pretest showed the least amount of growth on the posttest and ended up scoring lower than 12 other students or 80% of the class.

The percentage of growth for each individual student and the average student growth for the class was calculated (see Table 4.3) The growth for each individual student is as follows: Student 1 grew 63%, Student 2 grew 67%, Student 3 grew 37%, Student 4 grew 64%, Student 5 grew 73%, Student 6 grew 84%, Student 7 grew 74%, Student 8 grew 10%, Student 9 grew 73%, Student 10 grew 64%, Student 11 grew 53%, Student 12 grew 70%, Student 13 grew 63%, Student 14 grew 43%, and Student 15 grew 57% (see Appendix V). The average percentage of growth for this group of students was 60% from pretest to posttest. The range from the lowest amount of growth at 10% to the highest amount of growth at 84% was 74%. This growth indicates that the use of the *Start-Change-Result* had a substantial impact on the ability of first-grade students to solve dynamic addition math word problems.

MAP data analysis. The students in this school take the nationally-normed MAP test in the fall and spring of each year. The researcher compared the results of the MAP math test given prior to the implementation of the study to the results of the same MAP math test given after the study (see Appendices B-E).

Based on the initial testing for first-grade MAP math, their growth results from kindergarten to first grade shown on the growth quadrant summary display that twelve students had low achievement and low growth, two students showed high achievement and low growth, and one student showed high achievement and high growth (see Appendix B). Of the fifteen students in the study, ten of them scored in the bottom quartile at initial first grade testing (see Appendix C). Growth targets are set for MAP based on students' scores. Out of the fifteen students in the class that were part of the study, only one student met their given growth target for the time period.

Data from MAP math tests that were administered after the treatment took place show a completely different set of results. The MAP math test growth quadrant summary now shows that there are only two students in the low achievement low growth quadrant and both are very close to the high growth range (see Appendix D). Additionally, there are now six students with low achievement and high growth, six students with high achievement and high growth, and one student with high achievement and low growth. When compared to their kindergarten growth, rather than one student having high growth there are now twelve of the fifteen in the high growth sections (see Appendix D). Of the fifteen students only two are still in the bottom quartile compared to the original ten. Also, there are now five students in the highest quartile where there had only been one originally (see Appendix E). Finally, based on growth targets set by MAP all but one of the fifteen students met their predicted growth target compared to only one meeting the previous year (see Appendix D).

Of course, this entire amount of growth on the nationally normed MAP math test cannot be attributed to simply implementing the *Start-Change-Result* strategy, however, when comparing the MAP results from this classroom to the two other first-grade classes in the school there are large differences in gains (see Appendix W). All three classrooms implement the districted mandated curriculum but it must be remembered that all teachers have a different skill level. The researcher/numeracy coach can attest that all three classrooms had proficient mathematics teaching taking place. Analyzing the growth of the research class, it is seen that 93.3% of the students met or exceeded the projected growth, they met 152.3 % of projected growth target, and fourteen out of fifteen students successfully met or exceeded their individual growth goals (see Table 4.4).

Table 4.4. MAP summary data by subject. This table provides data on growth targets for this nationally normed test. Information retrieved from https://teach.mapnwea.org/report/map/asgOnlineReport

Summary data by subject

	Mathematics	Reading
Percentage of Students who Met or Exceeded their Projected RIT	93.3%	46.7%
Percentage of Projected Growth Met	152.3%	95.2%
Count of Students with Growth Projection Available and Valid Beginning and Ending Term Scores	15	15
Count of Students who Met or Exceeded their Projected Growth	14	7
Median Conditional Growth Percentile	81	42

Interpretation of Quantitative Results

The researcher used descriptive statistics when analyzing pretest compared to posttest results. The number of questions out of the 450 possible answered correctly on the pretest for all question types was 113 and on the posttest the number of questions answered accurately was 398. This translates into a mean class score of 25% on the pretest and a mean class score of 88% on the posttest which represents a gain of 63%. Each individual student gained from the pretest to the posttest. Pretest percentage scores for the fifteen students were {0, 10. 13, 20, 20, 23. 23, 23, 27, 27, 33, 40, 47, 63, 67}. The median for pretest percentage scores was 23, the mode was 23, the mean was 29.07, and the range was 67 with a maximum of 67 and a minimum of 0. After the six-week treatment period, posttest percentage scores for the fifteen students were {43, 73, 77, 87, 90, 90, 90, 93, 97, 97, 97, 97, 100, 100, 100}. The median for posttest percentage scores was 93, the mode was 97, the mean was 87.73 and the range was 57 with a maximum of

100 and a minimum of 43. The difference for these statistical measures of central tendency from pretest to posttest were calculated as follows: the median went from 23% to 93%, showing a gain of 70%; the mode went from 23% to 97%, an increase of 74%; and the mean changed from 29.07% to 87.3%, a growth of 58.23%.

All of the descriptive statistics data showed that the implementation of the *Start-Change-Result* strategy in this first grade classroom had a significant impact on the ability of these students to solve accurately dynamic addition math word problems. It should be noted that the 43% was scored by Student 14 who had originally scored a 0%, this is an English Language Learner (ELL) student who receives ELL and reading intervention services. Other than Student 14, all students received a grade of C or better on the posttest whereas all students scored at a failing or D level on the pretest.

Qualitative Data Analysis

Though not as in-depth as the quantitative analysis, the researcher looked at two different types of qualitative evidence to draw conclusions about students' development of reasoning skills and attitude toward solving dynamic addition word problems. These were in the form of a short interview with each student and general observational notes collected.

Interview results. After the pretest and again after the posttest, each student was asked two questions and their results were recorded (see Table 4.5). The two questions they were asked were 1) "How did you solve these problems?" and 2) "Was there anything else that helped you?" A few times the researcher prompted using the following: "Any strategies?; Was it helpful?; and "How?" in an attempt to get additional information.

Table 4.5. Student interview responses. This table is a record of student responses to interview questions asked by the researcher.

Name	Pretest Answers	Posttest Answers
Questions asked: 1) How did you solve these problems? 2)Was there anything else that helped you? Additional researcher questions are listed in **bold**. All responses are exact quotes.		
Student 1	1) Cuz heard when I said problem. 2) Noticed that was the answer.	1) Used my head. Thunk about it-wrote it to see if I had 2+2. 2) Wrote tally marks.
Student 2	1) Count. 2) Put some in my head then count on.	1) Thinked in my brain, counting lines, small number front, big number last. 2) Think about it.
Student 3	1) Draw tallies. 2) Easy, some in my head, first one count on.	1) I solved them because counting my fingers 10 + 7. 2) Because you say some or some more. **Any strategies?** Fingers, my head.
Student 4	1) Read the story. 2) Last part found first number.	1) You read it two times 2) No response given.
Student 5	1) Looked at numbers. 2) Count them	1) Looked at it-got a few wrong. 2) I listened to you read the sentence.
Student 6	1) Looked at the number line. 2) No response given.	1) My hand, number line. 2) Start-Change-Result, write so I can understand and circle start, change, or result.
Student 7	1) Count on my fingers. 2) No response given.	1) Counted on my fingers-counted in my head. 2) Start is going or result or change.
Student 8	1) Count up on my fingers. 2) No response given.	1) Put a box, then I put the lines like you Start-Change-Result **Was it helpful?** Yes **How?** Makes it easier.
Student 9	1) Looked at #s.	1) Saw hard problems counted on my fingers.

	2) I saw the numbers and put them together, figured out the problem. (Another student passing by volunteered that, "He always gets everything right.)	2) I used Start-Change-Result to like, solve problems.
Student 10	1) Put my fingers up. 2) Take some away.	1) Start-put in my hand Change-count backwards 2) No response given
Student 11	1) Write equation. 2) Know.	1) No response given.
Student 12	1) My brain says it 8-5-8. 2) Pattern.	1) Math skills and hard working. 2) Use Start-Change-Result.
Student 13	1) Draw pictures. 2) No response given.	1) Make my brain go better. 2) No response given.
Student 14	1) By my head. 2) No response given.	1) I drew circles to count. 2) No response given
Student 15	1) Count in my head. 2) Put them together.	1) I did plusses. 2) Start-Change-Result. First some at first start not it change had to be it.

After taking the posttest, when students were asked the question, "How did you solve these problems?" only two children referenced using the *Start-Change-Result* strategy. When prompted with the question, "Was there anything else that helped you?" an additional five students made reference to using the *Start-Change-Result* strategy. So altogether only seven of the fifteen students actually referenced the use of the strategy they had been taught.

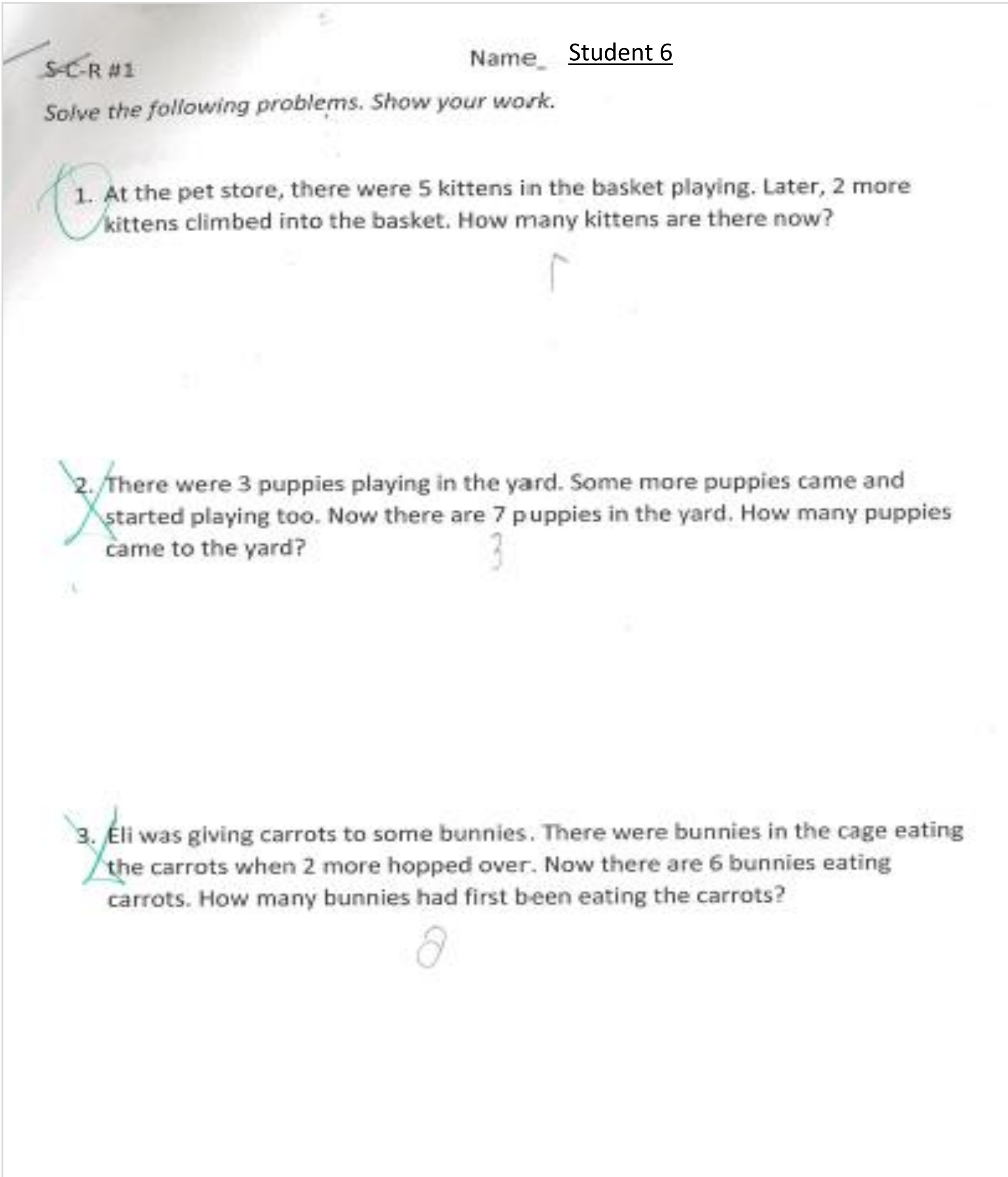
By looking at their posttest papers, the researcher saw that all of the students did indeed use the *Start-Change-Result* strategy as they solved these dynamic addition math word problems. However, as first-grade students, they do not articulate this though the words, "We are practicing using the *Start-Change-Result* strategy," was stated consistently and with very high frequency by the researcher throughout the treatment period in reference to completing the graphic organizer and deciding how to solve the problems. These students were able to successfully and independently use the schema they had developed for solving dynamic addition math word problems by completing the *Start-Change-Result* graphic organizer.

Observational data. For the pretest, thirteen of the students taking the test had nothing on their papers other than the number answer. There were no number sentences, pictures, or tally marks. Of the two remaining papers, one had written three number sentences for the thirty problems; the rest were just answers like the others. The other student had drawn squares or circles to represent the amount of the digits, but only wrote the answer. The majority of the papers did not show student thinking about the answers.

When examining their posttest papers, twelve out of fifteen students drew the *Start-Change-Result* graphic organizer that had been worked with during the treatment. Of the other three, one wrote the letters S-C-R on their paper for one of the thirty posttest questions, one wrote number sentences in which they labeled the numbers using S-C-R, and the final paper either underlined or circled the unknown in the number sentence, but there was no labeling of this unknown as a start, change, or result though the missing number matched the unknown location every time. There was also a large amount of evidence of the students reasoning the problems. For example, they circled the unknowns, drew pictures, tally marks, and other representations of the problem in addition to the *Start-Change-Result* graphic organizer. One could actually see by looking at their work on the posttest that reasoning was taking place, rather than just an answer appearing out of nowhere like on the pretest papers one saw the students had taken the time to draw a graphic organizer, fill it in with data, circle the unknown, and use some sort of marking to figure out the missing number.

As an example of this change in processing, a sample pretest for Student 6 has been included (see Figure 4.2). The example shows there is nothing but answers and only the first problem is correct due to the fact that it is a *result* problem and students typically just combine the given numbers and get this type of problem correct without actually thinking about what is happening in the question. There is no evidence of the student attempting to apply a strategy in the solving of these dynamic addition math word problems. Only having answers and not showing any type of strategy being applied to the solving of the problem is exactly how 13 out of the 15 pretest papers looked.

The posttest for the same child, Student 6, demonstrates that now some cognitive skills are taking place (see Figure 4.3). The student has drawn the *Start-Change-Result* graphic organizer. In the first two problems, Student 6 circled either the S, C, or R to show what is the missing unknown in the problem, then filled in the known numbers, and drew small circles as a strategy for arriving at the correct answer. Though the student did indeed get all the answers right on the posttest, what is even more important is that he has applied a strategy and developed a schema for recognizing problem types and is able to approach finding the solution with reasoning rather than just a guess. This is exactly what the researcher wanted to see happen as a result of implementing the *Start-Change-Result* strategy to solve dynamic addition math word problems. All students' papers at the end of the study showed this application of strategy use as they solved the problems.



S-C-R #1 Name_ Student 6

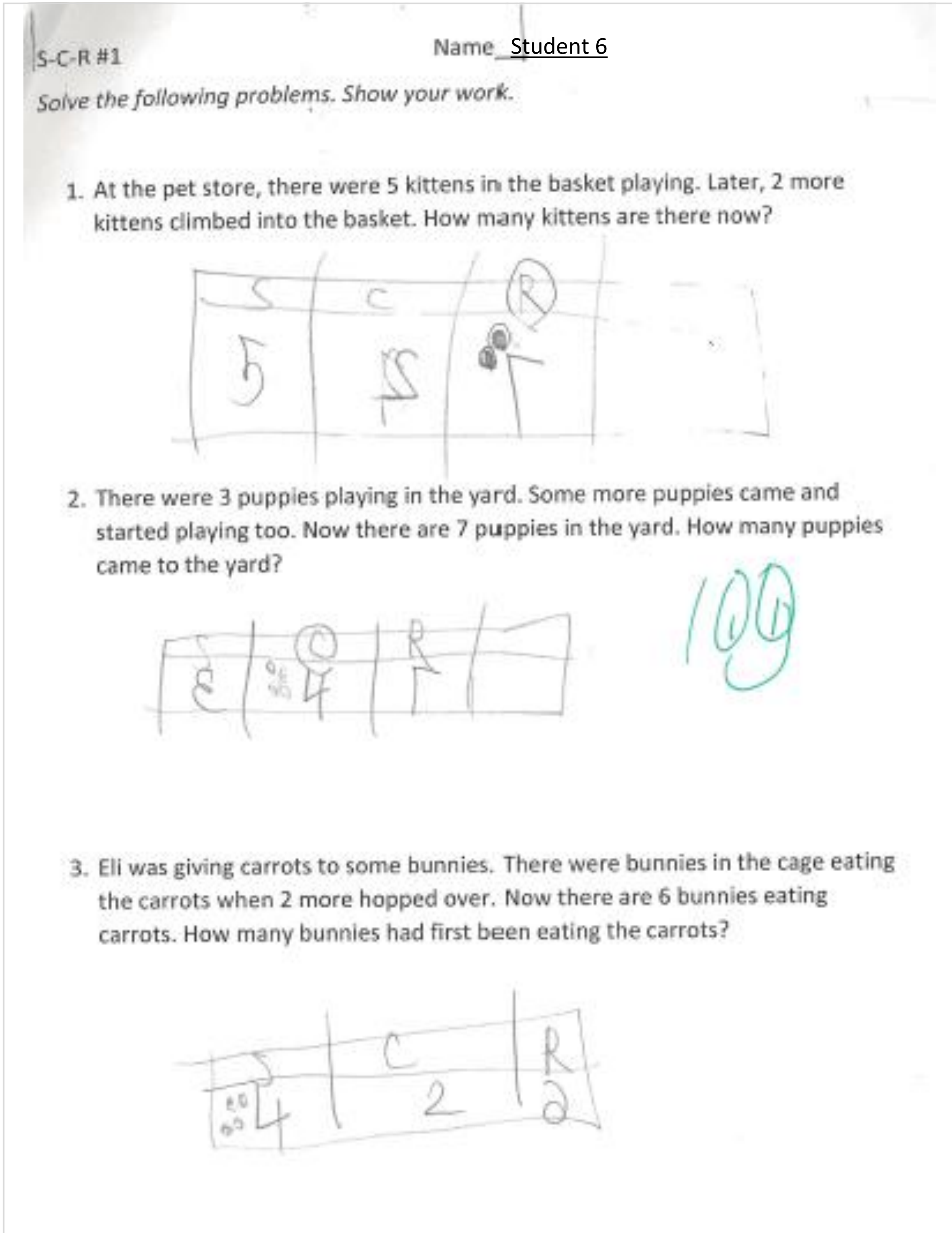
Solve the following problems. Show your work.

1. At the pet store, there were 5 kittens in the basket playing. Later, 2 more kittens climbed into the basket. How many kittens are there now?

2. There were 3 puppies playing in the yard. Some more puppies came and started playing too. Now there are 7 puppies in the yard. How many puppies came to the yard?

3. Eli was giving carrots to some bunnies. There were bunnies in the cage eating the carrots when 2 more hopped over. Now there are 6 bunnies eating carrots. How many bunnies had first been eating the carrots?

Figure 4.2. Student 6 pretest. This figure is a sample paper from the initial pretesting round.


S-C-R #1 Name_ Student 6

Solve the following problems. Show your work.

1. At the pet store, there were 5 kittens in the basket playing. Later, 2 more kittens climbed into the basket. How many kittens are there now?

2. There were 3 puppies playing in the yard. Some more puppies came and started playing too. Now there are 7 puppies in the yard. How many puppies came to the yard?

3. Eli was giving carrots to some bunnies. There were bunnies in the cage eating the carrots when 2 more hopped over. Now there are 6 bunnies eating carrots. How many bunnies had first been eating the carrots?

Figure 4.3. Student 6 posttest. This figure is a sample paper from the final round of testing after the treatment period was completed.

Additionally, the students gained a great deal of confidence about how to solve dynamic addition math word problems during the treatment period. This confidence was displayed both by the following described reactions to the teaching and by the students willingly sharing their answers and explaining their reasoning. After the first day, when it was explained that there were three different possible unknowns in each problem and shown where they fell on the graphic organizer, the students immediately began applying the principles. On the second day of teaching the treatment, when the researcher came to the room the students immediately wanted to know if they were working on the *Start-Change-Result* problems again. A challenge was made by the researcher to have students correctly identify the unknown without even trying to solve the problem. The students would hold up a sign language S, C, or R and wait for the correct answer to be announced. There was a lot of excitement about getting this part of the problem correct. Then the students would begin completing the *Start-Change-Result* graphic organizers and applying various math strategies such as counting up, using number lines, drawing tallies or circles, and hundreds grids to find the correct answer.

One day during the initial treatment week the researcher explained how they could make sure their answer was reasonable by remembering that the *result* always had to be the largest number, so if their *start* or *change* was larger, then they had to redo their computation. Applying this type of cross check was something they had never previously done. Also, the students always were interested in knowing if they had correctly solved practice problems. They were suddenly very engaged in trying to figure out the unknown and accurately answer the dynamic addition math word problems which was a huge difference over what had been previously observed when they just shouted out answers without giving any consideration to what was being asked in the question.

When these students would pass the researcher in the hall, they would make comments about *Start-Change-Result*, it was as if it was a special secret club in which they were participating. After the treatment was completed, these students would tell the researcher, "I still remember *Start-Change-Result*." For this group of students, the implementation of the *Start-Change-Result* strategy had a major impact on attitude about solving dynamic addition math word problems. The researcher recently observed in a second grade classroom and heard the teacher say, "You could use the *Start-Change-Result* forms if you want as a way to solve the problem." When asked about this, the teacher showed half sheets of paper that she had run off that had the graphic organizer that had been completed during the study when working with dynamic addition math word problems. The researcher asked where the idea came from and she shared that the after school students had told her about completing them in their first grade. Overall, the *Start-Change-Result* strategy proved to be very effective with this group of students.

Interpretation of Qualitative Results

Qualitative data collected also showed a marked increase in the students' attitude toward working with math word problems. One student stated, "I am really good at *Start-Change-Result.* Another student expressed, "I can always get them (the math word problems) right now." The students started to apply reasoning ability as they worked through problems. Going through the steps of deciding the unknown, completing the graphic organizer, solving the problem, and checking for accurateness became important to all the students in the class. This strategy met the criteria of building a schema for solving math word problems that would reduce load on their working memory capacity and allow them to be successful. The students were able to express what the missing unknown was prior to beginning the computation which was the goal of implementing this strategy. This showed that they could interpret the semantics of the question and plan an appropriate method for attack of the problem.

Conclusion

Data collected by the researcher shows that the implementation of the *Start-Change-Result* strategy had a positive impact on the ability of first-graders to accurately answer dynamic addition math word problems. Both quantitative and qualitative data indicates a marked improvement in these first-grade students' reasoning ability on how to go about solving any given dynamic addition math word problem regardless of the unknown. It was evidenced through observation and the collection of artifacts that the participants did indeed read the problem, determine what the unknown was, correctly complete the graphic organizer, and apply subject-specific strategies for finding an answer. Posttest scores show that the teaching of the *Start-Change-Result* strategy had a large impact on the ability of first-grade students to solve dynamic addition word problems accurately.

CHAPTER 5

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

In this mixed-methods research study, the researcher examined the impact on the problem of first-grade students not analyzing for the unknown in dynamic addition math word problems by implementing the *Start-Change-Result* strategy. This strategy developed schema for solving the three different types of dynamic addition math word problems in which the unknown could be the start of the problem, the change that occurred, or the result. Students learned to determine which part of the problem was the unknown, correctly complete a graphic organizer to visually represent the problem, and apply various mathematical strategies to solve the problem. Data from this study showed that the implementation of this strategy proved to be very successful at helping first-grade students accurately solve these dynamic addition math word problems.

Research Question

What impact will the *Start-Change-Result* strategy have on the ability level of first-grade students working to solve dynamic addition math word problems?

Purpose of Study

The purpose of this study was to examine the impact the *Start-Change-Result* strategy had on the ability level of first-grade students working to solve dynamic addition math word problems.

Overview/Summary of Study

Students need to develop the mathematical understanding to become twenty-first century learners. They need the ability to reason through a question and determine what has to be done to get an accurate answer. Too often this is an ability that is difficult for many students. As stated by Frawley (2014), "They are uncertain what the problem is asking and/or what the steps in solving the problem. With the increased rigor of state standards, students are expected to demonstrate what they have learned by solving word problems" (para. 2). Though this is an essential skill, it was often not effectively covered by teachers in the high-poverty setting in which this action research took place. Many elementary school teachers do not have a strong background in teaching math word problem strategies. According to Ostashevsky (2016), "What's needed is a class geared specifically to guiding teachers through problem solving from various angles and making connections between number operations, just like students are expected to do" (para.10). Therefore, this action research was centered on finding a way for teachers to provide students with a simple strategy that would not overload working memory for determining what the problem was asking and developing specific steps for solving for the appropriate unknown in dynamic addition math word problems.

This research took place in a first-grade classroom over a period of eight weeks with the school's numeracy coach acting as researcher. The first and last week were used to administer a pretest and then a posttest. During the second week of the study, the researcher introduced the students to the *Start-Change-Result* strategy. During weeks three through seven, the students practiced applying the strategy to multiple problems three days a week.

At first, the lessons concentrated on teaching students how to figure out what was the unknown in the problem: the start, the change, or the result. Once the students were able to successfully decide what was the missing unknown, they used this information to complete a graphic organizer. Then they applied various mathematical strategies they had developed as prerequisite skills for solving addition problems such as counting on, drawing tallies, using a number line, or working with manipulatives. The problem never had been that the students were unable to apply methods for computation, but rather they did not analyze for the unknown prior to performing this computation so they often ended up solving for the wrong unknown and getting the wrong answer. By implementing this simple strategy, the students in the study were able to successfully analyze the problem and solve for the correct missing unknown.

Each week during the treatment period, the researcher collected and analyzed the work of the students to determine if anyone needed further instruction and to look for misunderstandings. This information guided review of the process at the beginning of each session. An example of this would be that we talked about ways to check work. Students were told that the result always has to be the largest number in the graphic organizer, so if it was seen that it is not the largest number one must go back and correct the work. Additionally, the researcher worked individually with students who were displaying difficulty applying the strategy. In the end, all students were able to take a dynamic addition math word problem and solve it using the process outlined in the *Start-Change-Result* strategy.

As shown extensively in Chapter 4, the data from pretest to posttest growth, standardized testing results, observation field notes, and interviews support the success of all the participants in this study with applying the *Start-Change-Result* strategy as they solved dynamic addition math word problems. First-grade participants in this study learned to take their time to carefully analyze the question and figure out what was the unknown in the problem. After the participants determined if they were finding the missing start, the missing change, or the missing result they appropriately completed the graphic organizer. Finally, they applied various mathematical strategies such as counting on, using manipulatives, drawing a picture, using a number line… to find an accurate answer to the problem. The *Start-Change-Result* strategy indeed provided the students with a method of attack for how to solve each type of problem which eliminated their aimlessly combining numbers without giving thought to what they were doing. In correlation with statements by Zorfass and Gray, this strategy allowed students to plan, "They make conjectures about the form and the meaning of the solution, and they plan a solution pathway rather than simply jumping into a solution attempt" (para. 2). The use of this strategy provided the support necessary for these first-grade students to answer these dynamic addition math word problems with accuracy.

The student success in this classroom using this strategy has future implications for the researcher who is the school's numeracy coach. The researcher is responsible for all teachers in the school implementing the best instructional practices for mathematics instruction. Therefore, the researcher will do further action research to determine if this is a strategy that will assist all elementary mathematics teachers in the school to do a better job of teaching math word problem solving skills to their students.

Suggestions for Future Research

The researcher conducted this action research to see if teachers could be given a simple strategy that would increase student achievement on solving math word problems. The implementation of this action research proved to have a positive effect on the ability of first-grade students to accurately solve dynamic addition math word problems, when the researcher explicitly taught them a specific schema-based strategy of how to solve this type of word problem. The data showed that their success rates were significant based on the six-week treatment period. As the school numeracy coach, several questions have emerged from this study that support further research. First, the researcher would like to know if this success could be transferable with other first-grades teachers in the school. Would all first-grade teachers be able to implement the *Start-Change-Result* strategy for solving dynamic addition math word problems in their classrooms?

Additionally, the researcher would like to present dynamic addition math word problems that contain extra numbers not needed to solve the problem to develop another level of reasoning. According to Shannon (2007) students are often mislead by extraneous information in a problem so they focus on the wrong numbers and make errors. Therefore, the next research step would be to determine if the use of the *Start-Change-Result* strategy could help develop additional critical thinking skills by eliminating extraneous information in the process of analyzing the problem. Students would need to evaluate problems to recognize if there was any information that was not needed to solve the question being asked prior to completing the *Start-Change-Result* graphic organizer.

Future research studies of the use of this strategy would not only have to be conducted in other first-grade classrooms but also at other grade levels. In addition to determining if the success of this action research could be replicated with other first-grade classrooms, the researcher wants to see if the use of the *Start-Change-Result* strategy proves to be useful for other grade levels with the other mathematical operations of subtraction, multiplication, and division. Would this strategy have an impact on these students analyzing for the unknown in their word problems? Would they eventually be able to differentiate the needed operation, as well as, the unknown? This idea opens up a plethora of future research ideas for this researcher who is the school numeracy coach.

Finally, the results if favorable would have to be translated into providing effective professional development. All mathematics teachers within Sammy Seagull Elementary School would learn to use the *Start-Change-Result* strategy and implement this type of direct instruction on the use of a specific schema-based strategy for analyzing the unknown in various types of math word problems in their own classrooms. This could be an initial step in developing all students to become successful twenty-first century problem solvers.

Implementation of the *Start-Change-Result* strategy in this action research to develop mathematical thinking in first-grade students proved to be successful in increasing their ability to solve dynamic addition math word problems. Mertler (2014) outlined the steps in the action plan that included how the research results will be used and what else will be done based on these findings. As part of the plan, Mertler (2014) says the "researcher summarizes the results of the study, creates a strategy for sharing the results, and reflects on the entire process" (p.30). From this point, the researcher would like to follow the outlined steps in an action plan based on reflections of the study.

Action Plan

After reflecting on the positive implications from the study and thinking about future research questions, the researcher has developed an action plan. These steps detail what the researcher will do to include the instruction of the *Start-Change-Result* strategy in instruction for other first-grade classrooms, share findings with other math instructors, and conduct additional research based on the other questions that emerged upon reflection.

Action step one: Focus on further instruction. The first step would be to replicate the study with other classrooms of first-grade students with a different instructor to see if the same results were obtained. This would help to determine if the *Start-Change-Resul*t strategy was the major contributor to the student growth versus the instructor's teaching practices. Initially, the classroom teacher of the students that participated in the current study would implement this strategy independently next year with a new group of students to see if the data from the new study shows the same results. Additionally, the researcher would have the other first-grade classrooms implement this schema-based strategy in their classrooms, after they had received instruction on the process from the researcher.

Action step two: Focus on professional development. Next, the researcher will provide instruction and modeling of the implementation of the *Start-Change-Result* strategy in weekly professional development sessions. Then the teachers would be expected to go back to their classrooms and implement this strategy in their individual classrooms. Each week, they would return with student work and discuss implications from their observations and data. If additional teachers at Sammy Seagull Elementary are successful with the implementation of the *Start-Change-Result* strategy to develop math word problem solving skills, the researcher will present the findings to other numeracy coaches throughout the district at a coaches' meeting. Thus, this study could have a wide-spread influence by providing elementary teachers with a simple, subject-specific strategy to get their students to begin to analyze math word problems.

Action step three: Focus on future research. Finally, the researcher would focus on answering some of the additional questions that arose based on the initial study. First, the researcher wants to introduce extraneous information to the math word problems. After first-grade students have mastered the use of the *Start-Change-Result* strategy for solving dynamic addition math problems, the researcher would like to evaluate their ability to deal with extraneous information within the problem. Would the students be able to complete the graphic organizer for the specific unknown and eliminate the unneeded information in the problem? The researcher would have to model the process of thinking through what information is needed and getting rid of the extra information in each problem prior to completing the graphic organizer.

Then the next step would be for the researcher to introduce the *Start-Change-Result* strategy to other grade levels using different operations to determine if implementing this schema-based strategy at other levels with other operations will also have a positive impact on the ability of these students to solve math word problems accurately. To this end, the researcher would like to have second-grade students try it with subtraction math word problems, third-grade students use it to solve multiplication math word problems, and fourth and fifth-grade students try it with division math word problems. Eventually, the researcher would like to know if by using this strategy, students could not only determine the unknown in a problem, but also select the appropriate operation to use for a set of mixed-operation problems.

Conclusion

This study focused on the implementation of a schema-based instructional strategy by first graders from a poverty setting to solve dynamic addition math word problems. The question that was being answered was would the application of the *Start-Change-Result* strategy allow these students to analyze the problem being asked in order to find an accurate answer. The selected strategy was simple enough not to overload working memory, which is sometimes a problem for students when applying a strategy to solve math word problems. However, at the same time the strategy allowed students to develop understanding of the semantics of a problem to determine which unknown they needed to find. Additionally, this strategy applied the use of a graphic organizer to visually represent the problem, which is helpful in finding accurate answers to math word problems.

Initially, teachers would model the process and provide the students with an instructional strategy to analyze how to determine the unknown solution they were being asked to find and apply an appropriate method to arrive at an accurate solution. Zorfass and Gray (2014) support the need for teachers to explicitly teach a problem solving process, "For many students who struggle with mathematics, word problems are just a jumble of words and numbers. However, you can help students make sense of these problems by teaching them problem-solving processes" (para. 1). Literature showed that many teachers were uncomfortable teaching how to solve math word problems and expressed a need to be given specific strategies to teach their students. Arrighi and Maume (2007), felt that teachers having the knowledge base to plan for instruction, constructed on a careful assessment of problem types and strategies students use to solve them, would lead to higher levels of student achievement. The application of the *Start-Change-Result* strategy would meet this need.

Based on all the data gathered from the student-participants, the researcher determined the results of the implementation of the *Start-Change-Result* strategy for solving dynamic addition math word problems were significant. The results of this action research showed that implementing a specific schema-based strategy did markedly improve the ability of the first-graders in this study to solve dynamic addition math word problems accurately. Presenting them with a specific strategy to determine what was the unknown in a problem gave them a concrete way to go about solving the problem. In this study it was shown that the *Start-Change-Result* strategy was simple enough to use and did not put an overload on working memory of the participating students. The graphic organizer that the students completed helped them to visually organize the information and allowed them to successfully approach finding a solution. All students at the end of the strategy-implementation cycle were able to apply the appropriate schema for finding the unknown in the problem regardless of if it was the start, the change, or the result with accuracy.

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APPENDIX A

START-CHANGE-RESULT STRATEGY INFORMATION

Common Addition and Subtraction Situations

	Result Unknown	**Change Unknown**	**Start Unknown**
Add To	Two bunnies sat on the grass. Three more bunnies hopped there. How many bunnies are on the grass now? **2 + 3 = ?**	Two bunnies were sitting on the grass. Some more bunnies hopped there. Then there were five bunnies. How many bunnies hopped over to the first two? **2 + ? = 5**	Some bunnies were sitting on the grass. Three more bunnies hopped there. Then there were five bunnies. How many bunnies were on the grass before? **? + 3 = 5**
Take From	Five apples were on the table. I ate two apples. How many apples are on the table now? **5 – 2 = ?**	Five apples were on the table. I ate some apples. Then there were three apples. How many apples did I eat? **5 – ? = 3**	Some apples were on the table. I ate two apples. Then there were three apples. How many apples were on the table before? **? – 2 = 3**

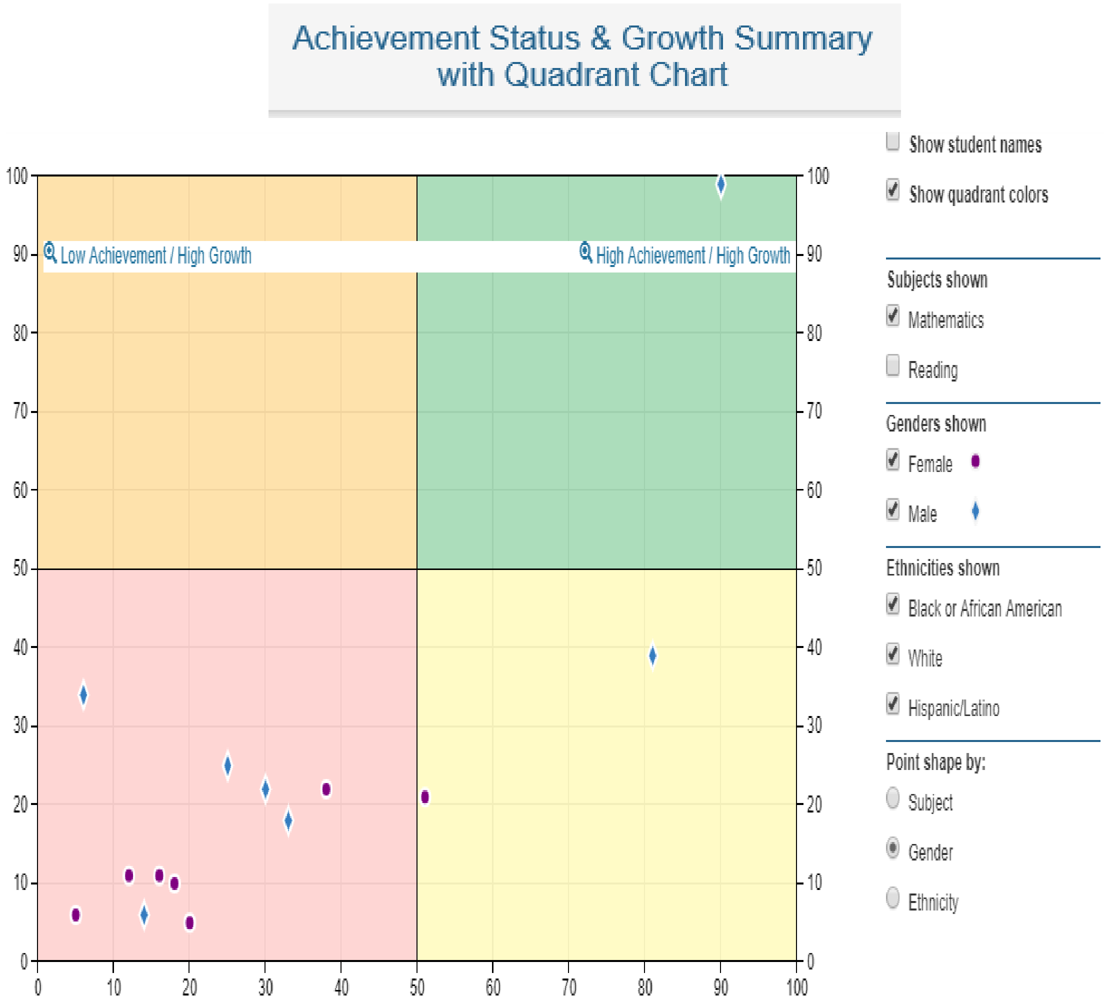
	Total Unknown	**Addend Unknown**	**Both Addends Unknown**
Put Together/ Take Apart	Three red apples and two green apples are on the table. How many apples are on the table? **3 + 2 = ?**	Five apples are on the table. Three are red and the rest are green. How many apples are green? **3 + ? = 5, 5 – 3 = ?**	Grandma has five flowers. How many can she put in her red vase and how many in her blue vase? **5 = 0 + 5, 5 = 5 + 0** **5 = 1 + 4, 5 = 4 + 1** **5 = 2 + 3, 5 = 3 + 2**

Compare	("How many more?" version): Lucy has two apples. Julie has five apples. How many more apples does Julie have than Lucy? ("How many fewer?" version): Lucy has two apples. Julie has five apples. How many fewer apples does Lucy have than Julie? **2 + ? = 5, 5 – 2 = ?**	(Version with "more"): Julie has three more apples than Lucy. Lucy has two apples. How many apples does Julie have? (Version with "fewer"): Lucy has 3 fewer apples than Julie. Lucy has two apples. How many apples does Julie have? **2 + 3 = ?, 3 + 2 = ?**	(Version with "more"): Julie has three more apples than Lucy. Julie has five apples. How many apples does Lucy have? (Version with "fewer"): Lucy has 3 fewer apples than Julie. Julie has five apples. How many apples does Lucy have? **5 – 3 = ?, ? + 3 = 5**

Common Core State Standards for Mathematics. (2010). National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington, D.C., p. 88.

APPENDIX B

MATHEMATIC QUADRANT GROWTH SUMMARY (PRETREATMENT)



One female student did not have a qualifying score from the previous year, however, she scored at the 4th percentile. She too would fall in the pink range of low achievement/ low growth.

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APPENDIX C

MAP MATH DATA (PRETREATMENT)

	Achievement Status				Growth					
					Student					
	RIT Range (+/- SEM)	Percentile Range (+/- SE)	RIT Range (+/- SEM)	Percentile Range (+/- SE)	Projected RIT	Projected Growth	Observed Growth	Observed Growth SE	Growth Index	Met Projected Growth
Student 2	***	***	135-**138**-141	2-**4**-6						
Student 5	135-**138**-141	41-**49**-56	152-**155**-158	25-**33**-41	162	24	17	4.1	-7	No
Student 12	136-**139**-142	44-**51**-59	154-**157**-160	30-**38**-47	163	24	18	4	-6	No
Student 9	127-**130**-133	23-**29**-36	174-**177**-180	85-**90**-93	157	27	47	4.1	20	Yes
Student 7	136-**139**-142	44-**51**-59	147-**150**-153	14-**20**-27	163	24	11	4.1	-13	No
Student 8	124-**127**-130	17-**23**-29	137-**140**-143	3-**5**-8	154	27	13	4.1	-14	No
Student 11	128-**131**-134	25-**31**-38	149-**152**-155	18-**25**-32	157	26	21	4.1	-5	No
Student 6	132-**135**-138	34-**41**-48	151-**154**-157	23-**30**-38	160	25	19	4.1	-6	No
Student 4	131-**134**-137	31-**38**-46	144-**147**-150	10-**14**-20	160	26	13	4.2	-13	No
Student 13	110-**113**-116	3-**5**-7	138-**141**-144	4-**6**-9	144	31	28	4.1	-3	No÷
Student 10	129-**132**-135	27-**34**-41	145-**148**-151	11-**16**-22	158	26	16	4.2	-10	No
Student 14	120-**123**-126	11-**15**-20	136-**139**-142	3-**5**-7	152	29	16	4.1	-13	No
Student 1	131-**134**-137	31-**38**-46	146-**149**-152	13-**18**-25	160	26	15	4.2	-11	No
Student 15	126-**129**-132	21-**27**-33	143-**146**-149	9-**12**-18	156	27	17	4	-10	No
Student 3	151-**154**-157	80-**85**-89	169-**172**-175	74-**81**-86	174	20	18	4.1	-2	No÷

Data on all 15 students (names have been removed). Colored squares depict where they fall on the achievement summary and growth summary quadrant chart.

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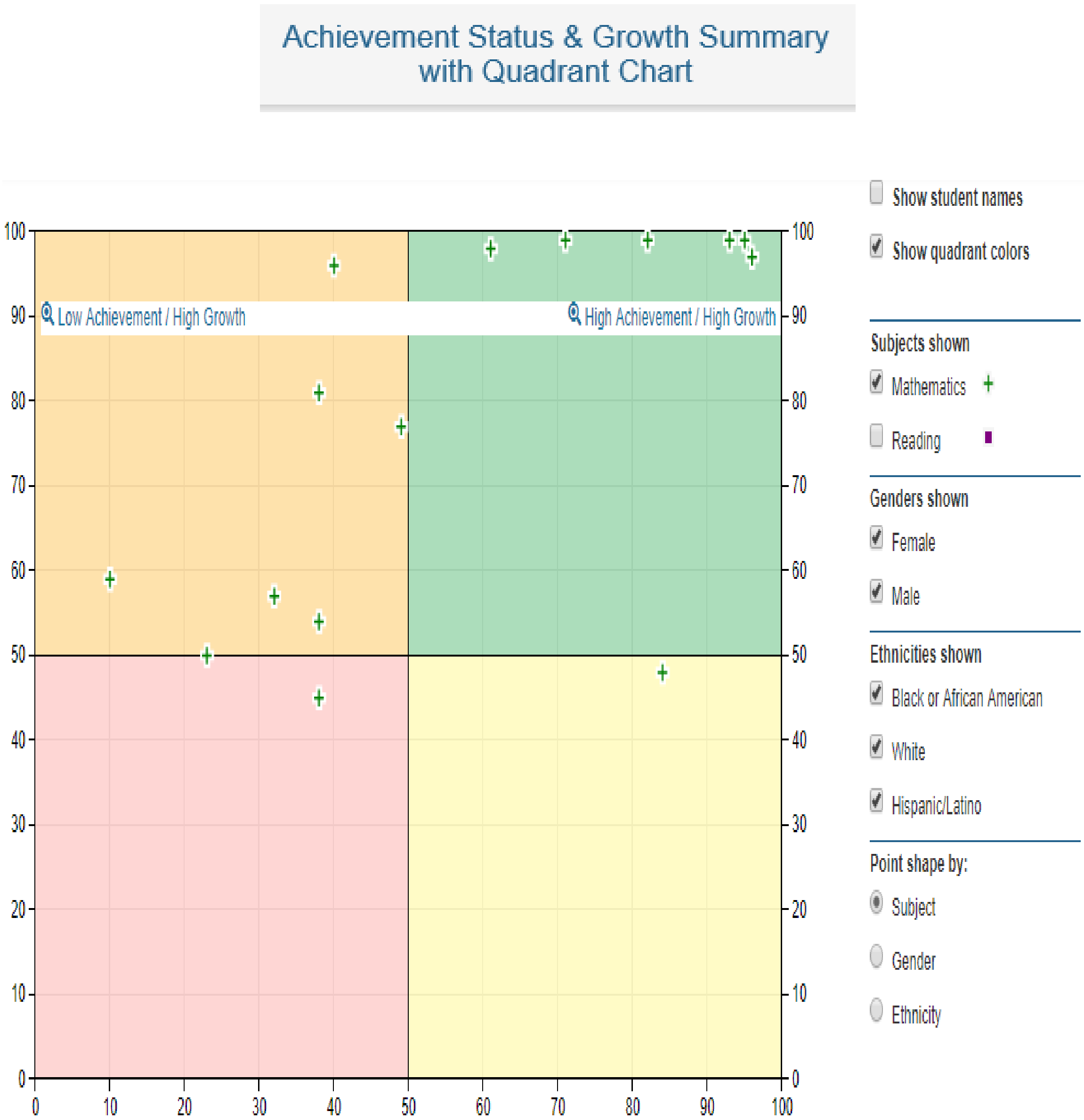
APPENDIX D

MATHEMATIC QUADRANT GROWTH SUMMARY (POSTTREATMENT)



Retrieved from https://teach.mapnwea.org/report/map/asgOnlineReport

APPENDIX E

MAP MATH DATA (POSTTREATMENT)

	Achievement Status				Growth					
					Student					
	RIT Range (+/- SEM)	Percentile Range (+/- SE)	RIT Range (+/- SEM)	Percentile Range (+/- SE)	Projected RIT	Projected Growth	Observed Growth	Observed Growth SE	Growth Index	Met Projected Growth
Student 2	135-138-141	2-4-6	191-194-197	76-82-87	161	23	56	4.2	33	Yes
Student 5	152-155-158	25-33-41	174-177-180	30-38-46	176	21	22	4.1	1	Yes‡
Student 12	154-157-160	30-38-47	174-177-180	30-38-46	178	21	20	4	-1	No‡
Student 9	174-177-180	85-90-93	192-195-198	78-84-89	195	18	18	4.1	0	Yes‡
Student 7	147-150-153	14-20-27	186-189-192	63-71-78	172	22	39	4.2	17	Yes
Student 8	149-152-155	18-25-32	172-175-178	25-32-41	174	22	23	4.2	1	Yes‡
Student 11	151-154-157	23-30-38	178-181-184	41-49-57	175	21	27	4.1	6	Yes
Student 6	144-147-150	10-14-20	182-185-188	52-61-68	169	22	38	4.2	16	Yes
Student 4	158-161-164	41-51-60	199-202-205	90-93-96	181	20	41	4.2	21	Yes
Student 13	138-141-144	4-6-9	175-178-181	32-40-49	164	23	37	4.2	14	Yes
Student 10	145-148-151	11-16-22	174-177-180	30-38-46	170	22	29	4.2	7	Yes
Student 14	136-139-142	3-5-7	161-164-167	7-10-15	162	23	25	4.1	2	Yes‡
Student 1	146-149-152	13-18-25	168-171-174	16-23-30	171	22	22	4.3	0	Yes‡
Student 15	143-146-149	9-12-18	200-204-208	92-95-97	168	22	58	4.5	36	Yes
Student 3	169-172-175	74-81-86	203-206-209	94-96-98	191	19	34	4.1	15	Yes

Retrieved from https://teach.mapnwea.org/report/map/asgOnlineReport

APPENDIX F

PERMISSION TO PARTICIPATE FORM

Beaufort Elementary

1800 Prince Street

Beaufort, SC 29902

Dear Parent or Guardian,

My name is Deborah Smith and I am working on my earning my doctoral degree from the University of South Carolina. As part of my final dissertation, I must present an action research project. Your child's classroom will be participating in this project with me as I teach them to use a specific strategy to solve dynamic addition word problems. This is the same type of intervention that takes place in the school on a daily basis in order to try to increase student achievement. Everything about your child will be kept anonymous. However, I want to obtain your permission so that I might use work samples or quotes that your child gives me in my final published paper. If you have any questions about what this entails, please feel free to call me at (843) 322-2710.

Sincerely,

Deborah Smith

PERMISSION GRANTED FOR THE USE REQUESTED ABOVE:

___________________________________ ___________________________________

Parent or Guardian Signature Please Print Name Here

APPENDIX G

START-CHANGE-RESULT #1

S-C-R #1 Name______________________

Solve the following problems. Show your work.

1. At the pet store, there were 5 kittens in the basket playing. Later, 2 more kittens climbed into the basket. How many kittens are there now?

2. There were 3 puppies playing in the yard. Some more puppies came and started playing too. Now there are 7 puppies in the yard. How many puppies came to the yard?

3. Eli was giving carrots to some bunnies. There were bunnies in the cage eating the carrots when 2 more hopped over. Now there are 6 bunnies eating carrots. How many bunnies had first been eating the carrots?

APPENDIX H

START-CHANGE-RESULT #2

S-C-R #2 Name______________________

Solve the following problems. Show your work.

1. When I was at the zoo, the first time I looked in the zebra area I saw 3 zebras. When I went by again, I saw 6 zebras. How many zebras came to the area since I first looked?

2. At the zoo there were 6 penguins standing on a rock. Then 3 more penguins jumped up on the rock. How many penguins are on the rock now?

3. At the zoo, there were 5 monkeys swinging from branches making a lot of noise. I saw some more monkeys climb into the branches. Now there are 9 monkeys in the branches making noise. How many more monkeys climbed the branches?

APPENDIX I

START-CHANGE-RESULT #3

S-C-R #3 Name______________________

Solve the following problems. Show your work.

1. Mom took the kids to the store to buy school supplies. Molly picked out some erasers. Then she saw some others she liked so she picked out 3 more. Now she has 8 erasers. How many did she pick out at first?

2. Eli was getting pencils. He found 5 black pencils in a drawer. Then he looked in a box and found some more. Now he has 7 pencils. How many did he find in the box?

3. Anna was looking for red notebooks. She found 4 red notebooks. Her mom gave her some more. Now she has 6 notebooks. How many notebooks did her mom give her?

APPENDIX J

START-CHANGE-RESULT #4

S-C-R #4 Name______________________

Solve the following problems. Show your work.

1. Brittany was watching the kids playing in the pool. She saw Eli pick up 4 rings from the bottom of the pool. Then she saw him pick up 6 more. How many total rings did Eli pick up?

2. Molly was practicing doing cannon balls. She did some before her mom called her to get the dog. Then she did 5 more. Molly did 7 cannon balls in all at the pool. How many had she done before her mom called her?

3. Anna was swimming laps. She did some laps then rested for a while. Then she swam 3 more laps. She ended up doing a total of 9 laps. How many did she do before she rested?

APPENDIX K

START-CHANGE-RESULT #5

S-C-R #5 Name______________________

Solve the following problems. Show your work.

1. The Smiths were having a cookout. The kids were toasting marshmallows. They toasted 3 and ate them right away. Then they toasted 4 more and made s'mores with them. How many marshmallows did the kids toast?

2. Brittany was putting pickles out of the jar on a plate for the cook out. She put some pickles on the plate when the dog knocked it to the floor. Then she put 4 more pickles out of the jar on a new plate. She used 6 pickles out of the jar. How many had been on the plate before the dog knocked it down?

3. Harry was cooking meat on the grill. He had 4 hamburgers on the grill. Then he added 3 hot dogs to the grill. How many pieces of meat did Harry have on the grill?

APPENDIX L

START-CHANGE-RESULT #6

S-C-R #6 Name______________________

Solve the following problems. Show your work.

1. Everyone was so excited because they were going to a rodeo. As soon as they arrived they saw a man selling arrowheads. Molly bought 3 arrow heads then went into the barn to see the horses. When she came out, she bought 5 more arrowheads. How many arrowheads did Molly have?

2. Anna counted the sheep in the pen. Then a cowboy put 2 more in the pen. Now there are 7 sheep in the pen. How many did Anna first count?

3. Eli was watching the clown make balloon animals. He saw him make 5 poodle dogs. Then he watched him make some other animals. Eli had seen the clown make 10 animals in all. How many other animals did he make?

APPENDIX M

START-CHANGE-RESULT #7

S-C-R #7 Name____________________

Solve the following problems. Show your work.

1. Everyone was going to watch Anna's soccer game. They saw her team score 4 goals in the first half. When the game ended, Anna's team had scored 5 goals. How many goals did the team score in the second half of the game?

2. The players kept kicking the ball out of bounds. Before the second half of the game, the coach yelled at them for kicking the ball out of bounds too many times. They only kicked the ball out 3 times during the second half. The team had kicked the ball out 11 times during the entire game. How many times did they kick the ball out the first half of the game?

3. During the game the referee kept blowing his whistle when the players went off sides. He blew his whistle 3 times in the first half of the game. Then he blew it some more during the second half. When the game ended, the referee had blown his whistle a total of 9 times. How many times did he blow his whistle in the second half of the game?

APPENDIX N

START-CHANGE-RESULT #8

S-C-R #8 Name______________________

Solve the following problems. Show your work.

1. Mrs. Woods was having the students make puppets for a play. She passed out materials that they could use. She put some feathers on the table. Then she found 7 more feathers and added them to the table. There were a total of 12 feathers on the table. How many were on the table at first?

2. Mrs. Woods put some eyes out for the children to use on the puppets. She put out 4 little eyes. Then she put out some big eyes. Altogether, Mrs. Woods put out 10 eyes. How many big eyes did she put out?

3. The children were using felt squares to make the puppets. First, Mrs. Woods gave them each 3 brown squares. Then she gave them some colorful squares. When she was done passing out felt squares each child had 6 squares. How many colorful squares had she given them?

APPENDIX O

START-CHANGE-RESULT #9

S-C-R # 9 Name______________________

Solve the following problems. Show your work.

1. The children were making shoe string number lines. They finished 4 before it was time to go to recess. They made 4 more after recess. How many shoe string number lines did they make?

2. The students were putting counters out to use for math class. They put 2 blue counters in each cup. Then they put 5 red counters in each cup. How many counters were in each cup?

3. The students were going to use pieces of candy to practice their math facts. The teacher gave each student 6 pieces of candy. Then she gave them each 7 more pieces of candy. How many pieces of candy did she give them?

APPENDIX P

START-CHANGE-RESULT #10

S-C-R # 10 Name_______________________

Solve the following problems. Show your work.

1. The clown was getting ready to do his act at the party. He put some balloons in his bag. Then he found 4 more balloons and added them to the bag. He now has 11 balloons in his bag. How many did he put in the first time?

2. The clown was putting cards up his sleeve for the magic trick. He put some up his first sleeve. Then he put 5 cards up his other sleeve. He has a total of 8 cards up his sleeves. How many cards did he put up his first sleeve?

3. The clown put 8 juggling balls in his bag. Then he found 4 more and put them into his bag. How many juggling balls did he have?

APPENDIX Q
ADDITION FACTS

Addition Facts Quiz

Name______________________

1) 5 + 7 =

2) 5 + 1 =

3) 2 + 3 =

4) 3 + 3 =

5) 7 + 2 =

6) 8 + 1 =

7) 2 + 0 =

8) 3 + 7 =

9) 4 + 7 =

10) 6 + 3 =

11) 5 + 4 =

12) 2 + 6 =

13) 0 + 5 =

14) 3 + 0 =

15) 9 + 9 =

16) 6 + 9 =

17) 4 + 3 =

18) 4 + 5 =

19) 6 + 8 =

20) 4 + 7 =

APPENDIX R

MISSING ADDENDS

Missing Addends Quiz Name______________________

1) ___ + 10 = 14

2) ___ + 7 = 14

3) 1 + ___ = 4

4) ___ + 7 = 12

5) 4 + ___ = 4

6) ___ + 4 = 6

7) 10 + ___ = 14

8) 3 + ___ = 4

9) ___ + 9 = 10

10) ___ + 10 = 19

11) ___ + 4 = 13

12) 4 + ___ = 11

13) 10 + ___ = 18

14) 0 + ___ = 6

15) ___ + 8 = 10

16) 8 + ___ = 16

17) 2 + ___ = 3

18) ___ + 5 = 10

19) 5 + ___ = 15

20) ___ + 0 = 10

APPENDIX S

DATA CHART (BLANK)

Student	1-1	1-2	1-3	2-1	2-2	2-3	3-1	3-2	3-3	4-1	4-2	4-3	5-1	5-2	5-3	6-1	6-2	6-3	7-1	7-2	7-3	8-1	8-2	8-3	9-1	9-2	9-3	10-1	10-2	10-3	%
1																															
2																															
3																															
4																															
5																															
6																															
7																															
8																															
9																															
10																															
11																															
12																															
13																															
14																															
15																															
#correct																															

Start Change Result

APPENDIX T

DATA CHART (PRETEST)

Student	1-1	1-2	1-3	2-1	2-2	2-3	3-1	3-2	3-3	4-1	4-2	4-3	5-1	5-2	5-3	6-1	6-2	6-3	7-1	7-2	7-3	8-1	8-2	8-3	9-1	9-2	9-3	10-1	10-2	10-3	%
1	x	x	x	1	x	x	x	x	x	x	x	x	x	x	x	x	x	1	x	x	x	x	x	1	x	x	x	x	X	x	10
2	1	x	x	x	1	x	x	x	x	x	x	x	1	x	1	1	x	x	x	x	x	x	x	x	1	1	x	x	X	X	23
3	1	x	x	1	1	1	1	x	1	1	1	x	1	x	1	1	x	1	x	x	x	x	x	1	1	1	1	1	1	1	63
4	1	x	x	x	1	x	x	x	x	1	x	x	1	x	1	1	x	x	x	x	x	x	x	x	1	1	1	X	X	1	33
5	x	x	x	1	x	x	x	x	x	x	x	x	x	x	1	1	x	x	x	x	x	x	x	x	x	1	1	X	X	1	20
6	1	x	x	1	x	x	x	x	x	x	x	x	x	x	x	x	x	1	x	x	x	1	x	x	x	x	x	X	X	X	13
7	1	x	x	1	1	x	x	x	x	1	x	x	x	x	1	x	x	1	x	x	x	x	x	x	x	x	1	X	X	X	23
8	1	x	x	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	X	X	67
9	1	x	x	x	1	x	x	x	x	x	x	x	1	x	x	1	x	1	x	x	x	x	x	x	1	1	1	X	X	X	27
10	x	1	1	x	x	x	x	1	x	x	x	x	1	x	x	1	x	x	x	x	x	x	x	x	1	1	x	X	X	X	23
11	1	x	x	1	1	x	1	x	1	1	1	x	1	x	1	1	x	1	x	x	x	x	x	x	1	1	x	X	X	1	47
12	1	x	x	x	1	x	x	x	x	X	X	X	1	x	x	x	x	x	x	x	x	x	x	1	X	1	1	X	X	X	20
13	x	x	x	1	x	x	x	x	x	1	x	x	1	x	1	1	x	x	x	x	x	x	x	x	1	1	1	X	X	1	27
14	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	X	X	0
15	1	x	x	1	1	x	x	x	x	1	x	x	1	x	1	1	x	x	x	x	x	1	x	x	1	1	1	X	X	1	40
#correct	10	1	1	9	8	1	2	1	2	6	2	0	9	0	8	9	0	6	0	0	0	2	0	3	8	10	8	1	0	6	25

Start   Change   Result

APPENDIX U

DATA CHART (POSTTEST)

Name	1-1	1-2	1-3	2-1	2-2	2-3	3-1	3-2	3-3	4-1	4-2	4-3	5-1	5-2	5-3	6-1	6-2	6-3	7-1	7-2	7-3	8-1	8-2	8-3	9-1	9-2	9-3	10-1	10-2	10-3	%
1	1	1	1	x	x	x	1	1	1	x	1	1	1	1	X	1	1	1	1	1	1	x	1	1	1	x	X	1	1	1	73
2	1	x	1	1	x	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	X	1	1	1	90
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100
4	1	1	1	x	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	97
5	1	1	1	x	1	1	X	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	93
6	1	1	1	x	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	97
7	1	1	1	x	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	97
8	1	x	1	x	1	x	X	x	X	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	X	1	1	1	77
9	1	1	1	x	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100
10	1	1	1	x	x	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	x	1	1	X	1	1	1	87
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	x	1	X	X	1	1	1	90
13	1	1	x	x	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	x	1	1	1	1	1	90
14	1	1	x	x	x	x	1		X1	x	X	X	1	X	1	1	X	X	1	1	1	x	X	x	1	1	1	X	X	x	43
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	X	1	1	1	1	1	1	1	1	1	1	1	1	1	97
# correct	15	13	13	5	11	12	13	13	14	13	14	14	15	14	14	15	13	14	15	15	15	13	14	12	14	13	10	14	14	14	88

Start — Change — Result

APPENDIX V

PRE- TO POSTTEST PERCENTAGE GAINED BY STUDENT

Student	Pretest	Posttest	Percentage Gained
1	10	73	+63
2	23	90	+67
3	63	100	+37
4	33	97	+64
5	20	93	+73
6	13	97	+84
7	23	97	+74
8	67	77	+10
9	27	100	+73
10	23	87	+64
11	47	100	+53
12	20	90	+70
13	27	90	+63
14	0	43	+43
15	40	97	+57
Total Average	25	88	+63

APPENDIX W

MAP MATH GROWTH COMPARISON OF ALL FIRST GRADE CLASSES

Summary data by subject

Research Class

	Mathematics	Reading
Percentage of Students who Met or Exceeded their Projected RIT	93.3%	46.7%
Percentage of Projected Growth Met	152.3%	95.2%
Count of Students with Growth Projection Available and Valid Beginning and Ending Term Scores	15	15
Count of Students who Met or Exceeded their Projected Growth	14	7
Median Conditional Growth Percentile	81	42

Summary data by subject

Comparison Class #1

	Mathematics	Reading
Percentage of Students who Met or Exceeded their Projected RIT	9.1%	9.1%
Percentage of Projected Growth Met	73.6%	42.3%
Count of Students with Growth Projection Available and Valid Beginning and Ending Term Scores	11	11
Count of Students who Met or Exceeded their Projected Growth	1	1
Median Conditional Growth Percentile	27	6

Summary data by subject

Comparison Class #2

	Mathematics	Reading
Percentage of Students who Met or Exceeded their Projected RIT	57.1%	71.4%
Percentage of Projected Growth Met	104.7%	109.3%
Count of Students with Growth Projection Available and Valid Beginning and Ending Term Scores	14	14
Count of Students who Met or Exceeded their Projected Growth	8	10
Median Conditional Growth Percentile	57	66