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Problem-Solving In An Early Childhood Mathematics Classroom

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PROBLEM-SOLVING IN AN EARLY CHILDHOOD MATHEMATICS
CLASSROOM

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DEDICATION

This dissertation is dedicated to my family. The value of education was instilled in me by my parents. From childhood, I have felt an undying support from my parents in more ways than I can count and I am beyond thankful for their guidance throughout my life. Words cannot express my gratitude for the counsel of my mom whenever needed. She has been there for me every step of every way. I am also grateful for my dad's support in this adventure but, most importantly, the comfort of knowing there is someone who thinks just like me. I would also like to dedicate this dissertation to my loving husband, Adam. I am thankful for his listening ear, patience, and helping hands that granted me the time and patience to develop this dissertation. I am in awe of the calmness of both my husband and mother and thankful to have their collected spirits to rationalize everything during this experience. The support of my husband and parents guided me through life with a sense of strength that comes from knowing I am not alone in striving for my goals and dreams. I also would like to dedicate this to my four-legged family members that made the long hours of writing bearable: Bo and Fraiser. Their quiet company provided a strength when working past my limits. Finally, this dissertation would not be possible without my school family. I am thankful for supportive teammates, parents, students, and an encouraging principal. My love for education grows every day in such a wonderful learning environment.

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ABSTRACT

Problem-solving occurs when mathematical tasks create opportunities that provide challenges for increasing students' mathematical understanding and development. This research study determined the influence of the *launch-explore-summarize/extend* problem-solving framework on second-grade student performance of place value tasks. The dissertation in practice measured problem-solving success. This action research study occurred at an elementary school in Columbia, South Carolina. The teacher-researcher determined appropriate problem-solving tasks and assessed students' academic achievement and critical thinking skills. Following a mixed methods action research design, the researcher analyzed qualitative and quantitative data to determine the significance of the problem-solving framework. The data indicated significant student growth during the six-week intervention.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Problem-solving is a cognitive skill that is essential to understanding all content areas in an educational setting. It requires the learner apply content knowledge to unfamiliar learning contexts. Problem-solving is the most compulsory skill in the classroom and in real world settings. Integrating problem-solving into the mathematics curriculum is essential to transferability of content knowledge. The goal of mathematics instruction is for students to develop an understanding of mathematical concepts. Over time, expectations of what defines *understanding* expanded to require updates of instructional methods. To accomplish this, teachers must develop a more comprehensive definition of the term *understanding* in a mathematics classroom to execute successful mathematical lessons.

Past researchers established numerous themes of mathematical understanding. Specifically, the National Research Council (2001) defined the five strands of mathematical proficiency: (a) adaptive reasoning; (b) strategic competence; (c) conceptual understanding; (d) productive disposition; and (e) procedural fluency. Carpenter, Fennema, Franke, Levi, and Empson (2015) highlighted four themes of mathematics classrooms through which students gain understanding. First, students develop understanding by making connections with other mathematical concepts and real-world scenarios. Second, knowledge must be generative. For knowledge to be

generative, students must be able to explain and justify their thinking (Carpenter et al., 2015). Third, teachers cannot teach in isolation; they must incorporate realistic applications of knowledge. Lastly, learners must see themselves as mathematicians with a sense of responsibility for the material they are learning. Students should be able to transfer the material they learn in the classroom to other scenarios, especially their own lives. Carpenter et al. (2015) and Battista (2012) provided guidelines for educators to plan lessons that emphasize understanding. Individually and collectively, the themes and levels of sophistication support the idea that problem-solving is essential to the development of understanding in mathematics.

Carpenter et al. (2015) outlined the levels of development for strategies that indicate understanding. Most children can use the first strategic level, direct modeling. Direct modeling strategies are those of students who can only think of one step at a time. Over time, learners replace the direct modeling strategies with counting strategies. Counting strategies work in conjunction with direct modeling strategies as students become comfortable using counting strategies. Next, students evolve their understanding by using flexible choice strategies. When students use flexible choice strategies, they analyze problems and determine the appropriate strategy for each problem. Finally, children eventually develop derived facts strategies; these strategies reflect a strong understanding of addition and subtraction beyond memorization (Carpenter et al., 2015).

Students demonstrate understanding through the ability to communicate their reasoning of mathematical concepts. In *Connected Mathematics Project*, Lappan, Phillips, Fey, and Friel (2002) stated that the goal of mathematics instruction is for students to gain enough knowledge about a skill to be able to reason and communicate

proficiently. Like Carpenter et al.'s (2015) definition of understanding, Lappan et al. (2002) defined a skill as the ability to apply knowledge, tools, and resources to make sense of problems in various situations. Students always used tools and resources to solve problems, but there were continuous gaps in their ability to make sense of problems and transfer mathematical knowledge to new situations.

Definitions of *skills* and *understandings* evolved over 40 years of cognitive research (Carpenter et al., 2015). Effective mathematics instruction involves students developing mathematical understandings that instructors foster through individual experiences with mathematical problems. Recent understandings of how children think shifted mathematical instruction from direct instruction and memorization to solving problems. In the previous form for instruction, teachers modeled how to solve problems and students mimicked the process; now, cognitively guided instruction gives students a chance to discover mathematical principals themselves (Carpenter et al., 2015). When students discover and reflect on mathematical understandings, they internalize skills and apply them to new situations. Instruction based on problem-solving reflects ideas of cognitively guided instruction (Carpenter et al., 2015).

The National Council of Teachers of Mathematics (NCTM) published *Teaching Mathematics through Problem-Solving* (Lester, 2003). The text includes issues and perspectives on problem-solving in the mathematics classroom, the role of technology, and research. The NCTM (2000) defined problem-solving as,

...engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will develop new mathematical

understandings. Solving problems is both a goal of learning mathematics and a major means of doing so. Students need frequent opportunities to formulate, grapple with, and solve complex problems that require a significant amount of effort and should then be encouraged to reflect on their thinking. (p. 52)

The NCTM (2000) promoted problem-solving as a mathematical framework; it strengthens mathematical understanding, helps memory, enhances the transfer of information, and positively influences student attitudes and autonomous learning. According to the NCTM (2000), problem-solving gives students opportunities to develop *habits of the mind*. Through problem-solving, students think about word meanings, justify their thinking, create their own perspectives, and analyze information to solve problems. The NCTM (2003) addressed the ability of young students to explore problems and develop solutions and considered ways for teachers to create rigorous and relevant problem-solving tasks.

Problem-solving promotes mathematical understanding (NCTM, 2000). Through problem-solving, students access mathematical concepts through autonomous learning. With a sense of responsibility and ownership of their learning, problem-solving increases the transfer of mathematical understandings to the real world (NCTM, 2000). Gojak (2013) created a problem-solving framework resource with a specific formula to help students build concrete mathematical understandings in early childhood. Teachers promote problem-solving through the *launch-explore-summarize/extend* framework to help students think critically about mathematical concepts. Problem-solving enables

learners to autonomously investigate mathematical understandings and gain concrete understandings that they can transfer to their daily and future lives.

1.2 Statement of the Problem of Practice

Mathematics instruction in the United States often includes explicit instruction, textbooks, procedural skills, and memorization (Lester 2003). Students often learn to solve problems by observing and mimicking direct procedural instruction using specific strategies. When problem-solving occurs in the mathematics classroom, it is typically an activity to enhance skills that students previously learned. These disconnected mathematical lessons result in a lack of critical thinking skills and a disconnection from real-world applications (Lester, 2003).

Mathematical instruction is most effective when teachers use problem-solving to teach new mathematical skills. Students need opportunities to create strategies and reflect on problem-solving methods to develop critical thinking skills (Cai & Lester, 2003). Instructors can use problem-solving to teach all mathematical standards. Data from the school and district of Cai and Lester's (2003) research indicated a need for focused instruction in number sense and base ten tasks.

The research found that in 2017, 47.9% of 3rd graders in the district SC Ready scored *low* on number sense and base ten tasks; similarly, 56% of 4th graders and 60% of 5th graders scored *low* on number sense and base ten tasks. Only 27.1% of 3rd graders in the district exhibited *high* achievement on base ten and number sense problems. Even more concerning, only 22% of 4th graders and 11% of 5th graders performed in the *high* category on number sense and base ten tasks. At this school, 21% of 3rd graders scored *low* and 20% scored *medium* on base ten problems; half of the school population was not

competent in base ten concepts (Cai & Lester, 2003). In 4th grade, 56% of students scored *low* or *medium* on number sense and base ten mathematical tasks and 76% of 5th graders scored *low* or *medium* on number sense and base ten tasks. These data demonstrated a need for better mathematical instruction, specifically regarding number sense and base ten understanding.

1.3 Research Question

The NCTM (2000) outlined four steps for successful problem-solving instruction in mathematics. According to the NCTM (2003), teachers should embed problem-solving into the curriculum so that these tasks are accessible and engaging for students. The role of the teacher is to support students in problem-solving processes by providing appropriate tools and scaffolding as students work towards solutions.

The researcher based the research question for the present study on the NCTM's (2000) steps to appropriately implement problem-solving in mathematics classrooms and selected an appropriate problem-solving framework that encompasses the four aspects of problem-solving. The *launch-explore-summarize/extend* problem-solving framework focuses on engaging and accessing problem-solving tasks; teachers use questioning to scaffold student learning. The summary of the lesson allows students to glean new information at their own level. The overarching research question of the present action research study is as follows:

What is the impact of the *launch-explore-summarize/extend* problem-solving framework on students' problem-solving success on place value tasks in a second-grade classroom?

1.4 Purpose of the Study

The purpose of the present action research study is to determine how to improve students' number sense and base ten understanding in a second-grade mathematics class by implementing the *launch-explore-summarize/extend* mathematical framework.

Number sense is the understanding of numbers and their relationships. Student develop an understanding of place value by recognizing, understanding, and applying the patterns of the base ten system (NCTM, 2000). Problem-solving may build critical thinking skills and increase mathematical understanding of place value in a second-grade class.

1.5 Theoretical Framework

The basic theories of curriculum in this action research study include progressivism, essentialism, and higher-order thinking skills. Progressivism is an approach to helping children become successful citizens that encourages curriculum that connects to real world scenarios (Dewey, 1938). Dewey (1938) believed children need opportunities to discover concepts for themselves. The basic idea of problem-solving aligns with this concept. In the present action research study, the researcher implemented a progressive mathematical framework that gave children opportunities to discover mathematical ideas for themselves through real-world situations. The role of the teacher is that of a facilitator as the students discover new knowledge.

Essentialism stresses the importance of reading, writing, and mathematics. Bagley (1938) promoted a strong focus on the basics of education in school systems and advocated for discovery and expression in the learning experience. Problem-solving is at the root of the essentialism approach. Through problem-solving, students discover mathematical understandings for themselves. Furthermore, students learn to express their

discoveries independently, in small groups, and as a whole class to develop a greater understanding of mathematical concepts as a learning community.

Lastly, higher thinking skills reflect Bloom's (1956) taxonomy for the categorization of thinking skills. Bloom (1956) believed that different types of thinking required more cognitive ability. Problem-solving requires students to have basic mathematic knowledge and requires them to analyze, evaluate, and create. Much of the importance of the *launch-explore-summarize/extend* framework is that the problems have a high cognitive demand. Problem-solving requires that students utilize all seven levels of Bloom's taxonomy, especially the higher order thinking levels of synthesis and evaluation. The problem-solving framework supports higher order thinking in mathematics. Cognitively guided instruction guides task selection and questions during the *launch, explore, summarize/extend* problem-solving framework.

1.6 Action Research Design

This action research study followed a mixed-methods research design. The researcher collected qualitative and quantitative data through place value problem-solving assessments over a period of 6 weeks and via student problem-solving journals. The researcher used a rubric to assess mathematical knowledge, strategic knowledge, and the communication skills of students (see Appendix A). The teacher-researcher collected data to determine how the problem-solving framework influenced students' mathematical knowledge of place value, strategic knowledge of problem-solving, and communication skills over time. Using a mixed-methods action research design, the researcher reviewed students' place value problem-solving ability by collecting data from problem-solving assessments and analyzing students' problem-solving journals. The study of the problem-

solving framework followed an action research cycle (Mertler, 2014) to improve mathematical instruction. Through planning, implementation, analysis, and reflection on teaching outcomes, the teacher-researcher determined the learning outcomes of implementing the *launch-explore-summarize/extend* problem-solving framework.

1.7 Significance of the Study

As a member of the district's second-grade curriculum team, the teacher-researcher is an advocate for the implementation of the *launch-explore-summarize/extend* problem-solving framework. In addition, the teacher-researcher serves as the school's early childhood math facilitator. Both positions yielded experiences that informed the teacher-researcher's goal to develop students' conceptual understandings of mathematics concepts through problem-solving. The teacher-researcher witnessed the benefits of teaching mathematics through problem-solving and the challenges educators face when implementing the *launch-explore-summarize/extend* problem-solving framework. Teachers struggled to understand how to execute the problem-solving framework in early childhood classrooms. The problem of practice is significant to this educational setting because it influences the potential positive effects of the *launch-explore-summarize/extend* problem-solving framework on students' mathematical achievement. As a district and school, standardized tests revealed a lack of understanding in place value concepts. The problem of practice demonstrated the impact of the framework on improving the teaching of place value. The significance of the study is the close examination of the problem-solving solving framework and its effectiveness in teaching place value and base ten skills to second grade students.

1.8 Limitations of the Study

Limitations of the study include the sample size and time frame. First, the study included one teacher and 22 students. Data from a larger sample of educators and students would provide more generalizable results. Second, the researcher conducted the study over a 6-week period. The data from the study is not generalizable to all second-grade early childhood mathematical students. A longer time frame for research would allow the teacher-researcher to perform a more detailed investigation of problem-solving in an early childhood mathematics classroom.

1.9 Dissertation Overview

This dissertation in practice includes five comprehensive chapters on the influence of implementing the *launch-explore-summarize/extend* problem-solving framework on place value understanding in a second-grade classroom. Chapter 2 includes literature relevant to the present action research study. Chapter 3 includes details of the action research design and implementation of the problem-solving framework. Chapter 4 includes data and results. Lastly, Chapter 5 includes a review of research findings regarding the problem-solving framework in a second-grade mathematics class.

1.10 Definition of Terms

Problem-solving: Problem-solving includes tasks and knowledge students use to ...draw on prior knowledge, employ strategies, and develop new mathematical understanding. Such tasks are thoughtfully selected, presented, and summarized so that students develop mathematical habits of mind such as persistence, curiosity, and confidence...the salutation method is not known in advance.

(NCTM, 2000, p. 52)

Communication: Communication occurs when students share and learn from their and others' mathematical thinking. (NCTM, 2000).

Connections: Connections occur when students recognize and explore the patterns within mathematical ideas and everyday life (NCTM, 2000).

Representation: Representation is when students explore and use different ways to represent their mathematical thinking. (NCTM, 2000).

Reasoning and proof: Reasoning and proof exist when students make connections and develop ideas through explanation, clarification, justification, and revision (NCTM, 2000).

Launch: Launch is “the portion of the lesson where the teacher engages students in both the context and the mathematical ideas of a task” (Markworth, McCool, & Kosiak, 2015, p. 3). The launch should last no longer than 10 minutes of the instructional time (Markworth et al., 2015).

Explore: Explore is the portion of the lesson in which students engage in problem-solving activities and the teacher asks questions, listens carefully, assesses understanding, and discusses student problem-solving strategies. During this time, students discover mathematical concepts through well-planned explorative tasks. The exploration takes up most of the instructional time (Markworth et al., 2015).

Summarize: The summarize portion of the lesson is when the teacher “engages the entire class in pulling together essential mathematical ideas” (Markworth et al., 2015, p. 5). Students explain, clarify, justify, defend, and revise their thinking in a small or whole group setting.

Extend: The extend portion of the lesson can occur in two forms. Students either engage in mathematical centers to practice essential mathematical ideas or apply essential mathematical ideas to another problem-solving task. During this portion of the lesson, the teacher can form small groups to challenge or correct misconceptions to ensure a higher understanding (Markworth et al., 2015).

Problem-solving success: Success occurs when students exhibit growth in organization of information, mathematical accuracy, or use of strategies as indicated on a problem-solving rubric (Gojak, 2013).

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

The literature review includes key concepts of the dissertation in practice. In the action research study, the teacher-researcher implemented the *launch-explore-summarize/extend* problem-solving instructional framework to strengthen student mathematical understanding of one component of number sense (i.e., place value). The problem-solving framework is a valuable instructional tool that elicits higher level thinking from students (Lappan, Phillips, Fey, & Friel, 2014). Mathematical problem-solving occurs when students complete tasks that expand prior knowledge by formulating new ideas and determining mathematical patterns (Cai & Lester, 2003). Problem-solving helps students develop a strong conceptual foundation of mathematics (Carpenter et al., 2015). Through problem-solving, students continually build a mathematical web of knowledge (Cai & Lester, 2003). Students think critically, explore mathematical ideas, and develop a better understanding of mathematical properties and relationships via rigorous problem-solving tasks (Cai & Lester, 2003). The *launch-explore-summarize/extend* problem-solving framework requires that students develop and explain mathematical strategies (Markworth et al., 2015).

There are many underlying causes of the problem of practice in this research. Direct instruction in mathematics rarely promotes understanding or transferability (Cai & Lester, 2003). Decades of past research confirmed the benefits of problem-solving

compared to traditional mathematics instruction (Cai, Moyer, Wang, & Nie, 2009). Past researchers supported the effectiveness of the *launch-explore-summarize/extend* framework (Cai et al., 2009). Problem-solving enhances students' abilities to make sense of mathematical ideas and transfer them to real world situations (Arbaugh, Lannin, Jones, & Park Rogers, 2006). Traditional mathematical instruction teaches mathematical concepts in isolation, which makes them hard to remember (Cai & Lester, 2003). Problem-solving applies mathematical ideas to help students remember the concepts (Markworth et al., 2015). Humans have natural curiosity; problem-solving engages this curiosity by linking understanding and success. In contrast, direct mathematical instruction often causes frustration if students fail to make sense of mathematical ideas. Instruction based on problem-solving relies on the natural motivation for success and knowledge rather than outside rewards required to make traditional mathematics motivating for students (Cai & Lester, 2003).

This literature review includes problem-solving literature that is relevant to the problem of practice. The research question addressed the impact of the *launch-explore-summarize/extend* problem-solving approach on place value understanding. The overarching research question of the present action research study is: What is the impact of the *launch-explore-summarize/extend* problem-solving framework on students' problem-solving success on place value tasks in a second-grade classroom? The literature review includes the history of problem-solving themes, the problem-solving framework, challenges, social justice, and the theoretical framework.

2.2 History of Problem-Solving Themes

Teachers integrated problem-solving into the mathematics curriculum decades ago (Stanic & Kilpatrick, 1988). Three themes characterize the role of problem-solving in the math curriculum: problem-solving as context, problem-solving as skill, and problem-solving as an art. According to Stanic and Kilpatrick (1988), problem-solving as context has historical subthemes. The first is *justification*. Historically, real-world problems are part of the mathematics curriculum to demonstrate the value of mathematics to teachers and students. Problem-solving tasks gain the interests of students through motivation. Through justification, teachers connect mathematics instruction with the real world. Motivation emphasizes student interests. Problem-solving can be *recreational* when instructors introduce it as a form of entertainment so that students enjoy using previously learned mathematics information (Stanic & Kilpatrick, 1988). The idea of problem-solving as recreation satisfies the need for human exploration. Problem-solving is also a *vehicle* for students to find new information through problem-solving tasks (Stanic & Kilpatrick, 1988). The problem-solving task itself is how students gain mathematical understandings. Finally, problem-solving is a *practice*. Problem-solving as a practice reinforces mathematical skills and is the most common historical subtheme in the American curriculum. After teaching skills directly, instructors used problem-solving to practice skills (Stanic & Kilpatrick, 1988).

The second historical subtheme is problem-solving as a *skill* (Stanic & Kilpatrick, 1988). Teachers teach problem-solving as a skill in isolation. Thorndike (1922) believed problem-solving was a skill that needed attention and indicated that mathematics improved students' real-world problem-solving abilities. Thorndike (1922) emphasized

the role of problem-solving in the classroom through the connection between mathematics problem-solving instruction and real-world experiences. When taught as a specific skill, problem-solving follows a trajectory by which students master tasks in order of difficulty. One weakness of this approach is that only students who master routine problem-solving tasks learn non-routine problem-solving tasks (Stanic & Kilpatrick, 1988).

Stanic and Kilpatrick (1988) stated that the third subtheme of problem-solving curricula is problem-solving as *art*. A forerunner in the thought of problem-solving as an art, Polya (1965) emphasized the need for the art of discovery in math curricula. Students gain understanding of mathematics if they understand the discovery of mathematical ideas (Polya, 1965). To develop intelligence, students must be insightful. The benefits of learning how to think about mathematics help all students, not just those who continue in mathematics careers. Polya (1965) encouraged educators to guide problem-solving strategies to develop students' problem-solving abilities. Education is an art and the key to the development of students' problem-solving abilities includes teacher sensitivity, good judgment, and mathematical insight (Stanic & Kilpatrick, 1988).

Dewey (1938) also described problem-solving as an art and emphasized the importance of reflective thinking. Dewey (1938) believed that thinking was reflection. Like Polya (1974), Dewey (1910) believed that teachers could inform students' thoughts and teach reflective thinking skills and mathematical understandings through problem-solving. Real world experience and problem-solving help impart mathematics instruction with proper educational guidance. Polya (1974) and Dewey (1938) agreed that students learn best from their own experiences and that a few well-planned problems for students

to explore and discover mathematical understandings were more important than numerous demonstrative reasoning tasks. Problem-solving as an art accentuates the importance of reflective thinking to develop understanding (Dewey, 1910).

2.3 Social Justice

Problem-solving is accessible to all students; therefore, it provides a form of social justice. Social justice is a pillar of education, including mathematics instruction. Kent and Caron (2008) discussed ways mathematics curricula can meet the diverse needs of students and suggested using student interests to engage all students. When teachers relate mathematics to authentic experiences, students access the curricular content on their own terms. Kent and Caron (2008) stated that traditional mathematics instruction creates a disconnect between the classroom and real-world mathematics application. Therefore, mathematics is only accessible for particular groups. The problem-solving framework in this action research study provides social justice by linking mathematics to real-world situations in different contexts. Students from traditional mathematics classrooms know how to compute but are often unable to problem-solve (Kent & Caron, 2008). Mathematics curricula must emphasize problem-solving and connect to the real world. Kent and Caron (2008) stated that a culturally relevant curriculum provides equity for all students by giving them “materials that challenge the status quo and provide opportunities for students to use these to critically examine the political and social order of our society” (p. 249).

2.4 Problem-Solving Framework

In 1997, the *Connected Mathematics Project* developed a mathematical curriculum to help middle school students develop mathematical understanding (Lappan

et al., 2014). Connected mathematics is problem-centered; teachers present important mathematical concepts through problem tasks. Students understand these concepts through exploration and discussion of the problems. With teacher guidance, the problem-centered curriculum encourages students to develop problem-solving strategies and mathematical ideas.

To ensure time for problem-solving, the *Connected Mathematics Project* included the *launch-explore-summarize/extend* model to facilitate exploration, conjecture, reasoning, and communication (Lappan et al., 2014). The instructional phases (launch-explore-summarize) helped educators create a problem-solving classroom environment (Lappan et al., 2014). The *Connected Mathematics* curriculum effectively builds students' conceptual understandings through problem-solving (Cai et al., 2009). Classrooms using the *Connected Mathematics* curriculum performed better on open-ended problems. For example, Eddy et al. (2008) conducted a quantitative study on the effectiveness of connected mathematics at Claremont University that supported this assertion. Similarly, Bray (2005) found that the *Connected Mathematics* curriculum was more effective when implemented over time.

In 2015, the NCTM incorporated instructional phases that the *Connected Mathematics Project* developed into its recommended framework. The *launch-explore-summarize/extend* instructional phases effectively demonstrated the evolution of mathematical instruction (Markworth et al., 2015). The NCTM (2015) suggested the framework was also relevant to early childhood and elementary education. The framework transfers the focus of mathematical instruction from teacher explanations to student explorations. Students build a strong understanding of mathematical concepts

through the activation of prior knowledge, engagement in problem-solving tasks, and summarizing of mathematical concepts (Markworth et al., 2015).

Launch. Markworth et al. (2015) identified the first step in the problem-solving framework as the *launch*. The launch is a 10-minute introduction to the problem-solving task. During this time, the teacher engages students in a problem-solving task (Carpenter et al., 2015). Through discussion, the teacher helps students understand the context of the problem by questioning students about the theme of the problem. The teacher elicits personal connections to the problem. If the teacher presents students with a problem outside of their experiences, this as an opportunity to extend their knowledge through pictures or short videos (Markworth et al., 2015). Before solving a task, students must have a clear understanding of the context of the problem (Markworth et al., 2015).

The launch helps students develop an understanding of the problem they are about to explore. Through questioning, the teacher helps students determine what they know about the problem, which may include information presented in the problem itself or the mathematical relationships within the problem. Students and teachers develop a problem-solving plan during the launch. Each student can share their plan to begin problem-solving with a partner. Ginsburg-Block and Fantuzzo (1998) conducted a randomized control trial and found that students who solve problems with partners, share with groups, and work on strategies with partners exhibit higher academic achievement on procedural posttests than students who work independently. At the end of the launch, the educator allows students to ask questions to clarify the problem-solving task. Markworth et al. (2015) noted that the teacher should not model solving a similar problem task to the class to maintain the cognitive demand of the task (Markworth et al., 2015).

Explore. The second portion of the framework outlined by Markworth et al. (2015) is *explore*. During exploration, students explore the problem-solving task. Van de Walle (2003) suggested that during this time in the lesson, the teacher must “let go” (p. 49). Markworth et al. (2015) and Van de Walle (2003) suggested that to successfully facilitate the explore portion of the lesson, teachers must critique how they help students. Teachers should assess students’ skill levels and guide them through questioning. Next, teachers listen to students’ ideas and strategies. Terwel, Van Oers, Van Dijk, and Van den Eeden (2009) found that when students generate their own visuals for word problems that involve data and analysis, rather than using a teacher’s visuals, they perform better on posttests and are better able to transfer the material. The students talk about their strategies to find a solution. Student responses help the teacher develop questions to extend student thinking. The teacher monitors the classroom to help students avoid frustration and encourage perseverance (Markworth et al., 2015).

Students complete the explore portion of the framework independently, with partners, or in small groups. Markworth et al. (2015) suggested that collaborative work ensures a higher level of success as students have more ideas about the mathematical task. Teachers must provide time for students to correct their own misunderstandings. After teachers give students a few minutes to explore, they begin to visit individual students, partners, or groups. During this time, the teacher identifies the challenges that students faced as they solved problems. The struggle of problem-solving is part of the process (Markworth et al., 2015).

Smith (2000) discovered that teachers in the United States often intervene rather than giving students a chance to struggle. When problem-solving, mistakes are valuable

opportunities to correct misconceptions, engage in mathematical discourse, and strengthen mathematical understanding. Markworth et al. (2015) encouraged teachers to write down challenges, strategies, and insights to refer to when choosing the order in which students share during the summarize portion of the lesson. By creating a reasonable order of sharing, the teacher helps students participate in productive conversations to strengthen their mathematical understanding (Markworth et al., 2015).

Summarize. Markworth et al. (2015) defined the *summarize* portion of the framework as the opportunity for collaborative mathematical discussion. The teacher facilitates conversations that emphasize the mathematical ideas in the problem. In addition to sharing strategies, students share connections between the strategies of their peers. These connections help students build generalizations about mathematical ideas and lead them to pose their own problems (Markworth et al., 2015).

Markworth et al. (2015) suggested that there are different strategies for summarizing within the problem-solving framework. There are many ways to share strategies during the summarize portion. Students explain their thinking with the whole group or through gallery walks. During a gallery walk, students walk around the classroom to observe the work of their peers. All students should have a chance to engage with others during the summary of the lesson. Students explain their thinking by sharing strategies, making connections, asking questions, or posing problems. Markworth et al. (2015) recommended that teachers choose a method of sharing ideas based on the concept the students are learning. During the summarize portion of the lesson, the teacher must elicit critical mathematical ideas from the students (Markworth et al., 2015).

2.5 Research Studies

The *launch-explore-summarize/extend* problem-solving framework was originally a part of the *Connected Mathematics Project* developed at Michigan State University (Lappan et al., 2014). This research revealed the effects of problem-centered, standards-based mathematical instruction. A need for conceptual understanding was evident based on the research of Alibali, Stephens, Brown, Yvonne, and Nathan (2014). Alibali et al. (2014) studied 257 middle school classrooms to determine the students' levels of conceptual understanding of equations. Following a qualitative methodology, the researchers found that students lacked the connection between the equation itself and their representation. Additionally, students struggled to execute multiple step problems with different operations. The findings indicated a lack on conceptual understanding (Alibali et al., 2014). The *launch-explore-summarize/extend* problem-solving framework develops conceptual understanding. The lack of understanding found in Alibali's (2014) middle school study is avoidable with mathematical instruction that develops conceptual understanding in early childhood mathematics.

In 2005, Adams et al. used a quantitative research design to determine how professional development via standard-based instruction influenced academic achievement. The study investigated twelve teachers who participated in 40 hours of standards-based professional development (Adams, 2005). Adams et al.'s research is applicable to the present study because the use of *launch-explore-summarize/extend* problem-solving framework is present in the South Carolina state standards. All problem-solving problems must reflect standards 2.NSBT.1 and 2.NSBT.3; therefore, the instruction is standards-based.

The *launch-explore-summarize/extend* problem-solving framework supports the development of mathematical skills through problem-solving. In a related study, Cai et al. (2013) studied the effects of problem-solving in middle school on high school achievement. They found that in comparison to a traditional curriculum, students who learned mathematical concepts through problem-solving showed greater academic achievement in high school. Cai et al. (2013) demonstrated the importance of a qualitative rubric to help guide students to reach goals when problem-solving.

An important aspect of problem-solving is explanation and justification. Bieda (2010) and Bieda, Ji, Drwencke, and Picard (2014) highlighted the importance of justifying student thinking. The ability to justify thinking is important because it shows that students understand the mathematical concept. Manipulatives (e.g., base ten blocks for place value) provide opportunities for younger students to provide proof of their thinking (Bieda et al., 2014). The combination of problem-solving, explanation, and justification is present in the *launch-explore-summarize/extend* problem-solving framework. More specific to the current research study, Bledsoe (2012) implemented the *Connected Mathematics Project* curriculum in a 7th grade classroom and studied the developing mathematical understandings of the students. Bledsoe used the *Connected Mathematics* curriculum for mathematics instruction. Bledsoe (2012) suggested that the opportunities provided by the *launch-explore-summarize/extend* problem-solving framework gave students an advanced understanding of rational numbers in comparison to procedural based curricula.

Fuchs et al. (2004) studied the effects of schema-based instruction on mathematical problem-solving. The researchers randomly selected 366 3rd grade students

and assigned them to classrooms with word problem instruction. The 16-week study showed that students with schema-based instruction made greater gains on the posttest than students without schema-based instruction (Fuchs et al., 2004). Schema-based instruction focuses on the underlying structure of the problem to determine the procedure for solution (Fuchs et al., 2004). The *launch-explore-summarize/extend* problem-solving framework also provides schema-based instruction through which students build an understanding of mathematical ideas based on pre-existing knowledge.

In 2018, Behlol, Akbar, and Sehrish investigated the effectiveness of problem-solving as a method for teaching elementary level mathematics. The study used an equivalent group design to determine student growth between the initial pre-test and final post-test. The test used was an achievement test. The study found that the students who learned mathematics through problem-solving had a significantly higher achievement score on the post-test in comparison to students who were in a traditional setting.

The problem-solving framework is effective because it aligns with cognitively guided instruction. Cognitively guided instruction supports the development of mathematical thinking in students (Carpenter et al., 2015). Students are more successful when teachers understand how students' mathematical thinking develops because they are better able to support student learning. When students develop their own strategies for mathematical problems and have opportunities to justify and discuss their intuitive thinking, learning outcomes improve (Carpenter et al., 2015).

2.6 Challenges

Mathematical instruction through problem-solving provides many benefits (e.g., differentiation and the development of conceptual understanding) but also presents

various challenges (Cai & Lester, 2003). Challenges include the development of a strong classroom community, differentiation, and the use of technology (Cai & Lester, 2003; Ray, 2013). With a strong understanding of cognitively guided instruction and careful planning, teachers can overcome the challenges of problem-solving.

Mathematical community. To successfully implement the problem-solving model, there must be a strong mathematical community. Students should feel safe to make mistakes (Ray, 2013). The mathematical community should support and encourage students to evaluate, analyze, and reflect on mathematical ideas. An important part of the problem-solving framework is summarizing the mathematical understandings within the problem-solving task (Ray, 2013). When summarizing, students share strategies, misconceptions, and their thinking with pairs, groups, or the entire class (Carpenter et al., 2015). The mathematical community should encourage critical thinking that helps build mathematical understandings. Mathematical discourse requires students to listen and respect each other's ideas. Ray (2013) stated that students must be able to “construct viable arguments and critique the reasoning of others” (p. 24). Teachers may struggle to create a learning community where students have productive mathematical conversations about problem-solving tasks. Ray (2013) stated that learning through communication can be a challenge due to its unfamiliarity. Students must persevere and share ideas so that others can gain from their findings and come to a consensus (Ray, 2013). Developing a classroom community that values multiple viewpoints benefits students.

The teacher plays a critical role in creating an interdependent learning community. Some teachers use direct instruction and practice through repetition. The *launch-explore-summarize/extend* problem-solving framework requires teachers to

release control of the lesson to the students. Ray (2013) suggested that to build student interdependence, the teacher must “not push too hard or too fast, welcome multiple representations, encourage student to student talk, and put students in situations that require abstractions” (p. 128). Jitendra et al. (1998) compared instruction in which students represented their thinking to tradition instruction in 2nd to 5th grade classrooms. The results of the quantitative study showed a 0.56 effect size; students could maintain use of the mathematical understanding and transfer the material to other contexts (Jitendra et al., 1998). Rather than modeling how to solve a problem, Ray (2013) encouraged teachers to model the thinking process. Cai and Lester (2003) suggested that teachers listen to students and use what they say to guide instruction.

Differentiation. For problem-solving to be productive, the material must be accessible to all students. Teachers often feel challenged to create one problem that is accessible to all students, which is difficult due to a wide range of students needs in one classroom. The NCTM (2000) suggested that students compensate for challenges through modifications. Hiebert et al. (1997) suggested that teachers provide support that does not impede students’ thinking processes but allows them to explore mathematical concepts. During the problem-solving lesson, it can be hard for teachers to support all students’ thinking processes. This support takes a large time investment during which teachers must not only aware of cognitively guided instruction but also common misconceptions. The basis of problem-solving is also grounded in questioning. The development of appropriate questions to ask students as a scaffold can provide differentiation. All these methods of differentiation are effective, but they take time and preparation from the teacher.

Assessment. Assessment is a vital part of mathematical problem-solving instruction and planning. When assessing, the teacher should begin with the end in mind by developing assessment goals (Lappan et al., 2014). Summative and formative assessment methods provide the educator and students with ongoing opportunities for reflection. The present action research study included Gojak's (2013) problem-solving rubric to measure problem-solving success.

According to the *Connected Mathematics Project*, assessment data should evaluate three dimensions: content knowledge, mathematical disposition, and the student's ability to reflect upon their own work (Lappan et al., 2002). Teachers should assess students' content knowledge to determine what students know and what they are able to do in order to evaluate mathematical disposition. Assessment of mathematical disposition measures students' views of themselves as mathematicians. In addition, mathematical disposition refers to student metacognition. An important aspect of problem-solving is a student's ability to think about thinking. Assessments should not neglect the evaluation of a student's ability to reflect on their own thinking (Lappan et al., 2002). In addition to assessing content knowledge, mathematical disposition, and the ability to reflect, teachers should also evaluate work habits. The ability to persevere is important to problem-solving. When problem-solving, students make valuable group contributions. According to Lappan et al. (2002), assessments should measure the contributions students make to the group when problem-solving. Teachers should give feedback on students' abilities to complete tasks. The assessment of work habits directly relates to the real world. Skills such as perseverance, confidence, and collaboration are valuable beyond the classroom. Feedback through assessment contributes to building

work habits, mathematical disposition, and content knowledge (Lappan et al., 2002). The NCTM (2000) stated that “assessment should support the learning of important mathematics and furnish useful information to both teachers and students” (p. 3).

There are many ways to assess problem-solving; assessment can be formal or informal. Collection of and reflection on data is essential for all aspects of the problem-solving curriculum to be successful (Gojak, 2013). The *Connected Mathematics Project* (2002) listed three categories for assessment of problem-solving: checkpoints, surveys of knowledge, and observations. Checkpoints provide an opportunity for teachers to check for students’ understanding (Gojak, 2013). Checkpoints guide teachers to make informed decisions about problem-solving tasks. The second category is surveys of knowledge (i.e., summative quizzes and tests that give the teacher a broad view of students’ understanding). Surveys of knowledge are useful during and after a lesson. Lastly, observations are a crucial assessment tool for problem-solving (Carpenter et al., 2015). Teachers observe student understanding via mathematical discourse during partner work, group work, or independent work. Observations are essential to effective teaching during the summarize portion of the lesson. Teachers assess students beyond traditional pencil-and-paper assessments. Observations drive problem-solving lessons and allow teachers to get to know students as problem solvers (Lappan et al., 2002).

For the purposes of the current action research study, the researcher assessed problem-solving tasks using Gojak’s (2013) rubric. Organization of information, mathematical accuracy, and use of strategies when problem-solving are the three main categories of the rubric. Through a series of indicators, the researcher grouped students as novice, apprentice, practitioner, or expert problem solvers.

Novice problem solvers exhibited random or incomplete organization of information. Indicators of novice problem-solving include missing information, major mathematical errors, and lack the application or explanation of strategies (Gojak, 2013). Apprentice problem solvers exhibit mostly complete organization or the use of a hit and miss approach. Apprentices understand the mathematical concept but lack the understanding to complete the task as their work indicates an incomplete strategy (Gojak, 2013). Practitioners exhibit complete representation, minor mathematical errors, and some explanation and/or representation (Gojak, 2013). Expert problem solvers display well planned, complete, and organized information with mathematical accuracy. Expert problem solvers use efficient and appropriate strategies with complete representation or explanation. The rubric in the action research project provides the teacher-researcher with clear indicators of problem-solving while also focusing on mathematical accuracy. Gojak's (2013) problem-solving rubric also allows students to reflect on their individual problem-solving process to improve.

2.7 Theoretical Framework

An understanding of the impact of educational theories is imperative to problem-solving education. The problem-solving framework integrates the theoretical views of progressivism and perennialism. Problem-solving as an instructional tool follows a learner-centered model. In accordance with the problem-solving framework, progressive and perennial theorists believed that child exploration is crucial to the learning process (Hirsh, 1996).

Progressivism. Progressivism changed education and left a lasting impression on the establishment of schools. Progressivism can be administrative or pedagogical, but this

dissertation in practice aligns most closely with pedagogical progressivism. Dewey is the father of progressivism (Labaree, 2005). A more recent contributor to progressivism, Hirsh (1996) was a progressivist who believed people are innately good and that education should encourage human nature. Hirsh (1996) believed in thematic units that integrated different subjects according to a child's development. Overall, progressivists suggest curricula should develop around the needs and interests of children (Labaree, 2005). Rousseau (1979) rejected the traditional view of education and suggested that teachers preserve a child's natural curiosity. Children have their own way of interacting in the world (Rousseau, 1979). Progressivists, like Rousseau and Dewey, believed that children should explore the world around them.

Problem-solving and progressivism. The *launch-explore-summarize/extend* problem-solving framework aligns with progressivism. Like progressivism, problem-solving focuses on human problems (Dewey, 1938). Problem-solving tasks engage students' interests. Progressivism and the *launch-explore-summarize/extend* problem-solving framework both position students as active agents in their educations (Cai & Lester, 2003). Problem-solving requires students to plan, solve, discuss, analyze, evaluate, and justify their thinking of real-world situations (Markworth et al., 2015). Problem-solving is progressive in nature due to its basis in exploration. The teacher's role is as a facilitator to guide students toward productive mathematical discourse (Ray, 2013). This also aligns with progressivism because students are explorers and the educator is simply a provider of real-world context.

The problem-solving framework focuses on the development of the student (Cai & Lester, 2003). Like progressivism, problem-solving is based on cognitively guided

instruction (Carpenter et al., 2015). Progressivism develops thought and problem-solving allows students to develop their own ideas through exploration. As a facilitator in the mathematical environment, the teacher is a guide for problem-solving. Students benefit from the learning process and the teacher builds on prior student knowledge (Dewey, 1938). Like the ideals of progressivism, students of the problem-solving framework discover mathematics for themselves. Dewey (1938) emphasized the importance of developing thought. The problem-solving framework aligns with progressivism because it strengthens mathematical understandings via constant reflection and analysis of a student's work and the work of their peers. According to the *launch-explore-summarize/extend* model, exploration is a main component of the problem-solving model (Lappan et al., 2002).

Perennialism. Perennialists believed that education should teach great ideas that others already discovered (Adler, 1972). Perennialism encourages the *growth mindset*; students should problem-solve and search for truths. Adler (1972) believed that learning requires that students develop meaning, think about thinking, and discuss knowledge. Perennialism emphasizes educational discourse as the main portion of lessons. Unlike progressivism, perennialism suggests that the teacher is the center of the classroom, sharing essential understandings for the students to discuss (Moss & Lee, 2010). Guided discussions help students learn main ideas via questioning that guides conceptual understandings (Moss & Lee, 2010).

Perennialism and problem-solving. Problem-solving is learner-centered, but there are some commonalities with perennialism. The problem-solving curriculum encourages teachers to develop students' ideas through questioning (Carpenter et al.,

2015). The *launch-explore-summarize/extend* framework encourages both problem-solving and discussion that Adler and Hutchins promoted in perennialism (Lappan et al., 2014; Moss & Lee, 2010). Problem-solving encourages students to think about their thinking (Carpenter et al., 2015).

Learner-centered model. Aspects of problem-solving align with the ideals of a learner-centered ideology. For example, problem-solving allows children to develop at their own pace (Carpenter et al., 2015). Cognitively guided instruction is based on the idea that children naturally develop some strategies (Carpenter et al., 2015). Students make their own discoveries without learning a certain method from a teacher. Learner-centered ideology emphasizes the importance of the learning environment, valuing a positive classroom environment (Ray, 2013). Students engage in mathematical discourse to strengthen their mathematical understanding. Most importantly, learner-centered instruction gives students opportunities to explore mathematical relationships and actions (Carpenter et al., 2015). The problem-solving framework values interactions between students. The *summarize* portion of the lesson aligns with learner-centered ideology because the job of the educator is to create a classroom that encourages growth and thinking (Markworth et al., 2015).

2.8 Conclusion

To determine the effects of the *launch-explore-summarize/extend* problem-solving instructional framework on student achievement on place value tasks, the researcher reviewed related literature. It was beneficial to conduct research on the problem of practice to strengthen mathematical instruction at the elementary school level. The results of the present action research study may show the improvement of students'

mathematical understanding of place value skills. Direct mathematical instruction is common at the elementary school where the researcher conducted the study. In contrast to a problem-solving framework, direct instruction does not promote understanding but rather emphasizes a set of rules or procedures (Cai & Lester, 2003). Procedural knowledge does not readily transfer to the real world. Problem-solving enhances students' abilities to transfer ideas to real-world situations (Carpenter et al., 2015). Problem-solving connects mathematical ideas through application and understanding (Ray, 2013) and ignites a natural curiosity for a deeper understanding of mathematical content (Cai & Lester, 2003). The information within this literature review strengthened the action research study by providing insight on past research pertaining to the topic. This knowledge helped the researcher develop a methodical research study based in historical theoretical perspectives.

In the action research study, the teacher-researcher measured the impact of implementing the *launch-explore-summarize/extend* problem-solving approach in a mathematics classroom. The research question was: What is the impact of the *launch-explore-summarize/extend* problem-solving framework on students' problem-solving success on place value tasks in a second-grade classroom? The literature review summarized relevant texts to establish a theoretical framework to answer the research question.

The researcher analyzed major themes and ideas of the dissertation in practice in the current literature and described theoretical frameworks for problem-solving. Problem-solving is progressive, following the ideas of Dewey (1938). Dewey (1938) believed that children are active agents who benefit from exploration. This learner-centered

methodology aligns with the idea of problem-solving and perennialism (Adler, 1972; Schiro, 2013). Problem-solving requires that students explore and ultimately create an understanding of mathematics on their own.

Stanic and Kilpatrick (1988) noted that problem-solving evolved over time. Whether as justification, practice, or a vehicle, problem-solving existed in mathematical instruction. Problem-solving in the present action research study aligns with Stanic and Kilpatrick's (1998) definition of problem-solving as a vehicle to learn new information. However, practice and justification are also crucial to the problem-solving framework. Practice allows students to deepen their understanding of mathematical concepts and justification helps tie mathematical understandings to the real world (Stanic & Kilpatrick, 1998).

The NCTM (2003) included descriptions of habits of the mind and their connection to problem-solving. Problem-solving instruction strengthens habits of the mind and cognitively guided instruction sets goals for problem-solving instruction (Carpenter et al., 2015). Cognitively guided instruction and the habits of the mind significantly influenced the present action research project. Instruction is most powerful with clearly defined goals. Each feature of the problem-solving model has a direct impact on students' conceptual understandings and achievement (Markworth et al., 2015). The *Connected Mathematics Project* provided necessary information to implement the *launch-explore-summarize/extend* problem-solving framework (Lappan et al., 2002).

Through the literature review, the researcher investigated the meaning and characteristics of problem posing. The analysis of problem posing included problem characteristics, task selection, and problem posing strategies. With exploration at the

heart of the problem-solving framework, problem posing is the main vehicle for students to develop strong mathematical understandings (Cai & Lester, 2003; Carpenter et al., 2015; Markworth et al., 2015).

An important aspect of the literature review was a synopsis of challenges to problem-solving curricula (NCTM, 2003; Ray, 2013). Knowledge of possible challenges is important to the action researcher, because it helps educators prepare for possible difficulties and reduce their impact. The literature review included journal articles and books about problem-solving assessment methods. The present action research project used a rubric as a formal assessment type (Gojak, 2013). Journal articles and books about the benefits and limitations of rubrics provided a holistic perspective of the chosen assessment method.

This literature review provided perspectives on the present action research study through the examination of various research studies. The teacher-researcher measured the impact of implementing the *launch-explore-summarize/extend* problem-solving approach in a mathematics classroom. Through the literature review, the researcher analyzed terms and ideas embedded in the research question: What is the impact of the *launch-explore-summarize/extend* problem-solving framework on students' problem-solving success on place value tasks in a second-grade classroom? Past literature provided a comprehensive understanding of important aspects of problem-solving as they relate to the present action research study. The information from the literature review strengthened the selection of methods for the action research study and provided a strong foundation for future research.

CHAPTER 3

ACTION RESEARCH METHODOLOGY

3.1 Introduction

The action research study's problem of practice illustrates 2nd grade students' lack of conceptual understanding of place value skills due to explicit mathematical instruction. Explicit teaching lacks opportunities for hands-on, higher-order, scaffolded mathematical instruction experiences for all students. Third through 5th grade students who attend schools in the district where the researcher conducted the study participate in a yearly state standardized test called SC Ready. In 2017, district SC Ready scores indicated that 47.9% of 3rd grade students have low number sense and base ten skills and 25% of 3rd graders have medium number sense and base ten skills. Likewise, 78.5% of district 4th graders have low or medium number sense and base ten knowledge. Strikingly, 88.4% of 5th grade students lacked a high sense of base ten and number sense knowledge on the 2017 SC Ready mathematics assessment.

Students demonstrated a need for growth in their number sense knowledge as well. At the research site, 21% of 3rd graders, 32% of 4th graders, and 38% of 5th graders scored *low* on mathematical problems pertaining to number sense and base ten concepts on the SC Ready assessment. On the SC Ready, 29% of 3rd graders, 24% of 4th graders, and 38% of 5th graders exhibited a *medium* sense of base ten and number sense understanding. The SC Ready standard performance report revealed a deficit in base ten understanding that was district and school-wide. The SC Ready data supported the

problem of practice for the action research study. The researcher developed the research question to help 2nd grade students obtain concrete number sense and base ten competency. In the past, mathematical instruction at the school left students lacking a conceptual understanding of foundational base ten and number sense skills.

To resolve the lack of base ten understanding, the researchers examined the impact of implementing a problem-solving framework to teach place value in a 2nd grade classroom. The researcher systematically inquired into the mathematical instruction process by assessing past mathematical instruction and implementing the use of the *launch-explore-summarize/extend* problem-solving framework to teach place value concepts in a second-grade mathematics classroom (Rittle-Johnson & Star, 2009). Through action research, the teacher-researcher studied the effectiveness of problem-solving instruction by using a concurrent mixed-methods research design to determine results.

3.2 Research Question

The dissertation in practice answered the following research question using the concurrent mixed-method action research design.

RQ: What is the impact of the *launch-explore-summarize/extend* problem-solving framework on students' problem-solving success on place value tasks in a second-grade classroom?

Success, in this context, is growth in problem-solving level as defined by Gojak (2013) (i.e., novice, apprentice, practitioner, or expert).

3.3 Chapter Overview

This chapter includes the steps of implementing the current action research study through a concurrent mixed-methods research design to determine effectiveness of the *launch-explore-summarize/extend* problem-solving framework in a second-grade mathematics classroom. The researcher explains the context of the study, role of the researcher, participant selection, and data collection methods. A research plan outlines the methods the researcher used to implement and analyze the data. The chapter concludes with a summary of the overall methodology of the current action research study was an investigation of the effectiveness of the *launch-explore-summarize/extend* problem-solving framework in a second-grade mathematics classroom.

3.4 Description of Intervention

The intervention in the action research study required a methodology of student discovery and problem-based learning. The researcher selected the *launch-explore-summarize/extend* problem-solving framework to give students the opportunity to discover mathematical understandings individually and develop strong conceptual understandings of place value concepts through problem-solving as a foundation for base ten knowledge. The intervention transformed the mathematics classroom with a *launch* that began the lesson by engaging the students in the mathematical context. The instructor *launched* students into a mathematical task through an interest-based activity. Once students exhibited an interest in the mathematical context, they received a problem-solving scenario and time to grapple with the mathematical principles. The teacher scaffolded the development of mathematical ideas by circulating the classroom and questioning students to elicit new mathematical understandings. As students explored the

mathematical concepts, the teacher noted individual accomplishments to highlight during the summary of the lesson.

Next, students had numerous opportunities to summarize their understandings and share their individual mathematical voice in pairs, small groups, and as a whole class. During the summary, the teacher scaffolded students' mathematical understandings from simple to complex to provide all students with access to the problem-solving task and an understanding that made sense to them. Finally, the problem-solving framework provided extensive or intensive intervention time during the extend portion of the intervention. The implementation of this specific mathematics intervention shifted mathematical instruction from explicit teaching to a hands-on, higher-order, scaffolded mathematical instruction experience for all students.

3.5 Rationale for Mixed-Methods Research Design

The action research study utilized a concurrent mixed-methods research design because the study measured whether the quality of problem-solving paralleled students' growth in number sense and base ten understanding. The study followed an action research cycle (Mertler, 2014). The action research design was an ideal way to improve classroom instruction. The cycle allowed the teacher-researcher to plan, implement, analyze, and reflect on teaching outcomes. This process determined the learning outcomes of implementing the *launch-explore-summarize/extend* problem-solving framework.

Educators assess students through various measures. Quantitative data is imperative to assess the transfer of base ten knowledge problem-solving from classroom practice to district assessments because it allows the teacher-research to assess accuracy

and growth. However, the basis of learning through problem-solving is qualitative. The researcher utilized quantitative and qualitative data to evaluate place value problem-solving success using triangulation to assess student understanding over a 6-week period. The quantitative data revealed overall student success on problem-solving assessments achievement over a 6-week period. Using qualitative data, the researcher analyzed students' mathematics journals over six weeks for mathematical accuracy, problem-solving strategies, and explanations of mathematical understanding.

3.6 Action Research Validity

As a teacher-researcher, it is important to ensure high-quality research through validity. Mertler (2014) stated, “the determination of validity ultimately has a substantial effect on the interpretation of those data, once they have been analyzed, and the subsequent conclusions drawn from those results” (p. 149). Action research validity, like other research, depends on whether the data measures the research question. When determining action research validity, the researcher must analyze whether the data measures the intended research question. The research question guides the intent of the research study and validity requires alignment of the study and the research question (Mertler, 2014; Mills, 2011).

The use of triangulation increased the validity of a research study. Triangulation is the use of more than one data source to measure the research question to determine validity and reliability of the findings (Mertler, 2013). When numerous data sources converge, the validity of the research is stronger. Researchers ensure the quality of research through internal research validity. The teacher-researcher practiced triangulation of data to increase validity and used various sources of data (e.g., students' daily

problem-solving journals, the problem-solving rubric, and district benchmark assessment scores) to check data consistency and confirm the findings of the action research study.

3.7 Context of Research Study

The research study takes place in an elementary school in Richburg School District Six. Richburg School District Six is in Columbia, South Carolina. The school serves approximately 440 students, a small portion of the 24,000 students in Richburg District Six. According to Powerschool (2016), the population of the school is 72% Caucasian, 20% African American, 2% Hispanic, 3% Asian, and 3% multiracial. Twenty-three percent of the student population receives free lunch and 2% receives reduced priced lunch. To meet the needs of such a large population, Richburg Six consists of 52 separate schools, of which 28 are elementary schools. The staff includes one principal, a curriculum resource teacher, guidance counselor, speech therapist, reading coach, librarian, and 23 teachers. Other professionals, such as occupational therapists, serve a cluster of schools.

Students and teachers benefit from parental support. The elementary school is a neighborhood school with an active parent-teacher organization and foundation. These groups provide outside support to the school, such as a math fact fluency mentor. However, the school lacks a math or reading interventionist. The only positions the district provides for teacher support are a curriculum resource teacher and a reading coach.

The teacher-researcher is a 2nd grade classroom teacher and early childhood math facilitator who teaches English language arts (ELA), math, social studies, science, and health daily. The early childhood department consists of three grades and ten self-

contained, general education classrooms. In this action research study, the teacher-researcher examined learning practices in one of the 2nd grade self-contained classrooms where a single instructor teaches all core subjects. The researcher conducted the study during the math block. Math workshop began at 9:50 A.M. and ended at 11:10 A.M. daily. The students had five academic blocks of math instruction weekly. The workshop, where the problem-solving framework occurred, lasted the entirety of the mathematics instruction timeframe. Outside of mathematics instruction, the seven-hour school day consisted of an ELA block, lunch, recess, related arts, social studies, and science blocks.

3.8 Role of the Researcher

The teacher-researcher is the lead 2nd grade teacher at R. Elementary School. The primary role of the researcher is to educate all students in the class. Along with mathematical instruction, the teacher-researcher is responsible for ELA, science, social studies, and health instruction for the group of 22 students in the sample class. Classroom teachers must maintain constant communication with parents and students. The teacher-researcher also maintained all responsibilities required by administration (e.g., lunch duty, recess, faculty meetings, and professional learning community meetings).

The teacher-researcher is also the early childhood math facilitator at R. Elementary and is responsible for sharing information from the district math consultant with teachers to develop their mathematical instruction. As a math facilitator, the researcher provides mathematical professional development opportunities within the school and serves as a mentor for teachers seeking to improve their mathematical instruction. During the study, the researcher assumed the role of an active participant

observer. As a classroom teacher, the researcher implemented the problem-solving framework, assessed the students, and analyzed the results.

3.9 Participants

The sampling method was a convenience sample. This method is appropriate for action research studies (Mertler, 2014). The sample included all 2nd grade students for the 2017-2018 school year. Participants included all 22 students in the teacher-researcher's general education 2nd grade class. The students were between the ages of seven and eight years old. The sample size was appropriate for the present action research study because it was sufficient to measure the effect of the problem-solving curriculum in an ordinary classroom setting for future development of individual, school, and district-wide mathematical teaching practices. The participants' parents completed guardian consent forms to permit their children to participate in the study. The teacher-researcher investigated the impact of the problem-solving framework on student problem-solving success. The number of participants effectively addressed the research question because they exemplified an average size of a 2nd grade class. To determine the effectiveness of the problem-solving framework in developing mathematical understandings in a 2nd grade mathematics classroom, a 2nd grade class was the most accurate group of participants to study.

The 22 students in the participant group exhibited a wide range of mathematical ability and understanding. The following students were participants in the action research study:

- J.F. is a seven-year-old African American female who lives in poverty. Neither of her parents have a college degree; yet, they emphasize school at home. Her

parents work full- and part-time jobs to provide for their family. In class, she is attentive, follows class rules, and exhibits a high level of work ethic. She began the school with below grade level mathematics skills.

- G.R. is a Caucasian seven-year-old male with two younger brothers. His parents recently divorced and remarried. He moves between both homes on a week-by-week basis. His father is in the military and neither parent is college educated. G.R. suffers from ADHD and works with an occupational therapist each week. The father and step-mother are very involved in his education. He desires to please the teacher, but often gets distracted. He began the research period with below grade level mathematics understanding.
- M.N. is a seven-year-old African American female. She is the daughter of a young, single mother with three other sisters. Her father passed away before she was born. They moved from Iowa this year. Neither of her parents had higher than a high school degree, but are supportive of M.N.'s successes in school. MN is new to the elementary school and is a below grade level mathematics student.
- C.B. is a seven-year-old African American male who was adopted as an infant by a Caucasian family. He has a large vocabulary and is very inquisitive. C.B. has a strong support system at home and is the son of a professor at the local university. Although advanced in ELA, he began the school year with minimal competence of grade level mathematics skills.
- A.F. is a seven-year-old biracial female who was adopted at infancy by a Caucasian family. A.F. began the year with a resistance towards mathematics, often escaping to the bathroom when math class would begin. She has a reliable

- and strong support system at home. She showed minimal competence on grade level math tasks at the beginning of the year.
- S.B. is a seven-year-old Caucasian female with divorced parents and a step-mother. She often isolates herself and requires constant monitoring to ensure that she stays on task. In the fall, S.B. exhibited minimal understanding of grade level mathematics concepts.
 - K.H. is a seven-year-old female and the third child of a Caucasian family. She exhibited competence in grade level mathematics instruction in the fall. K.H. is quiet yet participatory in class.
 - K.R. is a seven-year-old Caucasian female and is the older of two children. She seeks a lot of attention in class. K.R. shows substantial effort when it comes to her school work. She aims to meet all expectations. K.R. exhibited competence in mathematical understandings in the fall.
 - O.B. is a seven-year-old Caucasian female and the only child in her family. She is a hard worker and gets along well with others. She always goes above and beyond expectations. O.B. began the school year as a proficient mathematics student.
 - E.K. is the Caucasian daughter of French immigrants. E.K. is bilingual and the third child in her family. E.K. is an easy-going seven-year-old and a hard worker. She exhibits competence on grade level mathematics concepts.
 - R.B. is a Caucasian female, the second child of four, and is dyslexic. She is a proficient math student. She is easy-going and a very helpful seven-year-old. Her classroom job is the class mathematician, which demonstrates her enthusiasm for mathematics.

- A.S. is a seven-year-old male and the middle child in a Caucasian family. He has ADHD and often moves around in class. However, he is attentive during math instruction. He exhibited competence on grade level math concepts at the beginning of the year.
- C.J. is one of two boys in a divorced Caucasian family. C.J. struggles with motivation in school. He is an inquisitive seven-year-old but gets easily distracted. He often seems subdued in class. C.J. is a proficient math student and can verbalize his understandings, but often does not demonstrate his knowledge on tests.
- Z.B. is a biracial male of seven years old. His mother is Caucasian and his father is Lebanese. His parents were going through a difficult divorce at the time of the study. Z.B. has one younger brother. He is an active participant and always willing to learn and help. He is a proficient math student.
- J.H. is a seven-year-old Caucasian male and an only child. He is an exceptionally bright student who shows an advanced knowledge of grade level mathematical concepts in class. His mother is a teacher and holds him to high expectations. He is very interested in math and science.
- J.D. is a seven-year-old female and one of five children in a family of African immigrants. She is very inquisitive and bright. J.D. is a hard worker and exhibits advanced understanding of grade level mathematical concepts.
- J.M. is a seven-year-old female and the youngest of three children. She is a perfectionist and takes her time to make sure that her work is the best product possible. She has an advanced understanding of grade level math concepts.

- A.A. is a seven-year-old male and the youngest of three siblings in a Caucasian family. A.A. is autistic and is very bright, but struggles with social norms and getting along with others. He shows superior understanding of grade level mathematics standards.
- M.D. is a seven-year-old male and the older of two children in a Caucasian family. M.D. is an advanced math student. He is a bright student who is very verbal in class. M.D. also moves around a lot in class. He is interested in math.
- E.H. is a seven-year-old female and exhibits a superior understanding of grade level mathematics concepts. She is the younger of two siblings. She tries hard but requires a lot of attention in class. She often talks to classmates.
- E.G. is a seven-year-old female and the younger of two siblings. Her mother is a teacher. She is an overwhelmingly happy student. She always tries her best and participates in class. She exhibits a superior understanding of 2nd grade mathematical concepts.
- B.W. is a seven-year-old male and the younger of two children in a Caucasian family that is very involved in his school. He is a hard worker but takes time to complete tasks. He shows an advanced understanding of mathematical skills for 2nd grade.

Ethical considerations. The present action research study did not expose the participants to any kind of harm. Students and their guardians chose whether to participate in the action research study. Parents and students signed a letter to indicate their willingness to participate. The parent letter specifically outlined the research process to educate parents on the action research study and their child's involvement. The student

letter was kid-friendly and informed the students of the aspects of their work in the study. Both letters indicated that the choice to participate or abstain in the study would not affect the outcome of the student's grade in the class. Students who chose to abstain from participating in the present action research study continued to have the same educational opportunities in the everyday classroom.

The teacher-researcher's priority was the students. The researcher met the needs of all students during the action research study. The teacher enhanced instruction during the action research study. If at any point, the study impeded classroom instruction, the teacher-researcher modified the action plan to ensure a positive and productive learning environment. The teacher-researcher continued to meet expectations for any students with an individualized education plan (IEP) or 504 plan. Furthermore, the teacher-researcher met the academic needs of all students through intervention with any students performing below grade level. The teacher provided extension activities based on problem-solving tasks for gifted students to continue to expand their mathematical problem-solving potential. The teacher-researcher provided interventions and extensions throughout the problem-solving framework by creating tiered problem-solving tasks.

The teacher-researcher maintained the privacy of students' identities throughout the research process, particularly during the reflection process of action research. The researcher collected data through student interviews, assessment rubrics, and observations. In sharing and communicating the results of the influence of the *launch-explore-summarize/extend* framework on problem-solving success, student names remained confidential. The teacher-researcher communicated the results of the study to colleagues and the university while maintaining student confidentiality.

3.10 Data Collection Instruments

Problem-solving tasks. The researcher assessed problem-solving tasks using Gojak's (2013) rubric. Using the rubric, the researcher assessed the organization of information, mathematical accuracy, and use of strategies when problem-solving. The researcher measured students' success as a novice, apprentice, practitioner, or expert and monitored growth while analyzing a pre- and post-assessment to determine problem-solving success.

Level one, novice, problem solvers exhibited random or incomplete organization of information. Novice problem solvers missed some information as they attempted to solve the problem. Novice problem solvers exhibited major mathematical errors and lacked the application or explanation of strategies (Gojak, 2013).

Level two problem solvers, apprentices, either had mostly complete organization or used a hit and miss approach. Trial and error is a problem-solving strategy, but it is not the most effective or efficient (NCTM, 2010). Apprentices understood the mathematical concept but lacked the understanding to complete the task. When using strategies, apprentices exhibited an incomplete strategic approach (Gojak, 2013).

Level three problem solvers, practitioners, organized information in a way that all elements were present and a plan was obvious. Practitioners exhibited minor errors in mathematical accuracy. They were able to apply some strategies, explanation, and representation (Gojak, 2013).

Expert problem solvers exhibited well planned, complete, and organized information. They showed mathematical accuracy. In addition, expert problem solvers

used efficient and appropriate strategies with complete representation or explanation.

Figure 3.1 shows Gojak's (2013) rubric.

Criteria	Level One (Novice)	Level Two (Apprentice)	Level Three (Practitioner)	Level Four (Expert)
Organization of Information	<ul style="list-style-type: none"> • Random • Incomplete • Missing elements 	<ul style="list-style-type: none"> • Mostly complete • Hit-and-miss approach • Most elements are present 	<ul style="list-style-type: none"> • All elements represented • Shows a plan or appropriate strategy • Organized 	<ul style="list-style-type: none"> • Well-planned • Complete and displayed in an organized fashion
Mathematical Accuracy	<ul style="list-style-type: none"> • Major errors in computation and explanation 	<ul style="list-style-type: none"> • Chose appropriate mathematical concept but unable to accurately complete the task 	<ul style="list-style-type: none"> • Minor errors in computation but demonstrates conceptual understanding 	<ul style="list-style-type: none"> • Accurate
Use of Strategies	<ul style="list-style-type: none"> • Lack of strategic approach to task • No explanation 	<ul style="list-style-type: none"> • Some demonstration of strategic approach but incomplete or lack of follow through • No representation or explanation 	<ul style="list-style-type: none"> • Shows some application of strategies but not efficient • Some use of representation and or explanation 	<ul style="list-style-type: none"> • Use of efficient and appropriate strategy or combination of strategies • Includes a complete representation or explanation

Summary:

Organization of Information Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Mathematical Accuracy Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Use of Strategies Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Notes:

Figure 3.1. Gojak's (2013) rubric for problem-solving assessment.

The researcher measured student success over six weeks according to students' growth in the four problem-solving levels. The teacher-researcher used the data from the rubric to determine if the *launch-explore-summarize/extend* problem-solving framework contributed to problem-solving success.

Math journals. The students completed daily math journals to catalog their strategies when solving place value problem-solving tasks. The format of the daily math journals began with a problem-solving task. Students read the problem-solving task written on the board and independently grappled with discovering place value concepts for 10 to 15 minutes by writing in their journals. Students explained their thinking after attempting to solve the problem. The problem-solving tasks included South Carolina 2nd grade mathematics place value and problem-solving skills. Math journals provided students with an opportunity to consider new place value concepts, decipher truths about place value, and explain their thinking in a safe and positive environment (NCTM, 2000). The journals were a means of informal assessment. The teacher-researcher used them to develop insight on each students' conceptual understandings of place value (Gojak, 2013).

Summative district benchmark. The district benchmark is a district mandated summative math assessment that students complete at the end of the school year to assess understanding of 2nd grade math skills. There are 40 questions that assess grade level standards. The district benchmark also assesses place value concepts. Two standards directly relate to place value concepts: 2.NSBT.1 and 2.NSBT.3. Table 3.1 shows the correlation between the number sense base ten standards and the place value concepts that the teacher-researcher taught during the 6-week intervention.

Table 3.1
Place Value Skills in South Carolina Number Sense Base Ten Standards

Standard	Description	Place Value Skills
2.NSBT.1	Understand place value through 999 by demonstrating that: a. 100 can be thought of as a bundle (group) of 10 tens called a <i>hundred</i> ; b. the hundreds digit in a three-digit number represents the number of hundreds, the tens digit represents the number of tens, and the ones digit represents the number of ones; c. three-digit numbers can be decomposed in multiple ways (e.g., 524 can be decomposed as 5 hundreds, 2 tens, and 4 ones or 4 hundreds, 12 tens, and 4 ones, etc.)	Hundreds, tens, ones, multiple representations of place value, decomposition, bundling, representation
2.NSBT.3	Read, write, and represent numbers through 999 using concrete models, standard form, and equations in expanded form.	Concrete models of place value, standard form, expanded form

The summative district benchmark assessment includes 15 number sense and base ten assessment questions. Six of these questions directly assess place value concepts. The scores of the summative district benchmark are uploaded onto Mastery Connect by the teacher to provide detailed information of students' success on each number sense and base ten concept. Mastery Connect is an online portal that stores assessments and

assessment data. Table 3.2 outlines the data collection methods that the researcher used in this study.

Table 3.2
Data Collection Methods

Data Collection Method	Description	Frequency	Documents
Problem-solving task assessment (Gojak, 2013)	Student work. Documentation of student achievement based on weekly problem-solving tasks.	Weekly	Appendix C
Student math journals	Student work. Documentation of student achievement based on daily problem-solving tasks.	Daily	Student Journals
Summative district benchmark	Student work. Documentation of student mastery based on 40 assessment questions.	Once during research	Appendix F

3.11 Research Procedure

During the 6-week period of the action research study, the teacher-researcher implemented the *launch-explore-summarize/extend problem-solving* framework using Mertler's (2014) action research study design. The students solved a daily place value problem-solving task using the *launch-explore-summarize/extend* model in their math journals. Students worked on new place value concepts through problem-solving tasks and explained their thinking to develop a conceptual understanding of the place value system.

The teacher-researcher provided a problem-solving task and assessed it using Gojak's (2013) rubric each week to collect enough data points to determine success based on student growth. The teacher-researcher used the levels of problem-solving to determine how students progressed in problem-solving and the understanding of place value concepts. A sample place value problem-solving task stated,

The second-grade class at Emerson Elementary collected books for the library. They can be turned in to the school in large boxes that hold 100 books and small boxes that hold 10 books. The second-grade class collected a total of 265 books. What are the different ways the students can sort the books into boxes to take to the school? Chose which way you think is best.

Table 3.3 outlines the 6-week intervention by skills taught, the standard addressed, and assessment questions.

3.12 Data Analysis: Qualitative

Problem-solving tasks. The researcher analyzed the quality of student work using Gojak's (2013) rubric to determine overall growth in the use of strategies, mathematical accuracy, and organization. The assessments occurred weekly during the intervention. The teacher-researcher analyzed each criterion individually from each assessment to determine student growth in problem-solving and place value concepts.

Math journals. The researcher coded three math journal entries for each student in order to determine student growth during the intervention. The entries were from lessons that used the problem-solving framework during the first, third, and sixth week of the intervention. The researcher collected qualitative data collected from the math journals using priori coding. The researcher coded two problem-solving tasks to measure

the quality of students' problem-solving success on open-ended place value mathematics tasks. The researcher compared the first and second open-ended problem-solving task codes to determine problem-solving success. Following Boyatzis' (1998) steps for creating codes, the teacher-researcher generated codes, revised the codes in accordance with the math journals, and determined the reliability of the codes. Gojak's (2013) rubric places each student as a novice, apprentice, practitioner, or expert problem solver. The researcher developed the codebook with a team of 2nd grade teachers who also assessed student achievement using the rubric and student journals. While independently coding, the teachers discussed the codes and edited the codebook when necessary. The codebook (Appendix D) shows the definition of each code and two student examples that reflect the expectation for each code.

3.13 Data Analysis: Quantitative

Summative district benchmark. The school district administered a summative district benchmark at the end of the 2017-2018 school year and after the 6-week intervention. The researcher analyzed the district benchmark assessments for mastery. The researcher used the quantitative data from the district benchmark to determine how the problem-solving framework affected student place value understanding. Mastery Connect provided a breakdown of standard alignment for each assessment question. The researcher examined each question that assessed place value for student mastery. In addition, the researcher compared student performance on standards that were applicable to place value to student performance in the other two 2nd grade classrooms at R. Elementary to determine the effectiveness of the problem-solving framework in developing a conceptual understanding of place value concepts.

Table 3.3
Six-Week Intervention Skills and Assessment Questions

Week	Skill	Standards Addressed	Problem-solving Assessment Question
Week 1 (Pre-Assessment)	Three-digit place value, tens, ones, hundreds, multiple representations	2.NSBT.1 2.NSBT.3	The second-grade class at Emerson Elementary collected books for the library. They can be turned in to the school in large boxes that hold 100 books, small boxes that hold 10 boxes, and individually. The second-grade class collected a total of 265 books. What are the different ways the students can sort the books into boxes to take to the school? Chose which way you think is best. Show your work and explain your thinking.
Week 2	Two-digit place value, tens, ones	2.NSBT.1 2.NSBT.3	What is the largest number you can make with 5 and 8? Show your work and explain your thinking.
Week 3	Two-digit place value, tens, ones, multiple representations	2.NSBT.1 2.NSBT.3	Cade collected candy for the carnival. He collected 79 pieces. He can take them to school in bags of ten or individually. What are some ways that Cade can bring the candy to school? Which way would you choose and why? Explain your thinking.
Week 4	Three-digit place value, tens, ones, hundreds	2.NSBT.1 2.NSBT.3	What is the largest number you can make with the digits 7, 4, and 8? Show your work and explain your thinking.
Week 5	Three-digit place value, tens, ones, hundreds, multiple representations	2.NSBT.1 2.NSBT.3	How many different ways can you make 289 with ones, tens, and hundreds? Show your work and explain your thinking.
Week 6 (Post-Assessment)	Three-digit place value, tens, ones, hundreds, multiple representations	2.NSBT.1 2.NSBT.3	The second-grade students are going to an apple farm in the fall. They collected 453 apples together. They need to send the apples back to R. Elementary. The apple farm has crates that carry 100 apples, bags that hold 10 apples, or they can be carried individually. What are different ways the students can bring the apples back to Rosewood? What do you think is the best method? Show your work and explain your thinking.

3.14 Summary

The dissertation in practice followed an action research methodology. The teacher-researcher explored the influence of the *launch-explore-summarize/extend* problem-solving framework on the teaching and learning process. The context of the present action research study was a 2nd grade classroom in Columbia, South Carolina. During the action research study, the researcher ensured validity through triangulation of data sources and maintained all requirements for ethical conduct. The study followed Mertler's (2014) four-stage procedure for conducting action research. The teacher-researcher began by planning (i.e., identification of the topic of study as problem-solving). To understand the topic more clearly, the researcher gathered information on problem-solving from professionals, books, and journals. By reviewing the present literature, the researcher developed an effective research design and data collection plan.

The dissertation in practice followed a mixed-method design of action research. This research design was appropriate for the present study because the researcher used qualitative and quantitative data collection to explore *how* the problem-solving framework influenced student problem-solving success. The researcher collected data from problem-solving tasks via a rubric over a period of six weeks, a pre- and post-test, student journals, and district benchmark assessment scores. These data informed findings regarding student mastery through the constant comparative method the researcher used to assess progress. Through constant reflection, the teacher-researcher developed an action plan based on the findings. The action plan may improve future mathematics instruction at the elementary school level. The researcher communicated the results of the

study with other professionals to have the largest possible influence on mathematical instruction and student success.

CHAPTER 4

PRESENTATION AND ANALYSIS OF DATA

4.1 Overview of Study

A critical factor in developing number sense and base ten skills is engaging students in tasks for which they do not know the solution method prior to the exercise (Gojak, 2013; NCTM, 2000). Teaching mathematics through problem-solving allows students to explore new mathematical ideas to develop mathematical understandings (Lester, 2003). Problem-solving as a classroom approach provides students with rich problem tasks that foster an understanding of mathematical concepts (Lester, 2003; NCTM, 2000). The problem-solving teaching approach may include different structures to solve rigorous problematic tasks by accessing mathematical concepts, which results in the development of conceptual understanding and increases in student achievement (Lester, 2003; Markworth et al., 2015; NCTM, 2000).

The implementation of problem-solving in a classroom setting can be difficult for teachers. With the introduction of the Common Core State Standards for Mathematics, teachers implemented standards for mathematical practices so that all students could participate in critical thinking and mathematical discourse (CCSSO, 2010). The standards for mathematical practices require all students to have a chance to learn mathematics concepts by making sense of problems, perseverance, abstract thinking, and mathematical discourse (Markworth et al., 2015; CCSSO, 2010). Lappan et al. (2002) originally introduced a research-based, problem-centered mathematics framework for teaching

mathematics that was accessible for all teachers and students. Van de Walle, Karp, and Bay-Williams (2013) supported the mathematical framework's three essential characteristics that help build mathematical understanding and support student achievement. The three essential characteristics are problematic tasks, accessibility, and a requirement that students justify and explain their mathematical thinking (Markworth et al., 2015). To support the standards for mathematical processes, teachers should implement a three phases lesson format (Lappan et al, 2002; Van de Walle et al., 2013). The three phases support the conceptual development of mathematical skills through the activation of prior knowledge, scaffolded time for students to explore mathematical understandings, and discussion time for justification and explanation (Lappan et al., 2002; Markworth et al., 2015).

With previous research and theory in mind, the purpose of the present action research study was to improve student achievement on number sense and base ten place value tasks. The researcher determined the impact of the *launch-explore-summarize/extend* problem-solving framework on students' problem-solving success on place value tasks in a 2nd grade classroom. The researcher analyzed student work while implementing the problem-solving framework to monitor changes in student achievement. The study is significant because of the direct impact the results reveal regarding problem-solving and student mathematical achievement. Through problem-solving, students discover number sense and base ten concepts and develop a conceptual understanding of place value through mathematical discourse.

The sample included 22 students in a 2nd grade classroom. The sampling method was convenience sampling. The teacher-researcher taught all 22 students for the entirety

of the 2017-2018 school year. Each student participated in the problem-solving framework during math instruction during the 6-week period of the research study. The researcher collected data to effectively answer the research question because the sample was the average size, age, and skill level of a typical self-contained 2nd grade mathematics class.

This action research study had a concurrent mixed methods research design to determine the impact of the problem-solving framework. The researcher used problem-solving assessments, journal entries, and district benchmark assessment scores to measure problem-solving success. The essence of problem-solving is qualitative; therefore, the researcher analyzed the quality of student work using the constant comparative method to code student journals and Gojak's (2013) rubric to analyze student growth on weekly assessments. The researcher quantitatively analyzed student mastery of place value concepts on the district benchmark assessment to understand how learning place value concepts through the problem-solving framework transferred to standardized testing. The teacher-researcher effectively studied the impact of the problem-solving framework on 2nd grade students' success on place value problem-solving tasks through the concurrent triangulation of this mixed methods action research design.

4.2 General Findings

Place value problem-solving assessments. The researcher used Gojak's (2013) rubric to assess students' mathematical accuracy, use of strategies, and organization of information. Using the concurrent triangulation mixed-methods research design, the researcher used the rubric to address the research question by assessing both mathematical accuracy of place value skills and problem-solving success. At the

beginning and end of the intervention, students completed pre- and post-assessments. The problem-solving tasks assessed 2.NSBT.1 as well as the mathematical process standards. The researcher analyzed this data qualitatively for overall growth based on students' organization of information, mathematical accuracy, and use of strategies. Students exhibited novice, apprentice, practitioner, or expert skills as defined by the rubric. The first criteria the teacher-researcher analyzed qualitatively was the organization of information (Gojak, 2013). Novice problem solvers organized their information randomly, incompletely, and had missing elements. Apprentice problem solvers had mostly complete or hit or miss organization strategies. Practitioners represented all elements and showed an organized plan. Students who exhibited expert organization of information had well-planned and completely organized displays of information. Figure 4.2 shows the differences between how students organized information between the pre- and post-assessments.



Figure 4.1. Organization of information results. The number 1 connotes *novice*; 2 = *apprentice*; 3 = *practitioner*; 4 = *expert*.

All students began the intervention as level one or novice for organization of information. At the end of the study, 20 of the 22 students exhibited the skills of expert organizers of mathematical information. At the end of the intervention, all but two students organized their mathematical information in a well-planned, complete, and organized fashion.

The second component of the rubric was mathematical accuracy. Mathematical accuracy measured the students' understanding and application of place value skills. Students who scored as level one or novice in mathematical accuracy had major errors in computation and explanation of their work. Apprentice, level two, students chose the appropriate mathematical concept to solve the task but failed to accurately complete the problem-solving tasks. Level three students (practitioners) displayed conceptual understandings with minor errors. Experts in mathematical accuracy displayed an accurate answer and understanding of the place value problem-solving task. Figure 4.3 displays students' growth in mathematical accuracy on the place value assessments.

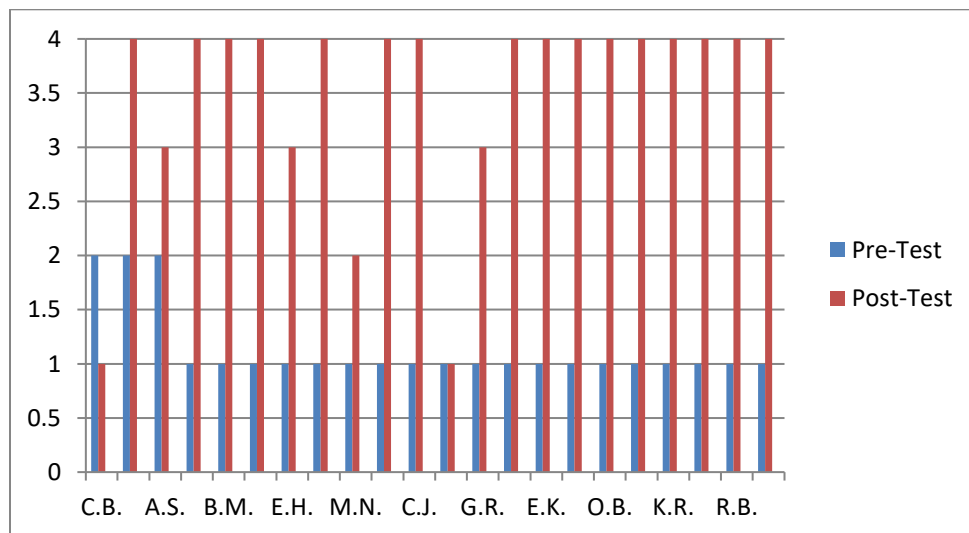


Figure 4.2. Mathematical accuracy results. The number 1 connotes *novice*; 2 = *apprentice*; 3 = *practitioner*; 4 = *expert*.

The data demonstrates that most students exhibited growth in mathematical accuracy on place value problem-solving tasks. Sixteen 2nd graders exhibited mastery of the place value skills with an expert rating on the post-assessment. Fifteen students exhibited distinguished growth from their novice place value skills on the pre-assessment to expert on the post assessment. Two students' place value skills developed from novice to practitioner. One student exhibited place value skills that developed from novice to apprentice. A.F. began the unit as an apprentice in place value and ended as an expert problem-solver after the intervention. One student did not show growth between the pre- and post-assessments. The third criteria on the rubric was use of strategies. Novice students exhibited a lack of strategic approach and no explanations. Apprentice students demonstrated some strategic approaches but did not complete the strategy or gave no representation or explanation of the strategy they used. Practitioners showed some application of strategies and some representation and explanation. Expert problem solvers used an efficient strategy and completely represented and explained their thinking. Figure 4.4 shows student growth in the use of strategies.

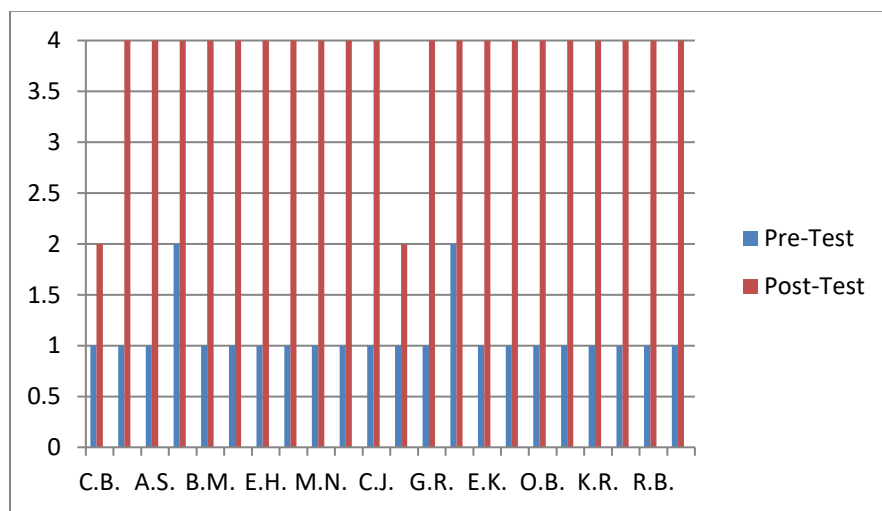


Figure 4.3. Use of strategies results. The number 1 connotes *novice*; 2 = *apprentice*; 3 = *practitioner*; 4 = *expert*.

All students demonstrated growth in the use of strategies. Twenty students were experts according to the post-assessment (i.e., they had a strong understanding of choosing an efficient strategy to solve a problem-solving task). These students were able to explain and represent their thinking. Two students showed growth, beginning the research period as level one (novice) in use of strategies and ending the research period at level two (apprentice). Two other students began the intervention as apprentices in use of strategies but grew to have expert use of strategies.

Problem-solving journals. During the action research, students' problem-solving journals revealed problem-solving success and place value understating. The teacher-researcher constantly compared student progress in problem-solving and mathematical accuracy through daily mathematical journals. Each day, during the problem-solving intervention, the teacher-researcher introduced a problem-solving task as part of the *launch-explore-summarize/extend* framework. After the students launched and became interested in the problem-solving task, the teacher-researcher gave the students time to explore mathematical concepts while circulating the room to scaffold understanding. During this time, the students worked independently to solve the problem before working in pairs or groups. The teacher-researcher used the first, middle, and last entries in the student journals to measure growth over the 6-week research period.

The first student journal task that the 2nd grade team coded during the research period asked, "What are different ways can you make 57 using tens and ones? Explain your thinking." The students used exploration time to solve the task before summarizing the mathematical understandings per the intervention framework. The teachers coded the organization of information, mathematical accuracy, and use of strategies exhibited in

student journals. Figure 4.5 indicates how the teachers coded the student journals. The 1 indicates novice, 2 indicates apprentice, 3 is practitioner, and 4 indicates an expert level of each domain.

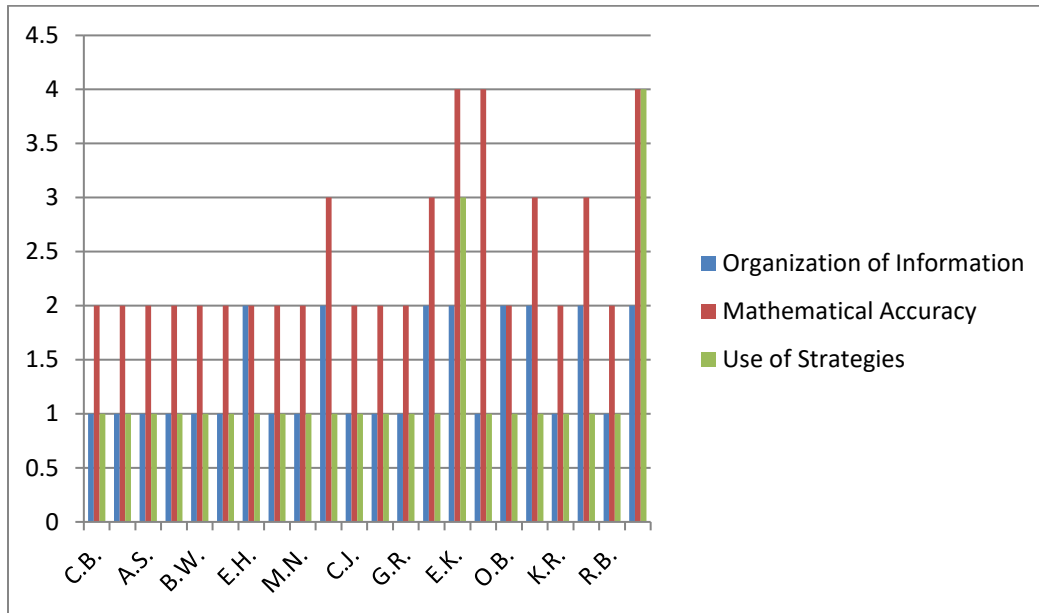


Figure 4.4. Week 1 journal entry coding data. The number 1 connotes *novice*; 2 = *apprentice*; 3 = *practitioner*; 4 = *expert*.

The coding of the first entry in the student journals indicated low organization of information and strategy use. However, the data demonstrated a large range of knowledge and application of skills. Entries ranged from students who represented their understanding of place value with base ten blocks to students who articulated their understanding using base ten vocabulary. An example of a student who exhibited expert accuracy and use of strategies was J.H. J.H.'s journal entry stated,

5 tens, 7 ones, you can make 4 tens and 17 ones, 3 tens and 27 ones, 1 ten and 47 ones, 0 tens and 57 ones. You can make 57 with 5 10s and 7 ones. You can trade one 10 for 10 ones.

An example of a novice student journal was M.N. M.N. wrote the number 57 and drew 57 ones in her problem-solving journal.

Fourteen students exhibited novice organization of information. The remaining students demonstrated an apprentice level of organization. Fourteen students had an apprentice level of mathematical accuracy. Most students had this score due to there being multiple possible answers. Many students such as C.B., B.W., S.B., M.N., J.F., C.J., and Z.B. only gave one way to make 57 using tens and ones. Three students exhibited a practitioner level of mathematical accuracy. J.H., A.A., and E.K. developed all possible ways to make 57 using tens and ones, exhibiting an expert level of mathematical accuracy. Finally, 20 students showed a lack of understanding of the use of strategies and the teachers coded their journals as novice for use of strategies. One student exhibited a practitioner level of understanding in the use of strategies and one student had an expert level of strategy use. The data indicated that most students had a baseline understanding of place value skills but lacked the ability to problem-solve.

The students continued to explore problem-solving tasks each day during the exploration time of the *launch-explore-summarize/extend* mathematical framework. A problem-solving task at the middle of the research period helped students learn place value concepts. The task asked, “Given the digits 2, 6, and 7, what are the smallest and largest three-digit numbers you can make with these digits?” The students had 10 minutes of individual exploration time to work on the problem-solving task. The teacher-researcher and another 2nd grade teacher analyzed the problem-solving journals to provide reliability of coding. A.F. created a T-chart with the headings *big* and *small* with numbers underneath. Although her answer was incorrect, she exemplified an expert

organization of information. Therefore, her journal was an expert organizer (EO). Many other students, such as B.W., simply wrote the two numbers on one line in their math journals, indicating they understood the concept. Because the work was missing elements, the teacher-researcher and colleagues scored the journal as novice organization (NO).

The next criterion was mathematical accuracy. S.B. scored AA (apprentice accuracy) because she exhibited the ability to choose appropriate mathematical concepts but was unable to accurately complete the task. In S.B.'s journal, her answer for the largest number was 762 and her answer for the smallest number was 627. S.B. showed an understanding of how to use place value concepts to make the largest number but was unable to accurately complete the task by also showing an understanding of place value concepts to make the smallest number with the three digits. E.K.'s problem-solving journal was EA because she was able to accurately complete the task.

Developing problem-solvers must choose an efficient and appropriate strategy with complete representation of information when completing problem-solving tasks. Many students chose efficient strategies but lacked representation of the information. For example, J.D. showed high mathematical accuracy but lacked any additional representation or explanation of information. Therefore, J.D.'s second entry was coded as an apprentice in the use of strategies because there was no representation or explanation.

Figure 4.6 demonstrates the students' levels of organization, mathematical accuracy, and use of strategies as the teachers coded them by using the constant comparative method. This mathematical task occurred approximately half way through the research period. In the figure, 1 indicates students with a novice understanding, 2

indicates students with an apprentice level, 3 indicates students with a practitioner level, and 4 indicates students with an expert level in each criterion.

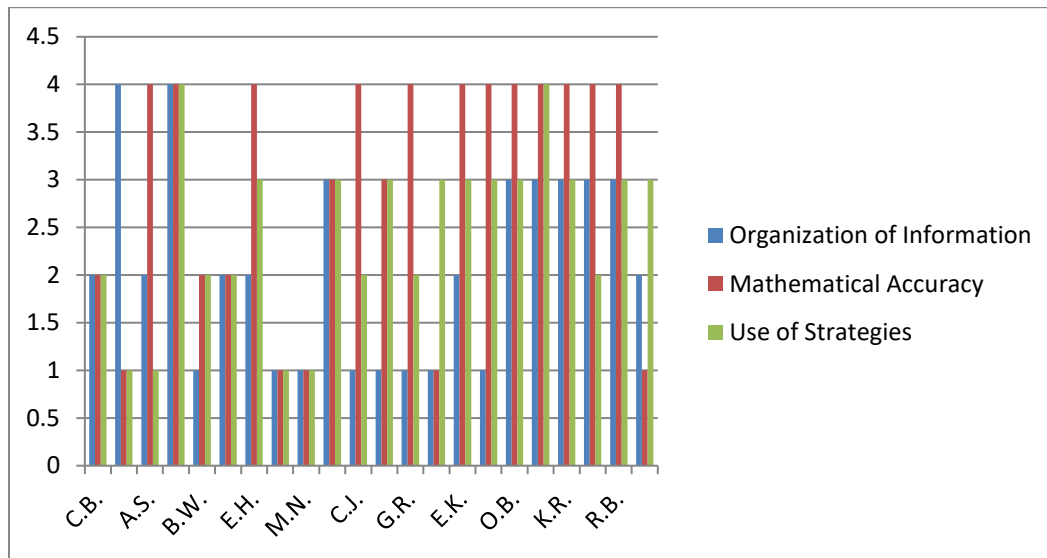


Figure 4.5. Week 3 journal entry coding data. The number 1 connotes *novice*; 2 = *apprentice*; 3 = *practitioner*; 4 = *expert*.

Figure 4.6 shows that students still exhibited weakness in organization half way through the research cycle. Eight student journals (36.6%) were *novice* organizers of information. Six students (27.2%) were apprentice organizers of information. Five students (22.7%) organized information on a fractioned level. Less than 1% of the class (two students) exhibited an expert level of organization.

Most student journals demonstrated expert mathematical accuracy half way through the research period. Over half of the class' journals (12 of 22 students) exhibited expert mathematical accuracy. One student had a practitioner level of mathematical understanding. Three students exhibited that they understood the mathematical concept but were unable to complete the task. The teachers coded these student journals as apprentice in mathematical accuracy. The five remaining student journals exhibited novice mathematical accuracy.

The third criterion for analyzing the quality of student journals during the implementation of the intervention was the use of strategies. Overall, the greatest weakness in terms of use of strategies was a lack of representation or explanation. Four students (18.1%) exhibited a novice use of strategies. Six student journals (27.2%) demonstrated an apprentice quality of work. Ten students showed some application of the strategies and some use of representation or explanation. Finally, the remaining two journals exhibited an expert level of use of strategies (i.e., efficient strategy use and complete representation or explanation).

The action research cycle requires constant reflection on student progress. During the research, the teacher-researcher and 2nd grade team constantly reflected on the progress students made in place value problem-solving skills. The final journal entries demonstrated student success. The teacher-researcher presented the class with the problem-solving task that stated, “We have 125 plates left over after the STEM experiment. We can put them in the closet in boxes of 100, bags of 10, and individually. What are the BEST ways to store the plates? How do you know?” Figure 4.7 shows how the teachers coded the student journals for this question.

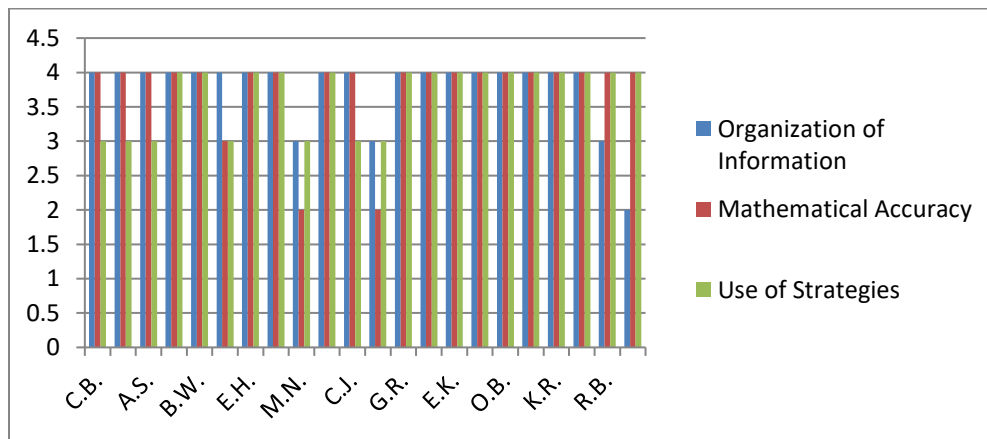


Figure 4.6. Week 6 journal entry coding data. The number 1 connotes *novice*; 2 = *apprentice*; 3 = *practitioner*; 4 = *expert*.

During the final week of the intervention, 20 of the 22 students (90.9%) exhibited the ability to organize information in a well-planned and organized fashion, indicating an expert level of understandings of how to organize mathematical information. The remaining two students (less than 1% of the class) exhibited all elements and were organized, indicating a practitioner level of organization of strategies. All students demonstrated a practitioner or expert level of organization.

In this problem-solving task, the accurate response was one box of 100, two bags of 10, and five individual plates. Nineteen students provided accurate answers to the problem-solving task. One student demonstrated a practitioner level of understanding because of minor errors in computation. The final student (M.N.) showed an understanding of the mathematical concept but was unable to accurately complete the task. The student journals indicated that all students understood the mathematical concept.

All students included a representation of information or explanation. Fifteen of the 22 students (68.1%) provided a complete representation or explanation. The 68.1% of students who demonstrated an expert use of strategies chose the most efficient strategy to solve the problem-solving task. An example of an expert explanation and representation was in O.B.'s problem-solving journal. O.B. illustrated one group of 100, two groups of 10, and five ones. In addition, O.B. explained her thinking and wrote, "So I could have one bag of one hundred plates, two ten bags, and five on bags. That would be the best way. It would be eight bags in all." The remaining seven students (31.8%) showed some application of the strategy but were practitioners in their use of strategies due to a lack of complete explanation or representation. To measure growth, the teacher-researcher

examined the growth of each domain: organization of information, mathematical accuracy, and use of strategies. Figure 4.8 shows student growth in organization of information during the intervention.

Figure 4.8 shows that between the first and third weeks of the intervention, ten students showed no growth, seven students showed one level of growth, two students showed two levels of growth, and two students shows three levels of growth in organizing information. One student decreased by one level in the organization of information between the first and third weeks of the intervention. However, by the sixth week of intervention, 12 students exhibited three levels of growth and ten students exhibited two levels of growth in the organization of information. Overall, 100% of the class showed growth in the organization of information in their problem-solving journals. The two main components to teaching place value skills through the problem-solving framework are the ability to problem-solve and mathematical accuracy. Figure 4.9 indicates the growth in mathematical accuracy over the 6-week intervention.

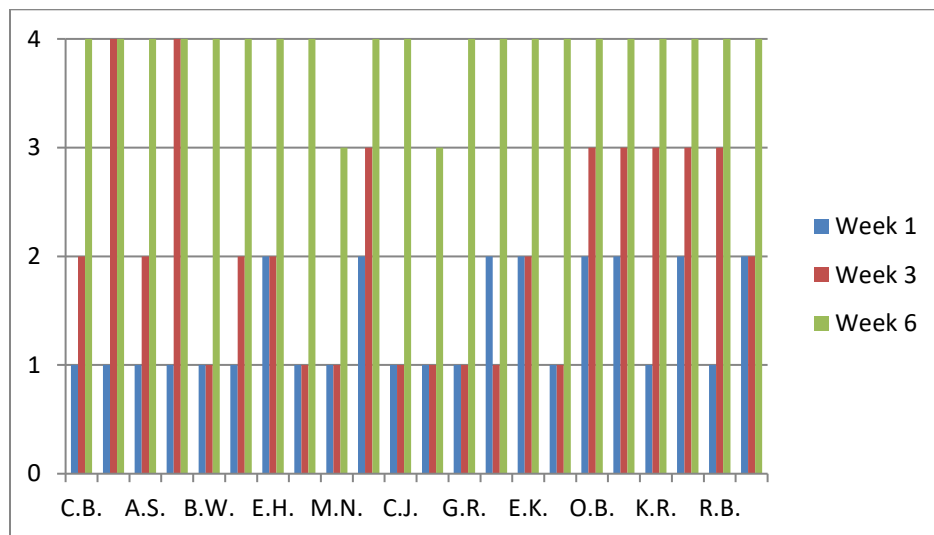


Figure 4.7. Organization of information growth. The number 1 connotes *novice*; 2 = *apprentice*; 3 = *practitioner*; 4 = *expert*.

Figure 4.9 shows students' growth at Week 1, Week 3, and Week 6 of the intervention. Students used their problem-solving journals daily but the researcher only used these three weeks for formal assessment of skills. Between the first and third weeks, five students showed a decrease in their level of mathematical accuracy. Six students did not show growth and three students increased their knowledge by one level. Eight students demonstrated a growth of three levels in mathematical accuracy. By the end of the intervention, four students exhibited the same level of mathematical accuracy. Five students demonstrated one level higher in their ability to perform accurate problem-solving tasks. Twelve students' mathematical accuracy increased by two levels. The third component of the student journals was students' use of strategies. Figure 4.10 outlines student growth in the use of strategies.

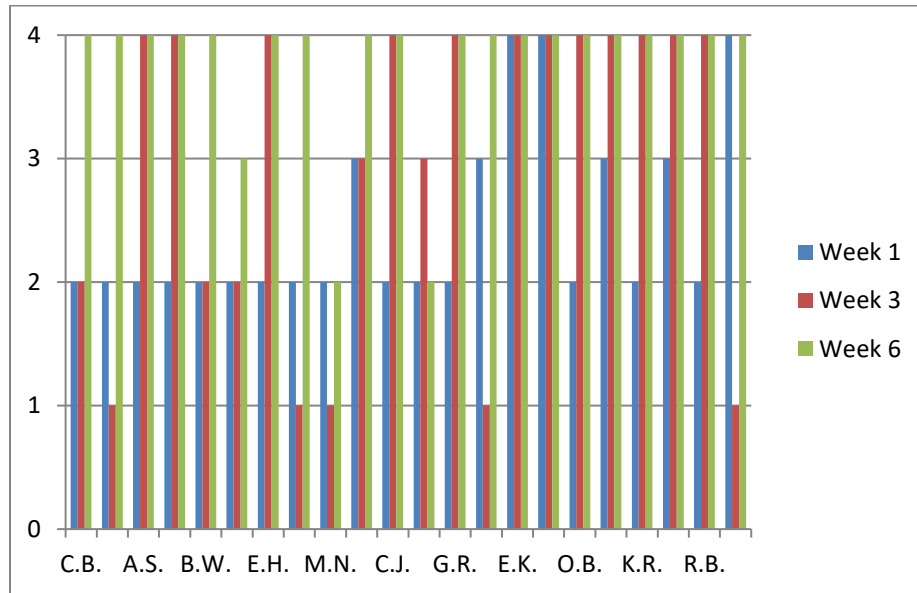


Figure 4.8. Mathematical accuracy growth. The number 1 connotes *novice*; 2 = *apprentice*; 3 = *practitioner*; 4 = *expert*.

The final component of the student journals was the use of strategies. The third week showed one student with negative growth, five students with no growth, six students with one level of growth, eight students with two levels of growth, and two

students with three levels of growth in the use of strategies. Twenty-one of the 22 students showed growth in the use of strategies by the sixth week of the intervention. The levels of growth in the use of strategies ranged from one student who exhibited one level of growth to thirteen students who demonstrated three levels of growth. Seven students showed two levels of growth in the use of strategies when problem-solving.

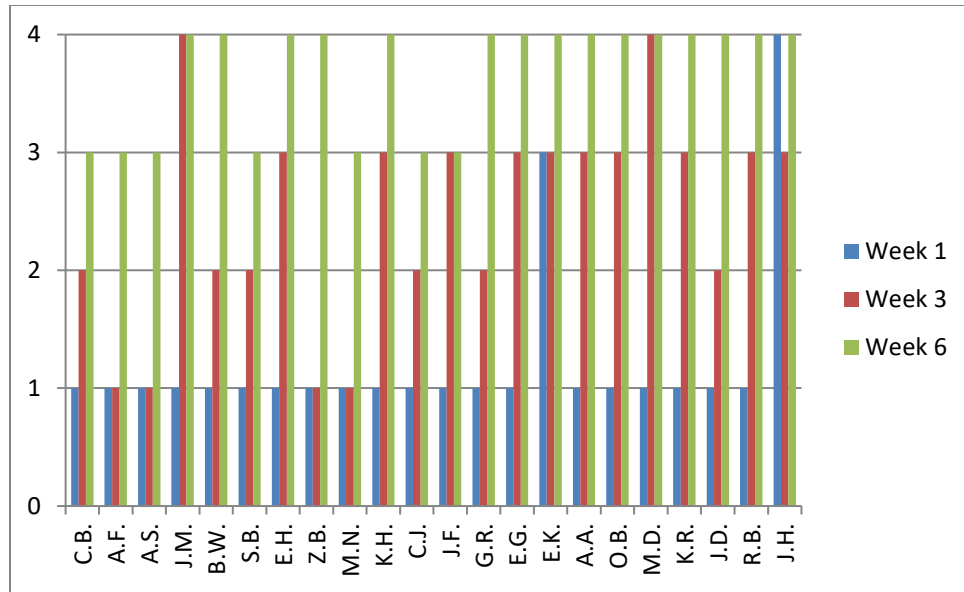


Figure 4.9. Use of strategies growth. The number 1 connotes novice; 2 = apprentice; 3 = practitioner; 4 = expert.

District benchmark. All 2nd grade students completed an end of the year mathematics benchmark assessment. The benchmark assessment indicated place value understanding. The problem-solving framework should improve conceptual understanding of the content (Markworth et al., 2015). The benchmark consisted of 40 questions that include all grade level mathematics standards. Appendix F shows each of the standards on the assessment. Students completed the assessment after the intervention study. The two standards that pertain directly to place value are 2.NSBT.1 and 2.NSBT.3. Table 4.3 includes the questions that align with the three place value standards the students learned during the research period.

Table 4.1
Benchmark Assessment Place Value Standards and Questions

Standard	Description	Benchmark Test Number
2.NSBT.1	Understand place value through 999 by demonstrating that: a. 100 can be thought of as a bundle (group) of 10 tens called a <i>hundred</i> ; b. the hundreds digit in a three-digit number represents the number of hundreds, the tens digit represents the number of tens, and the ones digit represents the number of ones; c. three-digit numbers can be decomposed in different ways (e.g., 524 can be decomposed as 5 hundreds, 2 tens, and 4 ones or 4 hundreds, 12 tens, and 4 ones, etc.	Question #8 Question #36
2.NSBT.3	Read, write, and represent numbers through 999 using concrete models, standard form, and equations in expanded form.	Question #4 Question #38

These four questions gave concrete data about how students translated learning place value concepts through problem-solving to a standardized test. Twenty-one of the 22 students in the sample took the assessment. There were two questions that tested the students' ability to understand place value through 999 (2.NSBT.1). On the eighth questions of the benchmark assessment, 19 students chose the correct answer and 2

students had incorrect answers. Question 36 also tested the students' ability to understand place value through 999. The information from the benchmark was scanned and uploaded on Mastery Connect, an online assessment tool issued by the district. Figure 4.11, generated by Mastery Connect, shows the data collected on the benchmark assessment based on each test item.

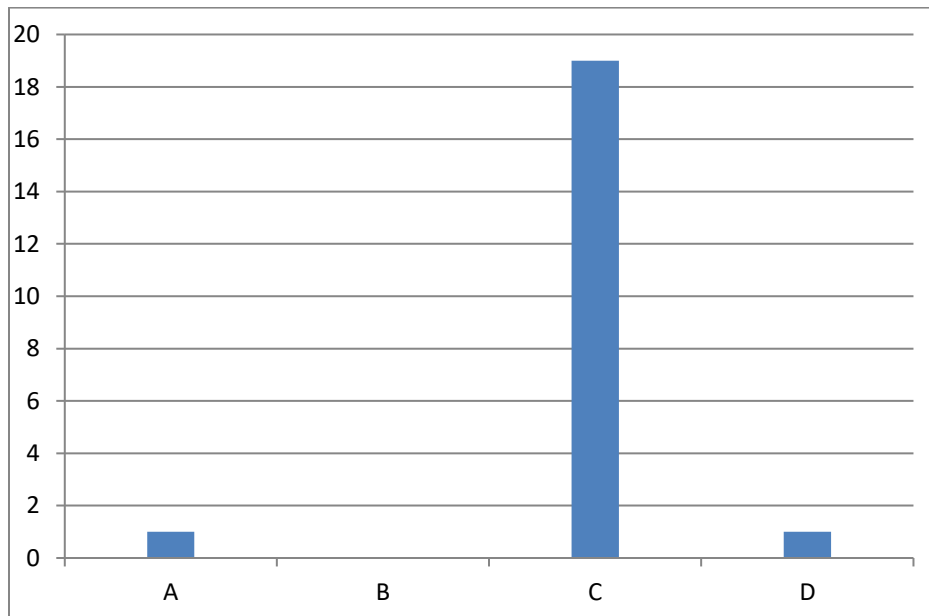


Figure 4.10. Benchmark assessment question 8 item analysis. The y axis connotes the number of students and the x axis connotes the answer choice.

All 21 students who took the test exhibited mastery of place value skills on question 36. The item analysis in Figure 4.12, generated by Mastery Connect, shows the student mastery exhibited on question 36 on the district benchmark assessment.

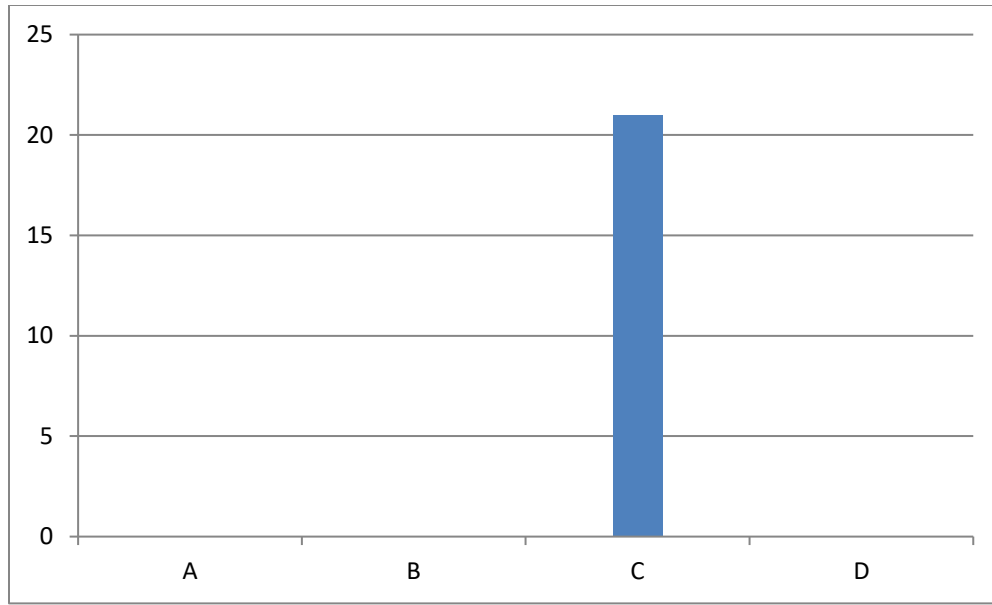


Figure 4.11. Benchmark assessment question 36 item analysis. The y axis connotes the number of students and the x axis connotes the answer choice.

The second applicable assessment on the benchmark test was 2.NSBT.3. Mastery of 2.NSBT.3 reflects that students can read, write, and represent numbers to 999. During problem-solving, students must represent and justify their mathematical thinking.

Question 4 on the benchmark assessment demonstrated student knowledge of 2.NSBT.3. Nineteen of the 21 students who took the benchmark assessment selected the correct answer. Two students chose incorrect answers. The item analysis from Mastery Connect appears in Figure 4.13.

The benchmark assessment also tested students' ability to read, write, and represent numbers through 999 on question 38. All 21 students exhibited mastery on question 38 of the benchmark assessment. Figure 4.14 shows data from Mastery Connect that demonstrates mastery of 2.NSBT.3.

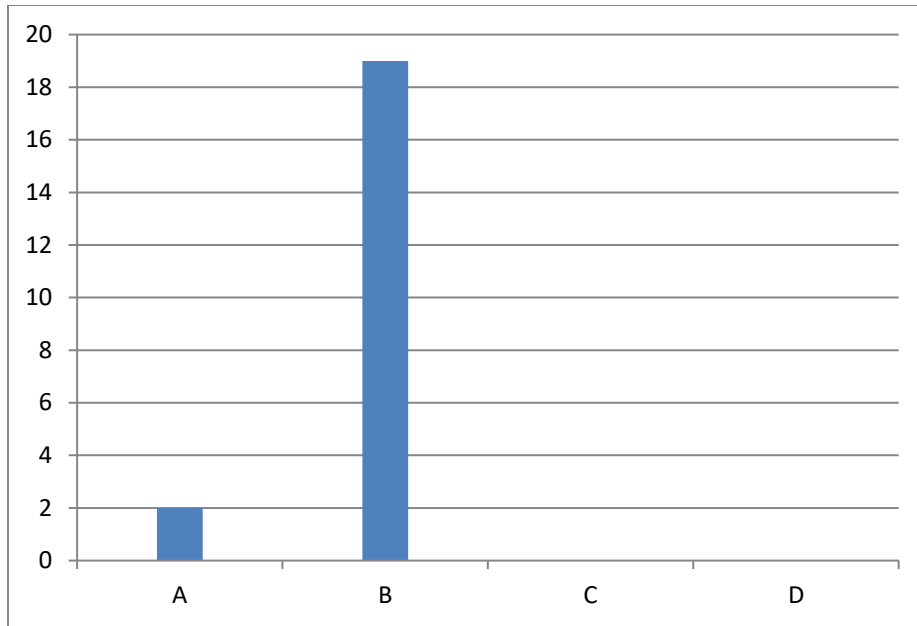


Figure 4.12. Benchmark assessment question 4 item analysis. The y axis connotes the number of students and the x axis connotes the answer choice.

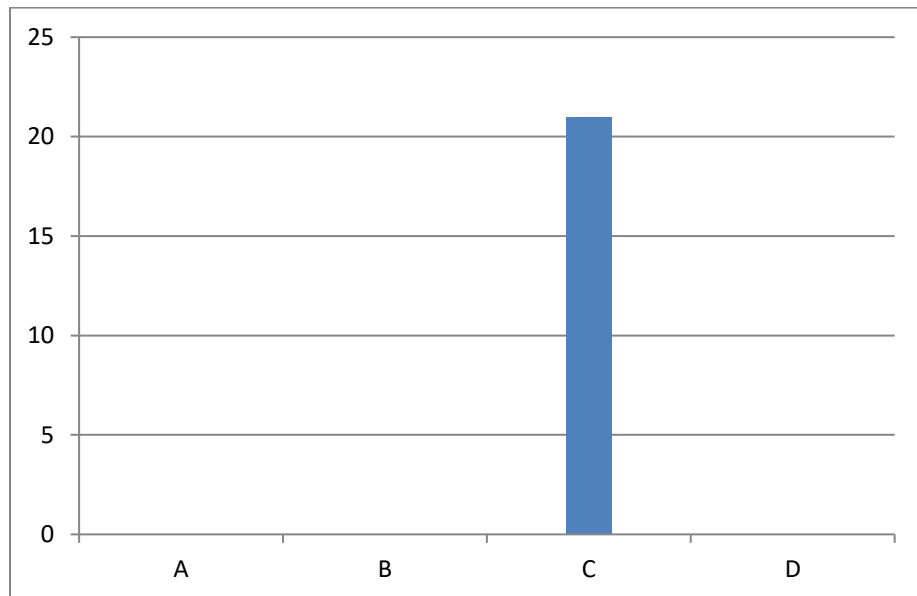


Figure 4.13. Benchmark assessment question 38 item analysis. The y axis connotes the number of students and the x axis connotes the answer choice.

The researcher analyzed each of the questions together to determine student mastery of the standards. The intervention focused on the place value standards. The Mastery Connect system graphed student mastery of this skill. If the students selected the correct answer on both items on the benchmark assessment that tested the same standard, then the program indicated mastery. If the students selected one correct and one incorrect item per standard, then the program indicated near mastery. Lastly, if a student selected two incorrect answers per standard question, the program indicated remediation was necessary. Figure 4.15, generated by Mastery Connect, shows the percentage of students who demonstrated mastery, near mastery, and remedial skills per standard.

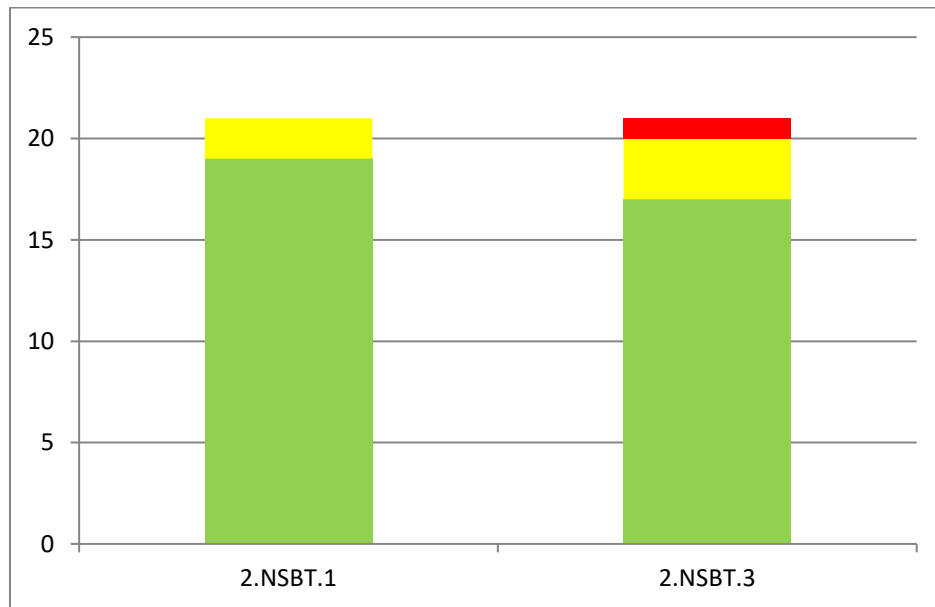


Figure 4.14. Class mastery by standard. The y axis connotes the number of students. Green connotes mastery, yellow connotes near mastery, and red connotes the need for remediation.

Figure 4.15 shows that 19 students (90.5%) exhibited mastery on problems that assessed South Carolina state standard 2.NSBT.1. The remaining two students (9.5%) demonstrated near mastery. Likewise, 17 students (81%) exhibited mastery of 2.NSBT.3 and three students (14.3%) exhibited near mastery. One student (4.8%) needed remediation to master 2.NSBT.3.

The researcher compared the scores of the students on the benchmark assessment to students who did not experience the intervention. There are two other 2nd grade teachers at R. Elementary. Mastery Connect generated a teacher comparison table based on mastery, near mastery, and remediation. Figure 4.16 indicates the differences between mastery of each standard per 2nd grade class. The teacher-researcher's class is in green.

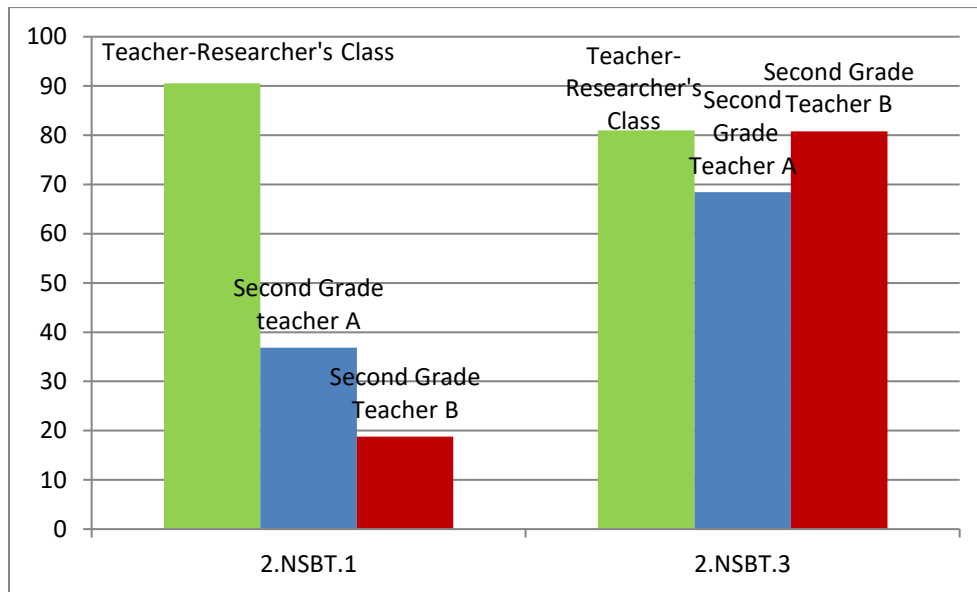


Figure 4.15. Mastery comparison of 2nd grade benchmark assessments. The y axis connotes the percentage of students in the class.

Figure 4.16 shows that 90.5% of the teacher-researcher’s class mastered 2.NSBT.1. In comparison, only 36.84% of the *blue* teacher’s students mastered 2.NSBT.1 according to the district math benchmark. Students in the *red* teachers class demonstrated only 18.75% mastery in understanding place value through 999. The teacher comparison shows that a greater number of students in the teacher-researcher’s class exhibited master on standard 2.NSBT.1 than the other two 2nd grade classes. Likewise, the teacher-researcher’s class showed 80.95% mastery on 2.NSBT.3. This score was equivalent to the *red* teacher’s class scores. The *blue* teacher’s class demonstrated 68.42% accuracy on reading, writing, and representing numbers to 999. The teacher comparison shows that the teacher-researcher’s class demonstrated an equivalent or greater understanding of 2.NSBT.3 on the district benchmark assessment.

Mastery Connect also generated a teacher comparison for near mastery students. Figure 4.17 shows the percentages of students who exhibited near mastery on the summative district benchmark. The teacher-researcher’s class is indicated in green.

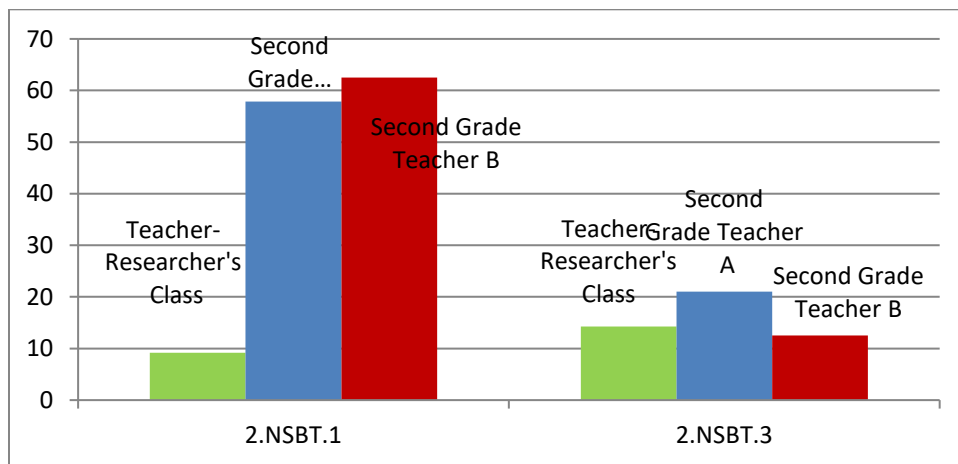


Figure 4.16. Near mastery comparison of 2nd grade benchmark assessments. The y axis connotes the percentage of students in the class.

The near mastery comparison shows that 9.2% of the teacher-researcher’s class, 57.89% of the *blue* teacher’s class, and 62.5% of the *red* teacher’s class almost mastered understanding place value to 999. Near mastery means the student correctly answered 50% of the 2.NSBT.3 assessment questions. Most students in the teacher-researcher’s class presented mastery on 2.NSBT.3. The *blue* teacher had the greatest number of students who nearly mastered 2.NSBT.3 compared to 21.05% to the teacher-researcher’s class in which 14.29% of the students nearly mastered the subject matter. The *red* teacher had 12.5% of her students score near mastery on 2.NSBT.3.

The third component of the teacher comparison was the group of students who needed remediation on place value skills as indicated by the benchmark assessment. Figure 4.18, generated by Mastery Connect, shows the percentage of students per 2nd grade class that required remediation of place value skills. The teacher-researcher is the green colored bar. The teacher-researcher developed a code book that aligned with Gojak’s (2013) problem-solving rubric (Appendix D). The codes helped the teacher-researcher analyze the students’ problem-solving journals for organization of information, mathematical accuracy, and use of strategies.

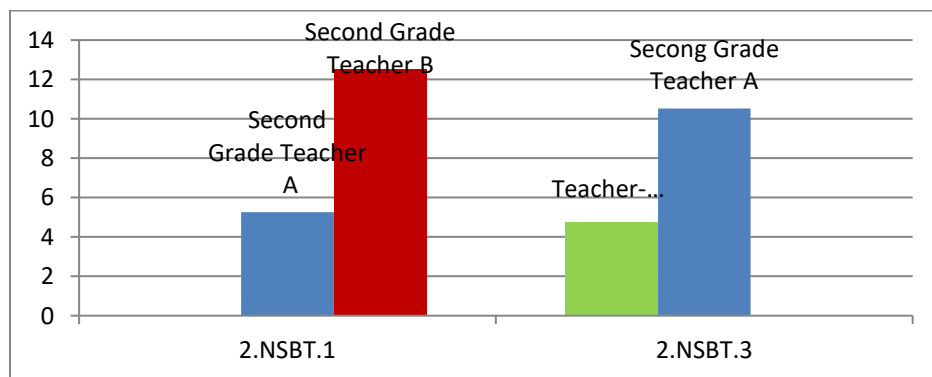


Figure 4.17. Remediation comparison of 2nd grade benchmark assessments. The y axis connotes the percentage of students in the class.

Figure 4.18 indicated that none of the teacher-researcher's students required remediation for 2.NSBT.1. There was a class-wide mastery of place value skills. Only 4.76% of the teacher-researcher's students required remediation on reading, writing, and representing place value. The *blue* teacher must provide remediation for 5.26% of her students and 10.53% of her students. The *red* teacher's benchmark test scores indicated that 12.5% of her class required remediation of 2.NSBT.1 and none of her class required remediation for 2.NSBT.3. Compared to other teachers, the teacher-researcher had the most students who mastered both place value standards. The teacher-researcher's benchmark assessment scores indicated the smallest percent of remediation.

4.3 Analysis of Data

According to the results of Gojak's (2013) rubric, all students using the *launch-explore-summarize/extend* framework demonstrated growth on problem-solving tasks in place value over the 6-week intervention period. Evidence of growth appears in Figures in chapter four. The data indicated the impact of the problem-solving framework on problem-solving success in a 2nd grade mathematics classroom. The researcher defined success as student advancement through the levels of problem-solving: novice, apprentice, practitioner, and expert. The data indicated that all but one student exhibited an advancement of problem-solving level, including place value accuracy.

The results of the researcher's analyses of journals indicated an increased understanding of organization, mathematical accuracy, and use of strategies. The students exhibited increased understanding of problem-solving and place value skills in their problem-solving journals. The data supported that the problem-solving framework affected student problem-solving of tasks in a place value unit.

The district benchmark assessment indicated that student place value knowledge increased after the intervention. The results of the benchmark are consistent with the student assessments the researcher graded using Gojak's (2013) rubric and the data from the student journals. Teacher comparisons indicated that students who learn place value skills using the problem-solving framework are more likely to develop mastery of the place value skills. Collectively, the rubrics, journals, and benchmark assessments indicate the impact of the problem-solving framework on student problem-solving success on place value tasks in a 2nd grade mathematics classroom. All data indicated student growth and/or significance in problem-solving success on place value tasks.

4.4 Summary

Overall, the results of the study demonstrated significant differences in problem-solving success on place value tasks in a 2nd grade mathematics classroom. Twenty-one of the 22 student participants exhibited advancement in problem-solving after the 6-week intervention. One student remained stagnant according the post-assessment via the problem-solving rubric.

Assessment of mathematical accuracy on the rubric and through constant comparative coding aligned with the results of the benchmark assessment. The *launch-explore-summarize/extend* problem-solving framework provides students with an opportunity to discover mathematical understandings (Lester, 2003). The assessment of mathematical accuracy ensures that the students developed a solid understanding of place value concepts by using the problem-solving model. The benchmark assessment data indicated that 90.5% of students exhibited mastery of South Carolina state standard

2.NSBT.1 and 9.5% (2 students) exhibited near mastery. In addition, 17 students (81%) exhibited mastery of 2.NSBT.3 and three students (14.3%) were near mastery.

The data determined the impact of the *launch-explore-summarize/extend* problem-solving framework on a 2nd grade mathematics classroom in South Carolina. As an action research study, the collection of data continues the cycle of improvement of instruction to best meet the needs of all students in the teacher-researcher's class.

The continuous cycle of reflection in the action research process required the teacher-researcher to critically examine mathematics instruction. The data indicated that the *launch-explore-summarize/extend* framework positively influences student success. Through assessments, student journals, and benchmark assessments, the cycle of reflection will continue to benefit students' understanding of problem-solving in place value.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

The researcher used a mixed-method design to investigate the impact of the *launch-explore-summarize/extend* problem-solving framework in teaching number sense and base ten skills to 2nd grade students. Using teacher-made problem-solving assessments quantitatively and student journals qualitatively, the teacher-researcher analyzed student growth. This chapter includes the conclusions and recommendations of the data collected during the intervention.

5.2 Problem of Practice

Varied mathematics instruction in the United States often includes explicit instruction, textbooks, procedural skills, and memorization. Each skill contributes to mathematical proficiency but all five strands are necessary to develop mathematical proficiency. Direct procedural instruction using specifically taught strategies is one teaching method in which students are often left lacking conceptual knowledge (Lester, 2003). Problem-solving is an integration of word problems into previously learned skills in the mathematics classroom. As a result, the lack of exploration results in low critical thinking skills and a disconnection from real-world applications (Lester, 2003).

Problem-solving can teach students new mathematical skills. Problem-based instruction allows students to create strategies and reflect on problem-solving methods to develop critical thinking skills (Cai & Lester, 2003). Instructors can use problem-solving

to teach all mathematical standards. Data from the school and district where the researcher conducted the present study indicated a need for focused instruction in number sense and base ten tasks.

School and district SC Ready scores exemplified the need for base ten and number sense instruction that fosters conceptual understanding. In 2017, 47.9% of 3rd graders in district SC Ready scored *low* on number sense and base ten tasks. Similarly, 56% of 4th graders had low number sense skills. Sixty percent of 5th graders scored *low* on number sense and base ten tasks. Overall, 27.1% of 3rd graders in the district exhibited *high* achievement on base ten and number sense problems. The SC Ready scores revealed a problem at the elementary school of study. Twenty two percent of 4th graders and 11% of 5th graders preformed in the *high* category on number sense and base ten tasks. At this school, 21% of 3rd graders scored *low* and 20% scored *medium* on base ten problems. More than half of the school population was *not competent* in base ten concepts; 56% of 4th graders and 76% of 5th graders were in the *low* or *medium* range. These data indicated a problem of practice for the research study.

5.3 Research Question

The research question of the action research study was as follows:

What is the impact of the *launch-explore-summarize/extend problem-solving framework* on students' problem-solving success on place value tasks in a second-grade classroom?

5.4 Purpose of the Study

The action research study determined how to improve students' number sense and base ten understanding in a second-grade mathematics class by implementing the *launch-*

explore-summarize/extend mathematical framework. The purpose of the study was to determine if problem-solving builds critical thinking skills and increases mathematical understanding of place value in a second-grade class.

5.5 Overview of Methodology

An action research design guided the dissertation in practice. Through the action research design, the researcher identified the benefits of problem-solving on place value understanding in a 2nd grade mathematics class. The researcher assessed the influence of problem-solving on student place value success using problem-solving assessments and student journals. Following Mertler's (2014) action research cycle, the researcher collected data in a 2nd grade classroom at an elementary school in Columbia, South Carolina while continuing the current educational process and maintaining a positive learning environment. Using the data from assessments and journals, the teacher-researcher found that the problem-solving framework substantially improved problem-solving success.

This chapter of the dissertation in practice contains discussions of the results, findings, the action researcher as a curriculum leader, and action plan. It also includes the recommendations for practice, implications for research, and an overall summary. Each section outlines the implications of the action research study.

5.6 Results and Findings

The research findings indicated that the *launch-explore-summarize/extend* problem-solving framework demonstrated a positive impact on problem-solving success on place value tasks in a 2nd grade mathematics classroom. Student growth in problem-solving success during the 6-week intervention was present in 21 of the 22 students in the

participant sample. The post-assessment revealed that one student did not experience growth.

Student journals indicated growth for all students in at least one of the domains: organization, mathematical accuracy, and/or use of strategies. By the end of the intervention, all students demonstrated growth in at least one domain. In addition, 19 of the 22 students finished the intervention as practitioner or expert problem-solvers in all three domains.

The district benchmark assessment provided triangulation. The benchmark assessment data indicated that 19 of the 22 students exhibited mastery of South Carolina state standard 2.NSBT.1 and two students exhibited near mastery. Seventeen students exhibited mastery of 2.NSBT.3 and three students exhibited near mastery. The data suggests that the *launch-explore-summarize/extend* framework positively influences students' problem-solving success according to the mastery of place value skills.

5.7 Action Researcher as a Curriculum Leader

The action researcher is a curriculum leader at the school in this study. As the early childhood math facilitator, the teacher-researcher educates and assists teachers in implementing research-based mathematical instruction. In addition, the teacher-researcher attends district mathematics professional development and collaborates with early childhood mathematics teachers from schools around the district.

The district where the researcher conducted the study advocates the use of the *launch-explore-summarize/extend* problem-solving framework. After the research cycle, the principal of R. Elementary asked the teacher-researcher to provide three professional development opportunities to the early childhood teachers at the school. All early

childhood teachers had the opportunity to observe the teacher-researcher's classroom after the study to see how the problem-solving framework guided instruction and built conceptual understanding. Through these presentations and observations, the staff at R. Elementary began to embrace and implement the problem-solving instructional strategy. Currently, all early childhood classrooms use the problem-solving framework to teach mathematics each day.

5.8 Action Plan

The researcher shared the findings regarding the impact of the *launch-explore-summarize/extend* problem-solving framework with teachers, administrators, the early childhood math consultant, and other educational leaders in the district. The researcher will continue to share the results of the study during school-wide professional learning opportunities to inform others of the impact of the framework on student understanding. The teacher-researcher shared the findings with the district math consultant to encourage the creation of a professional development session for the early childhood math facilitators on the *launch-explore-summarize/extend* problem-solving framework in the teacher-researcher's 2nd grade classroom. The results of the study may serve as a reference during professional development for the school and district.

Using Mertler's (2014) action research cycle, the teacher-researcher implemented the *launch-explore-summarize/extend* problem-solving framework for all mathematical standards during the school year. This action research study focused on the skill of place value. However, the teacher-researcher can use the problem-solving framework to teach all mathematical topics. In the upcoming year, the teacher-researcher plans to implement the problem-solving framework as the instructional technique for mathematics. The

teacher-researcher will continue to collect data using problem-solving assessments and student journals to determine the impact of the intervention on each standard. The teacher-researcher will continually perform the action research cycle each for each unit and every child to ensure all students have a conceptual understanding of the necessary mathematics skills for the 2nd grade. The 6-week intervention lacked parent communication outside of consent to participate and graded papers. The teacher-researcher plans to involve parents in the research process during the next cycle to create a home/school connection that is often lacking from mathematics instruction.

5.9 Recommendations for Practice

Based on the research findings, the teacher-researcher recommends the *launch-explore-summarize/extend* problem-solving framework to early childhood teachers teaching base ten and place value skills. Data from the pre- and post-assessments showed that 21 of the 22 students made gains during the 6-week intervention, which suggests that the *launch-explore-summarize/extend* problem-solving framework had a positive impact on the teacher-researcher's 2nd grade class' base ten and place value skills. Therefore, the teacher-researcher recommends the use of the problem-solving framework for teaching place value in the 2nd grade.

More specifically, 20 of the 22 students progressed from novice (level one) to expert (level four) when organizing information. Data on the organization of information suggests that the intervention helped students learn how to organize mathematical information. Twenty students improved in mathematical accuracy. The mathematical accuracy data suggests that most of the class learned place value skills through the *launch-explore-summarize/extend* problem-solving framework. Finally, all 22 students in

the participant sample exhibited growth in the use of strategies, suggesting that a strength of the framework is that students learn to use efficient strategies and justify their mathematical choices. Based on the data from Gojak's (2013) rubric, the teacher-researcher recommends using the rubric in early childhood classrooms to guide instructional goals and student problem-solving progress.

Data from the student journals indicated that by the end of the intervention, 19 of the 22 students improved their organization of information, mathematical accuracy, and use of strategies. Two students lacked growth in accuracy and one did not improve in the organization of information. This suggests that teaching with the *launch-explore-summarize/extend* problem-solving framework can enhance students' abilities to organize information and use strategies to form accurate mathematical answers. Therefore, the teacher-researcher suggests that mathematics classrooms use problem-solving journals as an effective way for students to practice organizing mathematics ideas.

Finally, the test items that assessed 2.NSBT.1 and 2.NSBT.3 on the district benchmark assessment indicated that all students understood 2.NSBT.1 and most students (20 students) understood 2.NSBT.3. The benchmark data suggests that students can master base ten and number sense skills using the *launch-explore-summarize/extend* problem-solving framework. The problem-solving assessment, journals, and benchmark data all suggest that the *launch-explore-summarize/extend* problem-solving framework positively influenced student place value and base ten understanding, use of strategies, and organization. The teacher-researcher suggests that the problem-solving framework be used to teach place value skills in 2nd grade mathematics classrooms.

5.10 Implications for Future Research

The research study had a participant sample of 22 students in a traditional 2nd grade classroom. The researcher selected this sample due to convenience. The study's sample size of 22 students is not generalizable. A suggestion for future research is to broaden the participant sample to multiple early childhood classrooms. The sample did not include racial diversity. The teacher-researcher's class had 16 Caucasian students. A suggestion for future research is to expand the sample size to include students of more ethnicities. The research sample included children from the upper/middle class. Future research should expand the sample size to include more socioeconomic diversity.

The researcher focused on place value skills. Future researchers should study the impact of the problem-solving framework on different standards and mathematical skills. Some examples of skills that may benefit from the problem-solving framework of instruction include addition, subtraction, geometry, arrays, time, measurement, and word problems. Each mathematical skill provides another topic for future research. Furthermore, researchers could compare the different mathematical skills to determine whether the problem-solving framework produces similar or different results based on the mathematical skill the students learn.

The impact of the *launch-explore-summarize/extend* problem-solving framework requires additional research with other grade levels across the country and world. Future researchers could delve into the impact of the framework on early childhood, elementary, middle, or high school students. Future studies could analyze the effectiveness of the intervention at private and public schools. A comparison of the results of each study could provide greater understanding of the accessibility of the problem-solving

framework for all students. The *launch-explore-summarize/extend* problem-solving framework may also be useful for science, social studies, and ELA classes. Future researchers should analyze the impact of problem-solving on various content areas for students of different grades and in different educational settings.

5.11 Summary

This action research study determined the effect of the *launch-explore-summarize/extend* problem-solving framework on an early childhood mathematics class that was learning number sense and base ten concepts. The researcher measured its overall impact on students using problem-solving assessments, student journals, and a benchmark assessment. The data collected during the intervention revealed that the *launch-explore-summarize/extend* problem-solving framework positively influences students' understanding of place value understanding.

As a curriculum leader, the teacher-researcher shared the findings from the literature review and data analysis with colleagues and district leaders to increase the likelihood of using the *launch-explore-summarize/extend* problem-solving framework for mathematics instruction throughout the school and district. The teacher-researcher will continue the action research cycle with other mathematical standards and different students in the coming years. The impact of this action research on the teacher-researcher goes beyond the 6-week intervention and will permeate all future mathematics instruction in the teacher-researcher's classroom. The results of this study indicated a significant difference in student achievement and mastery of base ten skills after use of the problem-solving framework for instruction. Future studies are necessary to confirm the effect of

the *launch-explore-summarize/extend* problem-solving framework on student base ten and number sense success.

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APPENDIX A

PROBLEM-SOLVING RUBRIC

Criteria	Level One (Novice)	Level Two (Apprentice)	Level Three (Practitioner)	Level Four (Expert)
Organization of Information	<ul style="list-style-type: none"> • Random • Incomplete • Missing elements 	<ul style="list-style-type: none"> • Mostly complete • Hit-and-miss approach • Most elements are present 	<ul style="list-style-type: none"> • All elements represented • Shows a plan or appropriate strategy • Organized 	<ul style="list-style-type: none"> • Well-planned • Complete and displayed in an organized fashion
Mathematical Accuracy	<ul style="list-style-type: none"> • Major errors in computation and explanation 	<ul style="list-style-type: none"> • Chose appropriate mathematical concept but unable to accurately complete the task 	<ul style="list-style-type: none"> • Minor errors in computation but demonstrates conceptual understanding 	<ul style="list-style-type: none"> • Accurate
Use of Strategies	<ul style="list-style-type: none"> • Lack of strategic approach to task • No explanation 	<ul style="list-style-type: none"> • Some demonstration of strategic approach but incomplete or lack of follow through • No representation or explanation 	<ul style="list-style-type: none"> • Shows some application of strategies but not efficient • Some use of representation and or explanation 	<ul style="list-style-type: none"> • Use of efficient and appropriate strategy or combination of strategies. • Includes a complete representation or explanation

Summary:

Organization of Information Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Mathematical Accuracy Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Use of Strategies Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Notes:

APPENDIX B

PROBLEM-SOLVING LESSON PLAN

RECYCLING CANS FOR EARTH DAY

The second-grade class at Emerson Elementary collected cans for Earth Day. They can be turned in to the recycling center in trash bags that hold 100 cans and grocery bags that hold 10 cans. The second-grade class collected a total of 372 cans. What are different ways the students can sort the cans into bags to take to the recycling center? Choose which way you think is best and write a letter to Emerson Elementary describing why your method is the best method.

CCSSM STANDARD FOR MATHEMATICAL PRACTICE

Practice 7: Look for and make use of structure.

CCSSM STANDARD FOR MATHEMATICAL CONTENT

2.NBT.A.1: Understand that the three digits of a three-digit number represent amounts of hundreds, tens, and ones; e.g., 706 equals 7 hundreds, 0 tens, and 6 ones.

PROBLEM DISCUSSION

This task builds on students' first-grade experiences in which they developed place-value understanding for two-digit numbers (1.NBT.B.2) and connected the number words, numerals, and quantities to these two-digit numbers (Clements and Sarama 2009). That is, first-grade students come to an understanding that thirty-five is represented as the numeral 35 and not 305 and that it can be represented as $30 + 5$ or as $10 + 10 + 10 + 5$ (three groups of ten and five ones). In second grade, students extend this understanding to three-digit numbers (2.NBT.A.1). This task explores the place-value concept "that all adjacent places have the same exchange values: exchange one unit to the left for ten units to the right and vice versa" (Clements and Sarama 2009, p. 89).

Students are asked to find multiple representations of the number 372 using groups of hundreds, tens, and ones. They will need to recognize the base-ten structure of the number system as they compose groups of 10 tens or 10 ones and decompose a group of 1 hundred or 1 ten into 10 tens or 10 ones, respectively (SMP 7). Through the context of the problem, students are able to make decisions about the reasonableness of three large trash bags, which they may not be able to carry, versus thirty-seven small grocery bags, which may take more trips, but are easier to carry. Students will also need to consider the practicality of breaking apart a bag of ten cans and two leftovers into twelve leftover cans. Students may use a variety of strategies to verify the number of cans they have, including skip counting by place value and combining place-value parts (Battista 2012).

STRATEGIES

- Students may decompose the 7 grocery bags and 2 leftovers into 6 grocery bags and 12 leftovers.



- Students use their knowledge of the expanded form of the number ($300 + 70 + 2$) to find the solution of 3 trash bags, 7 grocery bags, and 2 leftovers.
- Students may take away 10 cans from 300 to create an additional grocery bag, and then repeat this process, keeping track of how many times they have created a grocery bag, until they have 2 trash bags, 17 grocery bags, and 2 leftovers.
- Students may automatically decompose one trash bag of 100 cans into 10 grocery bags with 10 cans in each bag.
- When asked how many cans in all, students may skip-count by place value. For example, 2 trash bags, 17 grocery bags, and 2 leftovers are counted as "100, 200, 210, 220, ... 370, 371, 372."
- When asked how many cans in all, students may combine place-value parts such as grouping 5 grocery bags together and knowing this represents 50 cans without counting by tens. For example, 2 trash bags, 17 grocery bags, and 2 leftovers is the same as 2 trash bags, 5 + 5 + 5 + 2 grocery bags, and 2 leftovers and counted as "200, 250, 300, 350, 370, 372."
- When asked how many cans in all, students may use a number sentence to find the total number of cans; for example, the sum of 2 trash bags, 17 grocery bags, and 2 leftovers is found by $200 + 170 + 2$.

MISCONCEPTIONS/STUDENT DIFFICULTIES

- Students may not understand how to exchange adjacent place values; for instance, one group of 100 can be exchanged for ten groups of 10.
- Students may only focus on the digits that represent the number of bags and not remember what the bags represent (e.g., 3 trash bags represent 3 cans, not 300 cans.)
- If students focus on the number of each size bag rather than how many cans are represented by the number, they may notice that 3, 7, and 2 sum to 12 and find the solution 2, 8, 2.
- Students may think the number of each type of bag leads directly to the written numeral that represents the total number of cans; for example, 2 trash bags, 17 grocery bags, and 2 leftovers are represented as 2,172.

LAUNCH

Ask students to think about how many cans are recycled every second in the United State. Have students participate in a four-corners activity where they choose the range of number that represents their guess. Corners could be labeled less than 100, between 100 and 1,000, between 1,000 and 3,000, more than 3,000. According to the Can Manufacturers Institute website (www.cancentral.com), 105,800 cans are recycled each minute in the United States at approximately 1,763 cans per second.

Write the number 1,763 on the board. Ask students to discuss with a classmate in their corner what each of the digits in the number represents; for example, two students might discuss that the 7 represents seven groups of 100 or 700 cans. Finally, have students share with the larger group.

EXPLORE

Distribute the handout and read the task as a class. Clarify that the trash bags hold 100 cans and that the grocery bags hold 10 cans. Showing a trash bag and a grocery bag to students may help them better understand the context. Ask students to individually find two ways to organize the 372 cans into bags. For students who are struggling to decompose 100 into ten groups of 10, provide base-ten manipulatives. Have them record their work in the table on their handout. Students should then work with a partner to prove that each of their solutions does indeed total 372 cans.

Ask the following questions to check for understanding:




- What does the (number) mean in the trash bag (or grocery bag or leftovers) column? (You are seeking an answer that includes the number of cans in each bag and the total number of cans. For example, the 3 in the trash bag column means 3 bags each with 100 cans for a total of 300 cans.)
- How many groups of ten are in 170? How do you know?
- How did you decompose the number of cans in the trash bag? (Did they repeatedly take 10 away from 100 or did they automatically know 100 could be decomposed into ten groups of 10?)
- How do you know you have 372 cans? Can you count the total number of cans in a different way? (Do they skip-count by place value or combine place-value parts?)
- Is it possible to have more than 2 cans leftover? Why or why not?

SUMMARIZE

Select a student to fill in one line of the table and share his strategy for proving his numbers represent 372 cans. Ask students who had the same answer if they have another method for proving this entry represents 372 cans. Then ask if anyone has a different solution, repeating the process until all possible entries with no more than 2 leftover cans are entered into the table. Placing their solutions as ordered in the table below allows students to investigate the structure of place value in the task. For example, they may notice that when the number of trash bags goes down by one, the number of garbage bags increases by ten. The solutions in the table are those that contain the fewest number of leftovers. Students may find solutions that do not minimize the number of leftovers, such as 3 trash bags (300 cans), 5 grocery bags (50 cans), and 22 leftover cans.

Encourage a variety of strategies, including skip counting by place value and combining place-value parts. For the solution of 2 trash bags, 17 grocery bags, and 2 leftovers, a student may count "100, 200, 210, 220, ... 370, 371, 372." For the same solution a student who combines place-value parts may count "200, 250, 300, 350, 370, 372." If students use a number sentence such as "The total of 2 trash bags, 17 grocery bags, and 2 leftovers is found by $200 + 170 + 2$," include it in a fourth column. If a student has decomposed a group of ten into 10 ones, discuss the practicality of the solution in the context of the problem.



		
Trash Bag	Grocery Bag	Leftover Cans
3	7	2
2	17	2
1	27	2
0	37	2

DIFFERENTIATION

- To support struggling students, encourage the use of base-ten manipulatives.
- To accommodate struggling students, use a smaller number, such as 145, for the number of cans to be recycled.
- To extend this task, ask students to write a number sentence for each entry in the table; for example, 1 trash bag, 27 grocery bags, and 2 leftovers can be expressed as $100 + 270 + 2$.
- To extend this task, ask students to find different ways to transport 1,763 cans to the recycling center.
- To extend this task, ask students to predict how much a trash bag of 100 empty soda cans would weigh. (An empty 12-ounce soda can weighs approximately 0.5 ounce.)

APPENDIX C

ASSESSMENTS

Place Value Pre-Assessment

Name: _____

Date: _____

The second-grade class at Emerson Elementary collected books for the library. They can be turned in to the school in large boxes that hold 100 books and small boxes that hold 10 books. The second-grade class collected a total of 265 books. What are the different ways the students can sort the books into boxes to take to the school? Chose which way you think is best. Show your work and explain your thinking:

Criteria	Level One (Novice)	Level Two (Apprentice)	Level Three (Practitioner)	Level Four (Expert)
Organization of Information	<ul style="list-style-type: none"> • Random • Incomplete • Missing elements 	<ul style="list-style-type: none"> • Mostly complete • Hit-and-miss approach • Most elements are present 	<ul style="list-style-type: none"> • All elements represented • Shows a plan or appropriate strategy • Organized 	<ul style="list-style-type: none"> • Well-planned • Complete and displayed in an organized fashion
Mathematical Accuracy	<ul style="list-style-type: none"> • Major errors in computation and explanation 	<ul style="list-style-type: none"> • Chose appropriate mathematical concept but unable to accurately complete the task 	<ul style="list-style-type: none"> • Minor errors in computation but demonstrates conceptual understanding 	<ul style="list-style-type: none"> • Accurate
Use of Strategies	<ul style="list-style-type: none"> • Lack of strategic approach to task • No explanation 	<ul style="list-style-type: none"> • Some demonstration of strategic approach but incomplete or lack of follow through • No representation or explanation 	<ul style="list-style-type: none"> • Shows some application of strategies but not efficient • Some use of representation and or explanation 	<ul style="list-style-type: none"> • Use of efficient and appropriate strategy or combination of strategies • Includes a complete representation or explanation

Summary:

Organization of Information Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Mathematical Accuracy Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Use of Strategies Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Notes:

Place Value Assessment 1

Name: _____

Date: _____

How many different ways can you make 74 with ones and tens? Show your work and explain your thinking:

Criteria	Level One (Novice)	Level Two (Apprentice)	Level Three (Practitioner)	Level Four (Expert)
Organization of Information	<ul style="list-style-type: none"> • Random • Incomplete • Missing elements 	<ul style="list-style-type: none"> • Mostly complete • Hit-and-miss approach • Most elements are present 	<ul style="list-style-type: none"> • All elements represented • Shows a plan or appropriate strategy • Organized 	<ul style="list-style-type: none"> • Well-planned • Complete and displayed in an organized fashion
Mathematical Accuracy	<ul style="list-style-type: none"> • Major errors in computation and explanation 	<ul style="list-style-type: none"> • Chose appropriate mathematical concept but unable to accurately complete the task 	<ul style="list-style-type: none"> • Minor errors in computation but demonstrates conceptual understanding 	<ul style="list-style-type: none"> • Accurate
Use of Strategies	<ul style="list-style-type: none"> • Lack of strategic approach to task • No explanation 	<ul style="list-style-type: none"> • Some demonstration of strategic approach but incomplete or lack of follow through • No representation or explanation 	<ul style="list-style-type: none"> • Shows some application of strategies but not efficient • Some use of representation and or explanation 	<ul style="list-style-type: none"> • Use of efficient and appropriate strategy or combination of strategies • Includes a complete representation or explanation

Summary:

Organization of Information Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Mathematical Accuracy Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Use of Strategies Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Notes:

Place Value Assessment 2

Name: _____

Date: _____

What is the largest number you can make with 5 and 8? Show your work and explain your thinking:

Criteria	Level One (Novice)	Level Two (Apprentice)	Level Three (Practitioner)	Level Four (Expert)
Organization of Information	<ul style="list-style-type: none"> • Random • Incomplete • Missing elements 	<ul style="list-style-type: none"> • Mostly complete • Hit-and-miss approach • Most elements are present 	<ul style="list-style-type: none"> • All elements represented • Shows a plan or appropriate strategy • Organized 	<ul style="list-style-type: none"> • Well-planned • Complete and displayed in an organized fashion
Mathematical Accuracy	<ul style="list-style-type: none"> • Major errors in computation and explanation 	<ul style="list-style-type: none"> • Chose appropriate mathematical concept but unable to accurately complete the task 	<ul style="list-style-type: none"> • Minor errors in computation but demonstrates conceptual understanding 	<ul style="list-style-type: none"> • Accurate
Use of Strategies	<ul style="list-style-type: none"> • Lack of strategic approach to task • No explanation 	<ul style="list-style-type: none"> • Some demonstration of strategic approach but incomplete or lack of follow through • No representation or explanation 	<ul style="list-style-type: none"> • Shows some application of strategies but not efficient • Some use of representation and or explanation 	<ul style="list-style-type: none"> • Use of efficient and appropriate strategy or combination of strategies • Includes a complete representation or explanation

Summary:

Organization of Information Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Mathematical Accuracy Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Use of Strategies Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Notes:

Place Value Assessment 3

Name: _____

Date: _____

When you come into class on Monday morning some numbers are missing from the 100s chart. The numbers missing are 2, 15, 73, 85, 28, and 50. You only have five minutes to get them back up before class starts. What are some ways you could organize the numbers to quickly put them back? Show your work and explain your thinking:

Criteria	Level One (Novice)	Level Two (Apprentice)	Level Three (Practitioner)	Level Four (Expert)
Organization of Information	<ul style="list-style-type: none"> • Random • Incomplete • Missing elements 	<ul style="list-style-type: none"> • Mostly complete • Hit-and-miss approach • Most elements are present 	<ul style="list-style-type: none"> • All elements represented • Shows a plan or appropriate strategy • Organized 	<ul style="list-style-type: none"> • Well-planned • Complete and displayed in an organized fashion
Mathematical Accuracy	<ul style="list-style-type: none"> • Major errors in computation and explanation 	<ul style="list-style-type: none"> • Chose appropriate mathematical concept but unable to accurately complete the task 	<ul style="list-style-type: none"> • Minor errors in computation but demonstrates conceptual understanding 	<ul style="list-style-type: none"> • Accurate
Use of Strategies	<ul style="list-style-type: none"> • Lack of strategic approach to task • No explanation 	<ul style="list-style-type: none"> • Some demonstration of strategic approach but incomplete or lack of follow through • No representation or explanation 	<ul style="list-style-type: none"> • Shows some application of strategies but not efficient • Some use of representation and or explanation 	<ul style="list-style-type: none"> • Use of efficient and appropriate strategy or combination of strategies • Includes a complete representation or explanation

Summary:
Organization of Information Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___
Mathematical Accuracy Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___
Use of Strategies Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Notes:

Place Value Assessment 4

Name: _____

Date: _____

What is the largest number you can make with 7, 4, and 8? Show your work and explain your thinking:

Criteria	Level One (Novice)	Level Two (Apprentice)	Level Three (Practitioner)	Level Four (Expert)
Organization of Information	<ul style="list-style-type: none"> • Random • Incomplete • Missing elements 	<ul style="list-style-type: none"> • Mostly complete • Hit-and-miss approach • Most elements are present 	<ul style="list-style-type: none"> • All elements represented • Shows a plan or appropriate strategy • Organized 	<ul style="list-style-type: none"> • Well-planned • Complete and displayed in an organized fashion
Mathematical Accuracy	<ul style="list-style-type: none"> • Major errors in computation and explanation 	<ul style="list-style-type: none"> • Chose appropriate mathematical concept but unable to accurately complete the task 	<ul style="list-style-type: none"> • Minor errors in computation but demonstrates conceptual understanding 	<ul style="list-style-type: none"> • Accurate
Use of Strategies	<ul style="list-style-type: none"> • Lack of strategic approach to task • No explanation 	<ul style="list-style-type: none"> • Some demonstration of strategic approach but incomplete or lack of follow through • No representation or explanation 	<ul style="list-style-type: none"> • Shows some application of strategies but not efficient • Some use of representation and or explanation 	<ul style="list-style-type: none"> • Use of efficient and appropriate strategy or combination of strategies • Includes a complete representation or explanation

Summary:

Organization of Information Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Mathematical Accuracy Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Use of Strategies Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Notes:

Place Value Assessment 5

Name: _____

Date: _____

How many different ways can you make 289 with ones, tens, and hundreds? Show your work and explain your thinking:

Criteria	Level One (Novice)	Level Two (Apprentice)	Level Three (Practitioner)	Level Four (Expert)
Organization of Information	<ul style="list-style-type: none"> • Random • Incomplete • Missing elements 	<ul style="list-style-type: none"> • Mostly complete • Hit-and-miss approach • Most elements are present 	<ul style="list-style-type: none"> • All elements represented • Shows a plan or appropriate strategy • Organized 	<ul style="list-style-type: none"> • Well-planned • Complete and displayed in an organized fashion
Mathematical Accuracy	<ul style="list-style-type: none"> • Major errors in computation and explanation 	<ul style="list-style-type: none"> • Chose appropriate mathematical concept but unable to accurately complete the task 	<ul style="list-style-type: none"> • Minor errors in computation but demonstrates conceptual understanding 	<ul style="list-style-type: none"> • Accurate
Use of Strategies	<ul style="list-style-type: none"> • Lack of strategic approach to task • No explanation 	<ul style="list-style-type: none"> • Some demonstration of strategic approach but incomplete or lack of follow through • No representation or explanation 	<ul style="list-style-type: none"> • Shows some application of strategies but not efficient • Some use of representation and or explanation 	<ul style="list-style-type: none"> • Use of efficient and appropriate strategy or combination of strategies • Includes a complete representation or explanation

Summary:

Organization of Information Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Mathematical Accuracy Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Use of Strategies Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Notes:

Place Value Assessment 6 (Post Assessment)

Name: _____

Date: _____

The second-grade students are going to an apple farm in the fall. They collected 453 apples together. They need to send the apples back to the school. The apple farm has crates that carry 100 apples and bags that hold 10 apples. What are different ways the students can bring the apples back to school? What do you think is the best method? Show your work and explain your thinking:

Criteria	Level One (Novice)	Level Two (Apprentice)	Level Three (Practitioner)	Level Four (Expert)
Organization of Information	<ul style="list-style-type: none"> • Random • Incomplete • Missing elements 	<ul style="list-style-type: none"> • Mostly complete • Hit-and-miss approach • Most elements are present 	<ul style="list-style-type: none"> • All elements represented • Shows a plan or appropriate strategy • Organized 	<ul style="list-style-type: none"> • Well-planned • Complete and displayed in an organized fashion
Mathematical Accuracy	<ul style="list-style-type: none"> • Major errors in computation and explanation 	<ul style="list-style-type: none"> • Chose appropriate mathematical concept but unable to accurately complete the task 	<ul style="list-style-type: none"> • Minor errors in computation but demonstrates conceptual understanding 	<ul style="list-style-type: none"> • Accurate
Use of Strategies	<ul style="list-style-type: none"> • Lack of strategic approach to task • No explanation 	<ul style="list-style-type: none"> • Some demonstration of strategic approach but incomplete or lack of follow through • No representation or explanation 	<ul style="list-style-type: none"> • Shows some application of strategies but not efficient • Some use of representation and or explanation 	<ul style="list-style-type: none"> • Use of efficient and appropriate strategy or combination of strategies • Includes a complete representation or explanation

Summary:

Organization of Information Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Mathematical Accuracy Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Use of Strategies Level 1 ___ Level 2 ___ Level 3 ___ Level 4 ___

Notes:

APPENDIX D
CODEBOOK

Code	Type of Code	Definition
Novice Organization	Priori	Random, Incomplete, missing elements
Apprentice Organization	Priori	Mostly complete, hit-and-miss, most elements are present
Practitioner Organization	Priori	All elements represented, shows a plan or appropriate strategy, organized
Expert Organization	Priori	Well-planned, complete and displayed in an organized fashion
Novice Accuracy	Priori	Major errors in computation and explanation
Apprentice Accuracy	Priori	Chose appropriate mathematical concept but unable to accurately complete the task
Practitioner Accuracy	Priori	Minor errors in computation but demonstrates conceptual understanding
Expert Accuracy	Priori	Accurate
Novice Use of Strategies	Priori	Lack of strategic approach to task, no explanation
Apprentice Use of Strategies	Priori	Some demonstration of strategic approach but incomplete or lack of follow through, no representation or explanation
Practitioner Use of Strategies	Priori	Shows some application of strategies but not efficient, some use of representation and or explanation
Expert Use of Strategies	Priori	Use of efficient and appropriate strategy or combination of strategies, includes a complete representation or explanation

APPENDIX E

EXAMPLE CONSENT LETTER

Informed Consent

TITLE OF STUDY

The Effects of Problem Solving
in an Early Childhood Classroom

TEACHER-RESEARCHER

Lockey Plyler
University of South Carolina
Rosewood Elementary, Columbia, SC, 29205
3300 Rosewood Drive
Lockey.plyler@richlandone.org

PURPOSE OF STUDY

The purpose of the action research study is to examine ways to improve students' learning in an early childhood mathematics class by implementing the launch-explore-summarize/extend mathematical framework that emphasizes problem-solving to build critical thinking skills and increase mathematical understanding of place value. The study may determine the positive impact of implementing the launch-explore-summarize/extend place value problem-solving framework on students' problem-solving success. The data will be collected for Lockey Plyler's dissertation in pursuit of an Ed.D. in Curriculum and Instruction at the University of South Carolina.

STUDY PROCEDURES

The study will take place over a six week period of time. The students will take six problem solving assessments using the same test style and rubrics used throughout the school year. The students will learn mathematics using the district implemented problem solving framework.

CONFIDENTIALITY

Your child's problem solving assessments from the six week period of time are the ONLY data collected for the study. Your child's responses on the assessment will be anonymous and confidential.

VOLUNTARY PARTICIPATION

Your child's participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you decide to take part in this study, you will sign this consent form. After you sign the consent form, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. Your child will still participate in math lessons and assessments. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed.

CONSENT

I have read and I understand the provided information and have had the opportunity to ask questions. I understand that my child's participation is voluntary and that I am free to withdraw them at any time, without giving a reason. I voluntarily agree for my child to take part in this study.

Parent's signature

Date 11/7/17

APPENDIX F

MASTERY CONNECT BENCHMARK DATA

