The Dissertation Committee for Jill Noelle Choate Certifies that this is the approved version of the following dissertation:

A CASE STUDY ANALYSIS OF A MATHEMATICAL PROBLEM SOLVING PROGRAM

Committee:

Herbert J. Rieth, Supervisor

James R. Yates

Anne L. Fuller

Audrey D. Sorrells

Diane P. Bryant

A CASE STUDY ANALYSIS OF A MATHEMATICAL PROBLEM SOLVING PROGRAM

by

Jill Noelle Choate, B.S.; M.A.

Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

December 2012

Dedication

This dissertation is dedicated to the love of my life, my loving and supportive husband, Christopher, who has been a source of continual support and encouragement. Also to my children, the other loves of my life, who have been loving, understanding, and encouraging throughout. Thanks for all you have given up so my dream can come true.

Acknowledgments

I am deeply grateful for the following people who have supported and encouraged me during my graduate school experience: Dr. Herbert J. Rieth, my supervising professor, who had faith I would make it through; Dr. James Yates, Dr. Audrey Sorrells, and Dr. Anne Fuller for providing insight and guidance; and Dr. Diane Bryant for graciously helping at the last moment. Thank you to the study school district for allowing me to work in the district and providing access to the data necessary to complete this study. I was fortunate to have a wonderful support system of friends who would take kids, take care of my family when I was gone, and do whatever was needed so I could finish this project. I am truly grateful and blessed to have you in my life. To my father-in-law, Tom, who would never let me quit, no matter how many times I tried, thank you. Thank you to my parents, Dave and Maxine, who gave me a strong foundation from the beginning and the strength and courage to take on this challenge. Finally, and most importantly, my family—Chris, Sam, and Claire—who supported me, encouraged me, and kept pushing to the end so I could complete this project. I could not have done it without you.

A CASE STUDY ANALYSIS OF A MATHEMATICAL PROBLEM SOLVING PROGRAM

Jill Noelle Choate, Ph.D.
The University of Texas at Austin, 2012

Supervisor: Herbert J. Rieth

Students must be good problem solvers in order to compete in today's global economy. However, many students, including students with disabilities, do not have adequate problem-solving skills, thus eliminating potential job opportunities. In order to increase opportunities for problem-solving success, schools must find strategies that are effective and efficient for students to use and simulate real-world scenarios. Therefore, the purpose of this study was to investigate whether a direct, cognitive-strategy, problem-solving program (Solve It!), which is designed to enhance student skills in word-problem solving, could increase the accuracy with which students with and without disabilities correctly solved word problems and whether it affected students beliefs about problem solving. The research questions developed for this study were (a) does the Solve It! method affect the math problem-solving achievement of Grade 6 students, and (b) what are teacher and student perceptions of the efficacy of the Solve It! method of teaching word-problem solving?

A quantitative case study was used for this study to determine the efficacy of a specific cognitive instructional strategy with Grade 6 students. Participants in this study included 54 Grade 6 students, 7 with disabilities, from a middle school in Southwestern Colorado. Data were gathered from students through the use of pre- and posttests containing 10 word math problems. Students were also given short weekly quizzes to monitor progress and check for proper usage of the strategy. Finally, data were gathered from the Northwest Evaluation Association (NWEA) instrument, winter and spring testing periods, to investigate changes on the problem-solving strand of the mathematics test. Teacher interviews and student surveys were also used to gain deeper insight into the effectiveness of the strategy. From this analysis, conclusions were drawn to answer the research questions.

Comparison of means showed that although the Solve It! strategy did not statistically significantly improve students' mathematical problem-solving abilities on the standardized NWEA test, it did improve their scores in word-problem solving on the 10-item word-problem test. In addition, the students' perceived self-efficacy to solve word problems increased.

Table of Contents

List of Tables

Chapter 1: Introduction

It is imperative, in the 21st-century global economy, that students have a good working knowledge of mathematics in order to compete for jobs (Spellings, 2005). Whether a student is going to college or to the workforce, employers are looking for critical thinkers and practical problem solvers (Spellings, 2005). Due to the absence of qualified workers, some employers have set up remedial math programs in order to build the basic skills of new employees (Ferguson, 2000).

The World Economic Forum (Rauschenberger, 2001) indicated that the United States is one of the most productive economies in the world, but overcoming the lack of skilled workers is a major challenge. Employers are looking for workers who have portable problem-solving skills (Rauschenberger, 2001) enabling workers to be productive in many circumstances. However, many students enter the workforce without these skills, particularly students with learning disabilities.

Legislation, such as the Individuals With Disabilities Education Improvement Act (2004) and the No Child Left Behind Act of 2001 (NCLB, 2002), holds school administrators accountable for demonstrating progress in all students. At the same time, mathematical standards developed by the National Council of Teachers of Mathematics (NCTM, 2000) have placed greater emphasis on the ability of students to solve real-life mathematics problems. Finally, the National Mathematics Advisory Panel (NMAP, 2008) concluded American students need to have more experiences with real-world contexts if mathematics instruction within the kindergarten through Grade 12 system is going to generalize to employment. These events have forced school districts to examine and realign their mathematics curricula in order to be in compliance with state and federal legislation and to provide students with experiences that will be beneficial for future employment. Teachers and administrators are searching for math curricula that will increase student problem-solving skills to enable them to solve mathematics problems they encounter in everyday life. However, this is a dramatic shift from past curricula that focused on traditional rote memorization of facts and procedural processes.

Students with learning disabilities traditionally have had difficulty with the problem-solving process and the new math curricula. The change within the mathematics curriculum and the emphasis on problem solving place these students at greater risk for failure in mathematics (Bryant, Bryant, & Hammill, 2000; Fuchs & Fuchs, 2002; Jordan & Hanich, 2000; Owen & Fuchs, 2002; Vukovic & Siegel, 2010). Math problem solving is particularly difficult for adolescents at the secondary school level. This problem has required all teachers, general and special education, to seek effective evidence-based interventions (Bryant et al., 2000; Foegen & Deno, 2001; Graham, Bellert, Thomas, & Pegg, 2007), a task made difficult by a shortage of effective research-based strategies designed specifically for students with learning disabilities.

The prevalence of mathematical problem-solving disabilities has been difficult to assess, but researchers have agreed that mathematical disabilities are estimated to affect at least 6% of the general school population (Fuchs et al., 2005; Fuchs & Fuchs, 2002; Geary, 2004; Jitendra & Star, 2011; Mazzocco & Myers, 2003) and at least one fourth of students with learning disabilities (Dirks, Spyer, Van Lieshout, & De Sonneville, 2008; Garrett, Mazzocco, & Baker, 2006). The U.S. Department of Education (2003) stated that in the area of applied problems, only 11% of students with learning disabilities and aged 6–12 were above the 61st percentile, whereas 47% of the students scored between the 21st and 60th percentiles. Unfortunately, 42% of students with learning disabilities fell below the 20th percentile in problem solving.

Mathematics problem-solving competence is a critical link to employment, income, and work productivity (Vukovic & Siegel, 2010). Former U.S. Secretary of Education Richard Riley (1997) discussed the high-quality mathematics knowledge that middle school students need in order to be successful in life. He reported that employees in the U.S. Department of Education "recognize that mathematics is important for success in education and in life" (Riley, 1997, p. 4). Lewis (2004) indicated that high school academic preparation is absolutely critical for the workplace, and "in fact, nearly all students will require some postsecondary education, including on-the-job training, after completing high school" (p. 5), especially in the area of problem solving.

Mathematics instructors in secondary schools typically assume that most students have mastered basic computational skills such as addition, subtraction, and multiplication. Therefore, students should be able to move on to more complicated mathematical processes, such as word problems, with relative ease. These processes are at the core of secondary mathematics curricula. Problem-solving strategies at this level are not directly taught to students but are interwoven into mathematics instruction. These strategies encourage students to interpret the problem, develop a plan, and execute the plan to find the answer. However, students with disabilities often have a difficult time understanding and implementing strategies, unless they have been directly taught how to use the strategies (Owen & Fuchs, 2002; Xin, Jitendra, & Deatline-Buchman, 2005). Since this approach to instruction is not extensively used by secondary mathematics teachers, students with disabilities struggle to understand mathematical concepts taught in secondary schools.

Many middle school students with learning disabilities experience very little growth in mathematical competence, especially in the area of mathematical word problems, due to lack of exposure and knowledge of strategy implementation (Jitendra, DiPipi, & Perron-Jones, 2002; Vukovic & Siegel, 2010). These students traditionally receive instruction within the resource classroom, in small groups with direct or explicit instruction, that concentrates mainly on computation problems and fluency rather than real-life application such as word problems and problem solving (Woodward & Montague, 2002; Xin et al., 2005). Students with disabilities who are in the general mathematics classroom often are not able to independently implement and master strategies that allow them to advance in the curriculum, thus leaving them behind their peers. This may be a result of the fast-moving curriculum, not enough exposure to a variety of problems, or a lack of understanding of how to solve mathematical word problems (Fuchs et al., 2011).

There have been many different explanations for why students with disabilities have such a difficult time with problem-solving processes in general and word problems specifically. Some of these beliefs include problems with language schema (Cawley, Parmar, Foley, Salmon, & Roy, 2001; Xin, 2003), too much emphasis on memorization of basic facts (Woodward, Monroe, & Baxter, 2001; Woodward & Montague, 2002), not having exposure to higher level problem-solving skills (Jitendra et al., 2002; Vukovic & Siegel, 2010), and not having the appropriate schema in place to identify a strategy to use (Gonzalez & Espinel, 2002; Scheurmann, Deshler, & Schumaker, 2009). These problems lead to poor understanding of mathematical concepts and mathematical performance for students with learning disabilities (Garrett et al., 2006).

Problem-solving strategies have received a significant amount of attention since the NCTM in 1989 declared it to be the top priority in math instruction (NCTM, 2000). Problem solving is defined as "involving the application of knowledge, skills, and strategies to novel situations" (Fuchs, Fuchs, Finelli, Courey, & Hamlett, 2004, p. 420). Researchers have suggested that in order to improve problem-solving skills in students, teachers need to focus on developing interventions (Graham et al., 2007). Some of the implemented interventions include the use of manipulatives and drawings, cognitive strategy instruction, and schema instruction. These research-based strategies are rigorous, systematic and evidence-based and include the following steps: (a) reading the problem for understanding, (b) identifying the important parts, (c) drawing or diagramming the problem, and (d) solving and checking. However, some successful strategies include additional steps to help ensure student success and fluency in problem solving, such as teacher demonstration, modeling, practice, and feedback.

Another promising strategy that has gained research-based support is schematic diagrams. Schematic strategies teach students to look for patterns or structures in which words from the problems are translated into a meaningful representation in order to solve the problems. An example of a schematic strategy is using if–then statements or drawing diagrams to indicate relationships between the variables in a word problem. These types of strategies have been successful with students with learning disabilities and students who are at risk for mathematical failure (Jitendra et al., 2002; Xin et al., 2005). To date, this strategy has been shown to be most successful in helping students to understand addition and subtraction word problems, not multiplicative problems that trouble middle school students (Jitendra et al., 2002). However, students at the secondary level need to receive instruction in strategies that will help them to decipher and analyze word problems and that will also allow them to successfully use all basic computation operations, not just addition and subtraction (Gagnon & Maccini, 2007).

Specific strategy instruction (e.g., direct cognitive-strategy instruction) provided by general education or special education teachers is imperative if students with disabilities are going to be successful at the secondary level (Owen & Fuchs, 2002). Direct cognitive-strategy instruction provides students with a concrete, specific model to help dissect, understand, and solve word problems that typically are very difficult for secondary students. Once students with learning disabilities are able to effectively and efficiently solve word problems, they will be better equipped to compete with their nondisabled peers. Concentrating on teaching students with disabilities who are beginning their experience with higher level secondary curricula how to solve mathematical word problems may provide them with enough guidance and understanding to help them to be successful throughout their educational career (Owen & Fuchs, 2002).

Researchers in the area of mathematics instruction have indicated the importance of explicit instruction and practice in problem solving (Kroesbergen & Van Luit, 2003) and specifically the conceptual and procedural knowledge needed for word problems (Jitendra et al., 2002). Researchers have shown that direct instruction combined with strategy instruction increased students' ability to solve difficult and confusing problems, the type with which students with learning disabilities traditionally struggle (Owen & Fuchs, 2002; Woodward & Montague, 2002). Much of this research in direct strategy instruction has been developed and implemented, and students who used these strategies have had success (Jitendra et al., 2002; Montague & Applegate, 2000).

Special educators who know the characteristics of students with learning disabilities are especially concerned that these students will not be able to demonstrate academic growth comparable to their peers. Students with learning disabilities achieve academic growth more gradually (Hempenstall, 2004; Swanson & Hoskyn, 2001), making it hard for them to compete with regular education peers. Experts in the field of mathematics have estimated that students with math disabilities attain only 1 additional year of mathematics achievement for every 2 years of instruction (Miller, Butler, & Lee, 1998). Researchers have also shown that middle school students with a math disability often reach a learning plateau where they gain only 1 additional year of mathematical proficiency for the rest of their public school career (Wagner, 2006). These students leave high school with "demonstrably lower levels of mathematics achievement than their peer group" (Wagner, 2006, p. 22). This is alarming considering the current mandate that all students should be proficient or at grade level in all core areas by 2014 (NCLB, 2002); only a few of these students will ever be able to attain this proficiency due to their learning disability.

Teachers of these students are distressed because they observe students struggling with reading, language, and problem solving while taking state-mandated tests designed to meet federal guidelines. Recent research has emphasized how critical it is to help students, especially those with learning disabilities, to decipher and interpret word problems that tell a story and require a solution and to write out an equation once the information has been interpreted in order to solve word problems (Harskamp & Suhre, 2007; Muir, Beswick, & Williamson, 2008; Owen & Fuchs, 2002). However, these are the specific elements of word problems students with math disabilities need to be provided direct instruction on how to process and interpret these elements (Xin et al., 2005).

It is imperative that students with disabilities acquire efficient problem-solving strategies so that they can tackle the many demands of the secondary curriculum and the everyday situations they will encounter as adults. However, very little research has been conducted to determine which strategies are the most effective to help adolescent students with learning disabilities succeed in the area of mathematical problem solving (Vukovic & Siegel, 2010).

Statement of the Problem

Mathematical problem solving is one of the most significant factors that affect learning disability students at the secondary level (i.e., ages 12–18) preventing them from progressing with their peers. When they enter secondary school, they typically have significant skill deficits (e.g., limited fluency of basic facts recall), which complicate the development of higher level mathematic skills (e.g., problem solving) and compromise later achievement (Jitendra & Star, 2011). This is compounded at the secondary level with a more difficult and demanding curriculum. Typically, mathematics instructors at the secondary level assume that students have mastered the basic skills of addition, subtraction, multiplication, and division and that students are able to apply those skills in areas such as problem solving, decision making, and personal-social adjustment (Graham et al., 2007). However, this is seldom the case with students with learning disabilities.

Students with learning disabilities require access to classrooms with teachers who use research-based strategies that enable them to acquire, hone, and perfect problem-solving skills if they are expected in the job market. Problem-solving skills are essential in everyday life, and students must be taught explicit strategies if they are expected to be successful adults (Lewis, 2007; Rowh, 2007). Students with mathematics learning disabilities must have a chance to practice problem-solving skills repeatedly in real-life situations in order for them to become independent problem solvers (Butler, Beckingham, & Lauscher, 2005; Xin & Zhang, 2009).

Furthermore, with the implementation of new laws and standards, additional research is imperative to identify effective, direct, cognitive-strategy instruction that students with learning disabilities should receive at the secondary level. Effective instruction will help them to keep pace with their peers when solving mathematical word problems. Finally, such research will help to facilitate appropriate and meaningful mathematics instruction for students with disabilities, in the area of word problems, so they have strategies that are effective for them in everyday life.

Purpose of the Study

The purpose of this study was to investigate whether a direct cognitive-strategy program designed to enhance word-problem solving (Solve It!) would increase the accuracy with which students solved word problems at an instructional level and at grade level. Solve It! (Montague & Bos, 1986) has been implemented and shown to be successful with seventh- and eighth-grade populations. The program has not been found to be successful with sixth graders. Montague (1992) found that the Solve It! method worked well for seventh- and eighth-grade middle school students in an instructional setting because it provided both cognitive and metacognitive strategies for problem solving. However, she did not have the same success with sixth-grade students. Sixth graders were not able to meet the performance criterion and required more practice with learning and implementing the steps. Montague (1992) reported this was due to a lack of developmental readiness and the need for more explicit and extended instruction for sixth-grade students.

This research study was designed to investigate whether sixth-grade students, are developmentally ready and able to execute the Solve It! method.

Significance of the Study

Besides the implications for districts and schools being singled out for not making adequate yearly progress as mandated by NCLB (2002), students with learning disabilities must acquire the basic competencies needed to solve everyday problems they will encounter as adults. As adults, these students will be required to use mathematics skills in everyday life, and they must be taught specific strategies for approaching problems they will encounter in real-world situations. One of these strategies includes a process for (a) figuring out the problem, (b) determining what operation will be needed to solve the problem, (c) solving the problem, and (d) knowing whether the answer is acceptable. Without these skills, these adolescents will have a difficult time surviving in the ever-increasing technological world as an adult (Xin & Zhang, 2009).

Research Questions

This study addressed the following questions:

1. Does the Solve It! method affect the math problem-solving achievement of sixth-grade students?

What are teacher and student perceptions of the efficacy of the Solve It! method of teaching word-problem solving?

Chapter 2: Literature Review

Rationale for Study

The mathematical skills of students with learning disabilities have been reported in relatively few studies compared to the vast research on reading disabilities (Mazzocco & Myers, 2003; Robinson, Menchetti, & Torgesen, 2002). Even fewer researchers have specifically analyzed mathematical disabilities and problem solving among the special education population approaching the secondary level (Fuchs & Fuchs, 2005; Kroesbergen & Van Luit, 2003; Robinson et al., 2002). Maccini, Mulcahy, and Wilson (2007) argued that there is a strong need for research-based mathematics interventions that are effective with secondary students, specifically those with learning difficulties:

> It is imperative to incorporate instructional practices that are both effective and efficient . . . to access general education math curriculum in a meaningful way. Educators must have knowledge of the most recent research-based practices for assisting students with learning disabilities. (p. 59)

In this literature review, the researcher examined mathematical problem solving, specifically (a) the problem-solving process; (b) characteristics of problem solvers; and (c) research-based, problem-solving strategies for students with disabilities.

Background

Various venues, ranging from national councils to state and local agencies, have documented mathematics standards reform. Nationally, groups like the NCTM (2000), the NMAP (2008), and the Programme for International Student Assessment (PISA; Organisation for Economic Co-operation and Development, 2012) have discussed the drastic need for change in mathematics curriculum if students in the United States are to compete globally (NCTM, 2000). As the American education system has declined and caused stagnation in the U.S. workforce, international schools in other countries have been increasing college graduation rates and creating workers ready to participate in the global economy (Zakaria, 2011).

With this in mind, there have been many conversations, policy initiatives, legislative actions, and development of new standards at the national level to provide guidance for primary and secondary education. These actions have given rise to reforms, stringent national standards, and procedures not previously implemented. However, some special education advocates are cautious about these reforms because there is an inadequate research base depicting effective strategies for students at the secondary level. Special educators are concerned their students' skills will not allow them to solve the kinds of mathematical problems outlined in the guidelines (Bottge, Rueda, LaRoque, Serlin, & Kwon, 2007; Jitendra et al., 2005). Increasing the math achievement of this population of students has proven to be extremely difficult, especially in the area of word problems (Fuchs & Fuchs, 2005; Jitendra & Star, 2011; Kajamies, Vauras, & Kinnunen, 2010; Scheurmann et al., 2009).

In 1998, the NCTM released a statement that outlined principles and standards for the American education system (NCTM, 2000). These standards were the first of their kind to provide stringent and aggressive goals to help students become competitors in the global market. Unlike previous standards, the new standards placed more emphasis on conceptual knowledge, mathematical reasoning, and problem-solving skills with real-world applications (Maccini et al., 2007; NCTM, 2000). The guidelines stated that teachers are expected to provide effective instruction using higher level math skills while using open-ended, problem-solving tasks (Maccini & Gagnon, 2000).

These standards and guidelines described rigorous goals to help U.S. students be more globally competitive; however, these goals may be extremely difficult to attain for secondary students, especially those students with a learning disability (Maccini et al., 2007). Unfortunately, very little research has been conducted on various strategies needed to teach secondary school students with disabilities the new mathematics standards, which has left educators and special educators in a precarious position (Maccini et al., 2007).

NCLB (2002), an influential piece of legislation with implications for students with disabilities, was designed to facilitate the development of a standards-based curriculum. Legislators believed that adhering to this curriculum would enable all students to function at a high level documented by required accountability systems (Maccini & Gagnon, 2006). However, this legislation did not provide exceptions for students with disabilities or provide funding for research designed to develop effective and valid data-driven interventions for students with disabilities to learn mathematical concepts.

With this legislation providing new guidelines, regulations, and standards aligned with teaching methods employed in general and special education classrooms, teachers need to work together to provide consistent structure that is effective and meaningful (Maccini et al., 2007) along with a curriculum with high standards. Researchers have clearly laid out factors and researched-based practices that must be present in order to close the mathematics achievement gap (Gersten et al., 2009; Woodward, 2004).

The NMAP (2008), another group that advocated for more stringent mathematical guidelines, referenced the need for teachers to better understand the needs of their students and the wide variety of characteristics students bring into the classroom. Many teachers do not have the specialized instruction that is necessary to help students with disabilities, yet most students are mainstreamed and receive most of their instruction in general classrooms (Wadlington & Wadlington, 2008).

The NMAP (2008) specifically mentioned the benefits of good conceptual learning, procedural fluency, and automaticity of facts. The organization also described the need to provide students and teachers with research-tested strategies for mathematics, if mathematical scores are going to improve (NMAP, 2008). "Instructional practice should be informed by high-quality research and easily available to all mathematics teachers" (NMAP, 2008, p. 41).

Students in the United States lag behind their international peers in achievement on mathematics tests, both in higher order thinking skills and real-life application (Fleischman, Hopstock, Pelczar, & Shelley, 2010; Organisation for Economic Co-operation and Development, 2012). Similarly, the NMAP (2008) found that American students consistently achieved "at a mediocre level by comparison to peers worldwide" (p. xii). These findings highlight concerns about the education of U.S. students and how they will compete in the global market due to (a) the growth of technology, (b) transformation in the workplace, and (c) the expectations of the job market (Deshler et al., 2001; Witzel, Riccomini, & Schneider, 2008). Teachers must use practices consistent with research-based practices that are effective in helping students with mathematical difficulties. Interventions for secondary students must be both teacher and student centered in order to maximize student outcomes (Deshler et al., 2001). These strategies must be integrated into a comprehensive mathematics curriculum to be effective in closing the achievement gap. Additionally, school administrators need to support the strategies if the strategies are going to be successful (Sayeski & Paulsen, 2010).

To be successful, students must have effective problem-solving and critical-reasoning skills to be prepared for the jobs of the future (Maccini et al., 2007). Students must be able to relate to real-life problems and develop skill sets that are essential for competing in the global market (Deshler et al., 2001; Witzel et al., 2008).

Importance of Problem Solving

Former President George W. Bush created the NMAP in 2006 to address the issue that American students lagged behind the world in mathematics skills and students would have difficulty competing for jobs if these skills were not built up and strengthened. However, the NMAP (2008) report failed to address specifically many of the issues of mathematics education, such as research-based strategies, and barely mentioned how to help students with learning disabilities or students who have difficulty learning mathematics. In order for mathematical skills to be enhanced and developed, specific research needs to be conducted and then disseminated to teachers on how to teach the wide variety of students in the American educational system.

The ability to solve mathematical word problems is crucial in a global society and has been pushed to the top of NCTM (2000) standards and has been the focus of other national reports such as the NMAP (2008) report. Researchers for the American Association for the Advancement of Science also have supported this goal, stating, "Preparing students to become effective problem solvers, alone in concert with others, is a major purpose of schooling" (Nelson, Teich, McEnaney, & Lita, 2000, p. 282). The national mathematical performance of secondary students, as measured by tests given worldwide such as PISA (Fleischman et al., 2010; Organisation for Economic Co-operation and Development, 2012), suggests that American schools are not preparing students with the mathematical problem-solving abilities they need. Results of standardized assessments given at the state, national, and international levels over the last three decades have shown that U.S. students are "notably deficient" (National Research Council, 2001, p. 4) in problem-solving abilities.

However, despite this need to teach problem-solving skills, the challenge still facing teachers is how to help all students to be successful despite their diverse backgrounds and cognitive styles (Danesi, 2007). In a survey conducted in 2003, 83% of teachers stated their biggest challenge in teaching problem-solving skills was the inability of students to understand concepts found in typical word problems (Danesi, 2007).

Characteristics and Strategies of Good Problem Solvers

Researchers have shown that effective and ineffective problem solvers have very different characteristics. Problem solving involves a variety of skills, such as computation, strategy development, and transfer of knowledge (Callister, 2009; Muir et al., 2008). There is a range with which students use these skills, from the naïve to the sophisticated problem solver (Muir et al., 2008). The first major difference between these types of problem solvers is that good or sophisticated problem solvers have well-connected and rich schemata and are able to focus their attention on structural features of problems. These students are aware of their own strengths and weaknesses and regulate and monitor their thinking patterns through metacognition, which has been shown to be integral to problem solving (Muir & Beswick, 2005). Strong problem solvers often draw or develop visuals to help them understand the problem (Harper, 2006; Harskamp & Suhre, 2007; Teong, 2003). Naïve or ineffective problem solvers often rely on only one or two strategies and often will use the same strategy to solve all problems (Muir et al., 2008). Ineffective problem solvers also spend most of their time on procedures and calculations with little thought about whether the procedure is logical or appropriate for the problem (Harskamp & Suhre, 2007).

Researchers have shown that U.S. students do not encounter the rigor or sustained exposure to problem solving of students in other countries. If successful problem-solving strategies are to be implemented, students must be encouraged to solve many types of problems, not just a few problems from the lesson of the day.

They also must develop these skills slowly and over a prolonged period. Teachers must systematically teach students the steps to problem solving. Just exposing students to problems and the process will not help them become good problem solvers (Callister, 2009; Harskamp & Suhre, 2007).

Pólya (1945) conducted some of the earliest research on problem solving. He conceived the four-step problem-solving method that is considered essential to any problem-solving strategy. These steps are (a) understand the problem, (b) devise a plan, (c) carry out the plan, and (d) look back and reflect. This important work precipitated the development of a series of strategies with extra steps for further clarification, but these four steps are the most important when solving problems.

Understand the Problem

Obviously, the biggest difference between math computation and mathematical word problems is the addition of linguistic information (Mazzocco & Berch, 2007). Researchers have shown that "the manner in which problems are worded, including length, the grammatical and semantic complexity, and the order of statements helps determine the difficulty of the problem" (Helwig, Rozek-Tedesco, Tindal, Heath, & Almond, 1999, p. 114).

Students attempting to understand a problem are often most comfortable at a conceptual (i.e., showing a good grasp and understanding of the concept instead of just the numbers) rather than procedural level (i.e., learning how to perform and apply algorithms). Although procedural knowledge is important in order for students to move to a higher level of learning, they also must have a conceptual knowledge of mathematics. This has required a shift in thinking for many mathematics teachers and has been emphasized in national documents such as the *Principles and Standards for School Mathematics* (NCTM, 2000) and *Adding it Up: Helping Children Learn Mathematics* (National Research Council, 2001).

When learning how to solve problems, students not only must have a good grasp of procedural and conceptual knowledge but also must understand the semantics of word problems. Semantics is using "conceptual knowledge about increases, decreases, combinations, and comparisons involving sets of objects" (Griffin & Jitendra, 2008, p. 190). Students must understand the "semantic structure and mathematical relations as well as knowledge of basic numerical skills and strategies . . . along with the complexity of the solution process" (Griffin & Jitendra, 2008, p. 190) to solve problems successfully. One concern when examining semantics is how students attach meaning to larger chunks of text by breaking it down into smaller units of meaning. How students see the world and integrate those experiences into their conceptual knowledge is an important platform for problem-solving abilities (Miller, Stringfellow, Kaffar, Ferreira, & Mancl, 2011).

Students who have good mathematical understanding are more sensitive to the semantic distinctions implied by word problems (Fuchs et al., 2008; Jitendra, George, Sood, & Price, 2010). Semantic alignment allows people to use their background knowledge to enable appropriate application of abstract concepts and rules (Martin & Bassok, 2005). Additionally, students should be able to draw upon their worldly knowledge to develop problems, solve them, and then check problems while using semantic clues to highlight relationships among objects in the text of the word problem (Jitendra et al., 2010).

Bassok, Chase, and Martin (1998) "found that semantic relations between objects in the texts of mathematical word problems were highly positively correlated with arithmetic operations that took these objects as arguments of arithmetic operations" (p. 129). They examined this relationship by looking at mathematics textbook series for Grades 1–8. In these textbooks, they found that 97% of addition word problems had categorically related objects, whereas 94% of the division problems had functionally related objects. This indicated the degree of semantic structure and mathematical relations that many students rely on when solving word problems.

Martin and Bassok (2005) found that semantic knowledge was used to construct or retrieve an appropriate mathematical model. The researchers examined whether students used the semantic relation in mathematical operations and modeling. There was a correlation between the two processes, computation and modeling, and how students interpreted semantic cues, which determined whether they engaged in mathematical modeling. In addition, students who used semantic cues rather than translation cues had a deeper understanding of mathematical concepts; thus, they were better at mathematical modeling and problem solving.

Devise a Plan

When working through a problem, the second step is to develop a plan. These plans are typically built using mathematical models that students have used in the past. Models are developed over time as students are exposed to more complex and demanding problem sets. Martin and Bassok (2005) found that students used resources or previously solved solution sets to develop plans for similar but different word problems.

Therefore, students need to be exposed to many types of problems and semantic structure in order to build their knowledge base of varying types of word problems. Classroom opportunities that provide extensive exposure to a variety of word problems contributes to mathematical thinking and reasoning and is crucial for the development of problem-solving abilities as well as transfer and generalization skills (Martin & Bassok, 2005).

The issue of transfer is central to effective education in all domains, including the transmission of mathematical knowledge (Mestre, 2005). Transfer is integral to mathematical problem solving, but relatively few studies have shown changes in the transference of mathematical skills to other situations encountered in everyday life (Xin & Zhang, 2009). Many have argued that the only instructional goal of mathematics education, and education as a whole, is to teach for long-term retention and transfer (De Corte, 2003; Halpern & Hakel, 2003; Haskell, 2001), that is, to help students recognize and reason about a problem in a manner that permits them to see the same thing in different mathematical situations (Wagner, 2006).

Halpern and Hakel (2003) described similar principles for transfer of learning. The principles were (a) practice retrieval, (b) varying the conditions of learning, (c) rerepresentation of information, (d) use of prior or background knowledge, and (e) active engagement and attention to learning process. However, researchers have tried to expand the transfer of knowledge, accessing and using information in a variety of contexts, to include more of the active and constructive nature of learning (De Corte, 2003). Specifically, De Corte (2003) added preparation for future learning and productively using the new learning for results as an extension to transference of learning, thus explicitly making transfer an integral part of the problem-solving process.

Execute the Plan

A student must have a firm grasp on different types of knowledge in order to solve mathematical word problems, as multiple steps and processes are needed in problem solving. These types of knowledge include (a) contextual, (b) procedural, and (c) conceptual.

Contextual knowledge is "the knowledge of how things work in specific, real-world situations . . . developed from interactions with the world" (Rittle-Johnson & Koedinger, 2005, p. 316). Contextual knowledge is used to understand the semantics of the problem. Many students are proficient and effective at applying this knowledge to word problems (Koedinger & Nathan, 2004).

Students must also use procedural knowledge in problem solving. This type of knowledge requires an understanding of the many subcomponents of a procedure (Rittle-Johnson & Koedinger, 2005). Procedures are strategies that involve systematic actions for solving problems by breaking skills and concepts down to their smallest parts (Wadlington & Wadlington, 2008).

Conceptual knowledge is knowledge of important principles that can be maneuvered and applied to new tasks (Rittle-Johnson & Koedinger, 2005). This type of knowledge is often used by students to generate new problem-solving strategies by linking previous experiences with word problems to the current word problem (Peled & Segalis, 2005).

Finally, in a problem-solving model, students need to have basic computational skills in order to solve problems. Researchers have shown that students' computational skills progress as they age. Computation skills start out as basic counting skills. However, by late elementary school, computation skills progress to an automatic retrieval of facts, which allows students to focus on the problem-solving solution (Mazzocco, Devlin, & McKenney, 2008; Woodward, 2006). Swanson, Jerman, and Zheng (2008) showed that the calculation abilities of students gradually improve from second to sixth grade. Performance differences gradually decrease as students age and working memory becomes a bigger factor in problem solving. The growth from less efficient strategies (e.g., finger counting) to mental strategies using working memory relates to automatic fact retrieval, allowing space in the brain for complicated tasks, such as problem solving. Some researchers have suggested that this is normal development and that students develop a variety of strategies that become internalized over time (Barrouillet & Lépine, 2005; Geary, Hoard, Byrd-Craven, & DeSoto, 2004; Rittle-Johnson, Siegler, & Alibali, 2001).

Reflect

Finally, students are expected to reflect on how they solved mathematical problems and determine what they learned from the process. This involves the process of metacognition, which refers to the capacities that allows one to think about one's own cognitive processes (Pennequin, Sorel, & Mainguy, 2010). Metacognition is the ability to "reflect precisely on one's own thinking process" (Vukman, 2005, p. 214). Metacognition allows verbalization throughout the reflective process (Kramarski & Mevarech, 2003), making it a key component in the problem-solving process.

Metacognition is a skill that good problem solvers use, and it is influenced by a person's "ability and willingness to use strategies to monitor, adjust, and reflect on [the] problem solving process" (Hoffman & Spatariu, 2008, p. 881). Metacognition has been positively linked to beliefs about individual abilities and motivation in the classroom (Kramarski & Gutman, 2006; Pajares, 2003).

Other researchers have shown a direct correlation between metacognitive strategies and self-efficacy beliefs about problem solving (Braten, Samuelstuen, & Stromso, 2004; Kitsantas, 2000). In a study that focused on undergraduate college students, Hoffman and Spatariu (2008) found that metacognitive strategies helped students during the problem-solving process; however, these strategies were only used with complex problems that involved multiple steps. Teachers need to provide explicit instructions that describe how to use metacognitive strategies in order for students to easily access those tools.

A crucial facet of problem solving that is often overlooked is students' beliefs about their skill in math and at solving problems. Such beliefs are an important characteristic that is necessary in everyday life. Hoffman and Spatariu (2008) found that there was a significant relationship between students' beliefs and self-concept as related to math. Problem-solving accuracy and efficiency increased with students' self-efficacy. Students who believed they would do well did; those who did not believe they could succeed often struggled with even the simplest of word problems.

Ercikam, McCreith, and LaPointe (2005) found that self-confidence and beliefs about mathematical abilities were highly correlated with mathematics achievement in countries like Canada and Germany. The results were different for students in the United States. This suggests that U.S. students do not have a positive self-concept or beliefs in themselves and their mathematical abilities.

House and Telese (2008) indicated that students' beliefs about mathematical ability were significantly related to achievement in both the United States and Japan. Students who reported positive beliefs about their mathematical ability scored higher than students who had negative beliefs about mathematics.

Metallidou and Vlachou (2007) reported similar results when looking at fifth- and sixth-grade students. These researchers found that self-efficacy was a predictor of performance along with the use of self-regulatory behaviors. These findings about beliefs and mathematical abilities can help teachers assist students in developing stronger beliefs in problem-solving processes along with self-regulatory behaviors such as metacognition, while continuing to work on procedural steps of problem solving.

Importance of Research

Problem-solving researchers have shown that the biggest factors when solving problems are the ability to transfer or generalize knowledge and the ability to switch from procedural to conceptual knowledge. Students with disabilities typically have a difficult time with knowledge transfer and have difficulty with or are never exposed to deeper concepts in the mathematical curriculum, due to a focus on teaching procedural skills (H. G. Jackson & Neel, 2006; Jitendra et al., 2005).

Relating to Students With Disabilities

The prevalence of students with a mathematical disability has been estimated to be 5–8% of the school-age population (Geary, 2004; Maccini et al., 2007), although the definition of having a mathematical disability varies around the United States. Another discouraging fact is that 38% of adolescent students with disabilities will drop out of school, compared to 25% of their peers without disabilities (Deshler et al., 2004)

Several factors adversely affect skill acquisition by students with mathematical disabilities. These factors include (a) high rates of absenteeism, (b) high course-failure rates, and (c) poor self-esteem (Deshler et al., 2008; Woodward & Brown, 2006). Along with personal traits of the students, cognitive traits affect a student's achievement. These include visual processing problems (Bender, 2008), auditory processing and memory (Lerner & Johns, 2009), and organization and attention (Lerner & Johns, 2009; Sabornie & DeBettencourt, 2004). Students who have any of these problems may inefficiently process language, which prevents them from completing and understanding mathematical concepts in a timely manner (Alvermann, Swafford, & Montero, 2004; Farmer, Riddick, & Sterling, 2002; Henderson, 2001; Kintsch, 2004; Marolda & Davidson, 2000; Tomey, Steeves, & Gilman, 2003).

Students with mathematical disabilities also struggle with the curriculum due to diverse teaching methods used in the special education and the general classroom. New standards set forth by NCTM changed the general education classroom to a more inquiry-based classroom, while special educators use specialized instruction (Cole & Wasburn-Moses, 2010). Students with disabilities in the general classroom must be provided intense modifications or they will not achieve success (Baxter, Woodward, & Olson, 2001; Baxter, Woodward, Voorhies, &Wong, 2002; Woodward & Brown, 2006). Woodward and Brown (2006) reported that in order for students with disabilities to be successful in the general education classroom, instructors had to integrate research-based strategies that were found to be successful within the special education classroom.

In a research study that examined general and special education students, Chung and Tam (2005) noted that a significant difference was the ability to transfer knowledge to novel situations. The stated top priority in education has been the transfer of knowledge to other domains (De Corte, 2003; Halpern & Hakel, 2003; Haskell, 2001) as the demands of the workforce increase (Deshler et al., 2001).

Although the transfer of knowledge—applying what has been learned in one context into other domains—can be difficult, there are a few effective strategies. Halpern and Hakel (2003) described these strategies as (a) practice at retrieval, (b) varying the conditions of learning, (c) rerepresentation of information, (d) use of prior knowledge, and (e) active engagement and attention to learning. These strategies should be incorporated into learning to enhance the likelihood of transference to other circumstances.

Other strategies found to be effective for students with disabilities include (a) depicting problems visually and graphically, (b) explicit instruction, and (c) peer-assisted learning activities during instruction (Baker, Gersten, & Lee, 2002; Cole & Wasburn-Moses, 2010; Fuchs, Fuchs, Yazdian, & Powell, 2002; Griffin & Jitendra, 2008; Jitendra, Griffin, Deatline-Buchman, & Sczesniak, 2007; Kroesbergen, Van Luit, & Maas, 2004; Van Garderen & Montague, 2003). Deshler et al. (2008) indicated that students with disabilities need to have teacher-directed, highly intensive, and explicit instruction. Researchers also indicated these students benefit from instruction in cognitive and metacognitive strategies related to building solutions (Jitendra et al., 2002; Maccini & Hughes, 2000; Vaughn & Linan-Thompson, 2003).

Research-Based Problem-Solving Strategies

In a meta-analysis, Xin and Jitendra (1999) analyzed types of instruction and their effects on mathematical problem-solving success of students with learning disabilities. Twenty-five different studies were examined that had outcomes associated with the implementation of problem-solving strategies. Most of the analyzed studies incorporated some type of explicit instruction or metacognitive strategies. Xin and Jitendra found that interventions presented in multiple steps were effective in increasing students' problem-solving abilities; however, computer-aided instruction was found to have the greatest effect. They reported individual instruction produced better results than group instruction, a finding that is prominent throughout the research literature. They also found that long-term interventions (i.e., more than a month) were most effective in maintaining and generalizing problem-solving strategies within a variety of settings and for an extensive period of time. Xin and Jitendra provided support to the following assertions: (a) Specific instruction in word-problem solving assists in the maintenance and generalization of skills for students with learning disabilities, and (b) student-directed interventions provide the greatest results for maintenance and generalization. The NMAP (2008) also found that "explicit instruction with students who have mathematical difficulties has shown consistently positive effects on performance with word problems and computation" (p. 48). The meta-analysis of Xin and Jitendra identified three distinct methods of mathematical problem solving that are effective with secondary students with learning disabilities: (a) cognitive-strategy instruction, (b) technology-based learning, and (c) schema building.

Cognitive-Strategy Instruction

Cognitive-strategy instruction focuses on the use of "cognitive and metacognitive processes, strategies or mental activities to facilitate learning and improve performance” (Montague & Dietz, 2009, p. 286). Cognitive-strategy instruction is based upon behavioral and cognitive theory, integrating what students do with how they think. The purpose of cognitive strategy instruction is to provide students with strategies on how to think and act like proficient problem solvers and strategic mathematics learners (Montague & Dietz, 2009).

One focus of cognitive-strategy instruction is modeling the process through think alouds by the teacher. Teachers should demonstrate and model strategies used in the problem-solving process while also verbalizing the thinking processes in their heads. This verbalization helps students to make connections while also internalizing the strategies (Chung & Tam, 2005). Strategy instruction also facilitates higher order thinking skills by incorporating self-regulation strategies and helping students to learn to question the process of problem solving.

Marjorie Montague, who has conducted extensive research into the area of cognitive strategy instruction (e.g., Montague, 1992; Montague Applegate, & Marquard, 1993; Montague & Bos, 1986; Montague & Dietz, 2009; Montague, Enders, & Dietz, 2011), developed a strategy called Solve It! (Montague, 2007). Solve It! is a research-based approach that has had great success with improving problem-solving abilities in learning-disabled students. This strategy involves direct student participation in the acquisition and application of the problem solving processes using cognitive and metacognitive strategies.

One of the earliest research studies of the Solve It! strategy involved teaching six high school students a problem-solving process (Montague & Bos, 1986).

Montague and Bos (1986) selected six secondary school students and provided direct instruction on how to use the problem-solving strategy of Solve It! After receiving training in this seven-step process, all students increased the accuracy of their problem solving and enhanced their ability to correctly pick the correct operation and solve the word problem. Thus, Montague and Bos found that providing cognitive-strategy instruction to students with learning disabilities helped them increase their accuracy in solving word problems. Another important finding was that students were able to effectively use this strategy with math word problems, which in turn could lead to generalization and help students to become more effective in other academic arenas such as scientific problem solving.

In 1992, Montague refined the problem-solving process, implemented it with six students in Grades 6–8, and reported that middle school students benefited from an instructional program that provided instruction in both cognitive and metacognitive strategies. This study was important because it helped to demonstrate that strategies that failed to address metacognitive strategies were not as successful. Montague (1992) indicated that problem solving in mathematics, as taught in many basal-type math books, does not address the metacognitive part of problem solving. This creates a disconnect in problem solving for many students with learning disabilities. Students need to be taught metacognitive strategies so they can link the three types of necessary knowledge (declarative, procedural, and conditional) in order to solve word problems. Without the connection developed through metacognitive strategies, students are unable to link the various types of knowledge and successfully complete the problem. Montague (1992) hypothesized that because the sixth graders in the study failed to reach the goal, the Solve It! strategy might be too developmentally advanced for younger students. Solve It! requires an integration of cognitive and metacognitive strategies that may be too advanced and complex for younger students or students who do not have the requisite skills in place to use this strategy (Montague, 1992).

Montague et al. (1993) implemented the Solve It! strategy with a large number of students in Grades 7 and 8 and found that students were able to use this strategy effectively for weeks after instruction. Students needed one booster session, a few months after the initial session, to remind them how to use this strategy. Seventh-grade students with learning disabilities showed they were able to compete favorably with average-achieving students.

Owen and Fuchs (2002) examined the effects of problem-solving strategy instruction with third-grade students to determine whether the instruction improved their ability to solve word problems. Students who received direct instruction along with direction instruction on transfer were significantly more successful in solving word problems than students who only received direct-strategy instruction (Owen & Fuchs, 2002). This was significant because it showed the importance of providing students with guidance regarding how to use the newly acquired strategies on novel problems that may not follow the pattern of previous problems.

F. B. Jackson (2002) suggested a strategy similar to the Solve It! program to help students to make sense of word problems. The strategy involved reading the problem, imagining the problem, deciding what to do, and doing the work. She found that students who learned this strategy reported that it was very helpful to use in other curricular areas.

Chung and Tam (2005) examined 30 Chinese students with mild intellectual disabilities. They found that students taught cognitive strategies for problem solving performed better on problem-solving testing than students who used a traditional method of problem solving. These results were also evident in the generalization and transference of problem-solving strategies to novel problems, which indicated that cognitive-strategy instruction was a successful strategy for students with disabilities.

Fuchs and Fuchs (2005) discussed ways to enhance problem solving in mathematics for students with disabilities and described how instruction helped these students. The researchers worked with a group of students and developed four conclusions for this research process:

1. Even young students (i.e., 8 and 9) benefited from direct instruction on problem solving in mathematics.
2. A foundation in problem solution was necessary for success; that is, students must understand how math processes work in order to free up their working memory to select and implement other calculations in the problem.
3. Students needed to have explicit instruction about how to transfer their new knowledge to new types of problems.

4. Finally, Fuchs and Fuchs (2005) found that small-group tutoring provided the best results when students learned a new strategy and had to apply and generalize the strategy to other word problems.

Scheurmann et al. (2009) conducted a study with 14 middle school students to determine the effects of the explicit inquiry routine. This approach consists of a combination of explicit skill instruction along with questioning and inquiry about how students made decisions about problem solving. Students with learning disabilities were able to generalize newly acquired problem-solving skills to novel problems with similar formats. These skills were maintained for up to 11 weeks following instruction (Scheurmann et al., 2009).

Additionally, Kajamies et al. (2010) found cognitive-strategy instruction to be successful in providing long-term effects with problem solving for 10-year-olds. In an experimental study, they examined eight students aged 10 who struggled with word problems. They provided intensive, systematic, explicit instruction on the use of cognitive and metacognitive strategies. Students showed a significant improvement in problem-solving ability through pre- and posttests. This improvement continued in the follow-up tests.

Montague et al. (2011) implemented cognitive-strategy instruction in an inclusive general education classroom with 24 middle school classrooms. Students were matched by their performance level on the state assessment and then divided into control and intervention groups. The intervention was implemented for 7 months, and progress was monitored in both groups. The researchers showed that students in the intervention group significantly outperformed the control group in all mathematics areas, including the progress-monitoring tests. However, the intervention effects were the same for all students (i.e., learning disabled, low achieving, and average achieving) in the classroom. These findings provided evidence that cognitive-strategy instruction can be beneficial for all students, thus making it a feasible program for the general education classroom.

Technology-Based Learning

Another strategy that has shown to increase student mathematical problem solving abilities is technology-based learning. Technology-based learning is a strategy that provides students experiences with technology (e.g., videos, computers, software) designed to solve real-life problems. Typically students watch videos about a problem. Then students use a variety of problem-solving strategies and mathematical computations to solve the problem. This strategy provides students with motivation and hands-on experience to problem solving (Bottge, Heinrichs, Chan, Mehta, & Watson, 2003).

The earliest studies regarding technology-based problem solving are from Shiah, Mastropieri, Scruggs, and Fulk (1995). They found that the use of computer-assisted cognitive-strategy instruction for word problems led to improved student performance on posttests. Researchers had students work at different academic levels on the computer, with groups of students receiving tutorials and animation, static picture and tutorials, or static pictures depicting the problem. All three groups performed significantly better than they did on the pretest.

Bottge (2001b) conducted research based on anchoring student learning to a problem so that students developed an answer, solved, and explained the problem under the guise that the problem had many answers and could be solved in different ways. For example, Bottge, Heinrichs, Chan, and Serlin (2001) examined the differences between eighth-grade students who used video anchoring for problem solving, also known as enhanced anchored instruction (EAI), and students who utilized the traditional method of problem solving using direct instruction. Bottge et al. (2001) found that both groups of students significantly improved their performance on the posttests after receiving either type of instruction. However, students who used the video anchoring, in which they could see the problem, were able to perform better on maintenance tests than those exposed to the traditional method of direct instruction. Bottge et al. (2001) attributed this significant difference to the motivation of students in the anchoring group. Students were highly motivated to figure out the problem and anxious to put their ideas to work, compared to students without a video or visual for the project, whose motivation to solve the problem was not as high as the video group.

Bottge, Heinrichs, Mehta, and Hung (2002) found very similar results. In their study, seventh-grade students with and without learning disabilities received EAI in place of traditional basal instruction. Bottge et al. (2002) found that the students who used the anchoring instruction made progress but did not have significant gains compared to those with a mnemonic device instruction, such as the Solve It! strategy. Bottge et al. (2002) attributed the results to the significant help provided by nondisabled peers during the process, because students with disabilities were not actively engaged in the problem-solving activities.

Bottge et al. (2004) replicated the study with sixth-grade students who did and did not have learning disabilities. The researchers showed that students with disabilities performed equally well and made approximately the same progress with both types of instruction. The greatest difference occurred in long-term transfer; those who received the video anchoring scored substantially better. However, all students needed to receive additional assistance to learn the concepts. Students were not able to make significant gains without instruction in both the general education classroom and the resource room.

In a comprehensive study using EAI, Bottge, Rueda, Serlin, Hung, and Kwon (2007) reported that middle school students with and without mathematics disabilities benefited from video anchoring. Students with a learning disability scored lower on the pretests, but after completion of the unit, their learning-trajectory line matched that of their nondisabled peers. Second, on maintenance tests, the students with disabilities performed equal to their peers, which indicated retention of the information learned. However, these tests only queried information in the video sessions, which limited the discussion about generalization of skills to similar situations.

Bottge, Rueda, LaRoque, et al. (2007) completed a study where EAI was used by the special education teacher in a special education classroom. The study was significant because previous studies had taken place in the general education classroom where students had special education support. The researchers reported some positive outcomes, but not as many as in previous studies by Bottge and colleagues. Students showed an increase in posttest scores but were lower as compared to the students with a mathematics disability (Bottge, Rueda, LaRoque, et al., 2007). Students in the study also did not score as high on maintenance tests conducted to check retention of knowledge, which suggested they did not achieve the deeper learning of the peer group.

Schema Instruction Strategies

Schema-based instruction is explicit instruction on the structure of mathematical word problems (Maccini et al., 2007). A schema is defined as a "framework, outline, or plan for solving a problem" (Marshall, 1995, p. 21). In mathematics, students use schemas to represent the underlying structure of a problem type (Powell, 2011). Schema-based instruction is different from other word-problem strategies because students must first identify the word problem as belonging to a problem type and then use a specific problem-type schema to solve the problem (Jitendra, Griffin, Haria, et al., 2007; Powell, 2011). Schema-based strategies were found to be successful with students with learning disabilities because they are explicitly taught and help students to organize information by using semantic relations and creating appropriate diagrams or equations to solve word problems (Jitendra, Griffin, Haria, et al., 2007; Powell, 2011).

Zawaiza and Gerber (1993) conducted some of the first studies that used schema-based instruction. They examined adults with learning disabilities enrolled in a community college. The researchers provided translation instruction, schema-diagram instruction, or no-specific-strategy instruction. They showed that providing students with a schema to solve story problems allowed students to be more successful on the posttest. The schema included how to figure out what the problem asked and then how to draw a picture or diagram to represent it. Although there were no significant differences in scores among the three groups, the group that received diagram instruction attained scores comparable to the mathematically competent peer group; thus, drawing diagrams helped students with learning disabilities to understand and solve word problems.

A similar study conducted by Jitendra and Hoff (1996) also used a schema-based strategy with three elementary school students with learning disabilities. These students increased their performance and retention of the strategy as they solved word problems and were able to maintain the skills for a 2-week period. These findings supported the use of schema instruction because it allowed students to be successful with previously difficult math content. In postinterviews, the students reported that they enjoyed using these strategies, the strategies were helpful learning tools, and they recommended teaching them to their friends.

Jitendra et al. (1998) used the same process with a larger number of students (N = 34) who had a learning disability or were at risk in mathematics. The authors successfully replicated the results of the prior study by Jitendra and Hoff (1996). Jitendra et al. (1998) examined two groups of students; one received schema-based instruction while the other received the traditional basal method of instruction to solve word problems. Both groups had similar pretest scores, 51% and 49%, respectively. Posttest scores increased to 77% and 65% for the respective groups. However, the most significant factor was that the group who received schema-based instruction achieved results similar to a normative sample of third graders (i.e., schema group, 81%, and sample set, 82%) and maintained these newly acquired skills. These findings supported previous results from the Jitendra and Hoff (1996) study, which indicated that direct schema-based instruction allowed students with learning disabilities to be more successful when solving word problems.

Jitendra, Hoff, and Beck (1999) examined schema-based instruction in middle schools by implementing schema strategy with four students with learning disabilities in sixth and seventh grade. Their research followed the same pattern as the research for the elementary students in that (a) baseline data were collected, (b) intervention or schema instruction was provided, and (c) maintenance of skills was monitored for a 2-week period. The middle school students were also taught how to use schema building with two-step word problems instead of only one-step word problems. Jitendra et al. (1999) found schema-based strategies helped students to organize information in a manner that was useful in the problem-solving process.

Jitendra et al. (2002) conducted one of the few studies that specifically examined schema-based instruction at the middle school level. This study involved four middle school students with learning disabilities who received schema-based instruction to improve their understanding of word problems. The researchers introduced two sets of schema: problem (i.e., conceptual) and problem solutions (i.e., procedural). The results of the Jitendra et al. (2002) study suggested schema instruction (a) improved word-solving accuracy; (b) facilitated maintenance of the new skills over time; and (c) provided greater understanding of the core concepts, which allowed for generalization into other areas and problem sets.

Schema-broadening instruction takes schema-based instruction further by helping students to transfer schemas to novel and different problems. This allows the expansion of the conceptualization of previously built schema. Schema-broadening instruction has produced positive results for students with disabilities. Fuchs et al. (2004) found that students who received instruction on the transference of schema to novel problems significantly outperformed students who only received schema instruction. Specifically, students with disabilities showed tremendous growth, with changes between .82 to 1.96, as compared to students in a control group.

Fuchs et al. (2008) researched schema-broadening tutoring in mathematics with third-grade students. A control group received instruction in the general education math program, while the research group received schema-based preventive tutoring for 12 weeks. Experimental instruction focused on (a) the mathematical structure of problems, (b) recognizing which schema a problem belonged to, (c) solving the problem, and (d) then transferring the method to novel problems with irrelevant information. After the 12 weeks of intervention, students with mathematics disabilities who received schema-based tutoring significantly improved compared to those who received general instruction.

Jitendra and Star (2011) examined middle school students taught schema-based instruction for ratios and proportions. The control group received the standard district curriculum and instruction, while the test group received schema instruction for the same amount of time. Students in the treatment group significantly outperformed the control group on the posttest, with a 24% improvement compared to only 2% for the control group.

Instructional Implications

When looking at research regarding mathematics problem-solving and students with disabilities, it is clear that thinking patterns can affect daily instruction. Issues surround the instruction of secondary students with learning disabilities: (a) How do students and instructional models fit together; (b) how do teachers gain access to research-based, appropriate, teaching models; and (c) how do special and general educators work together to facilitate fidelity of implementation (Reys, Reys, Lapan, Holliday, & Wasman, 2003; Woodward & Brown, 2006)?

Bottge (2001a) developed the key model that provides a structure for examining mathematics instructions for students with disabilities. In building this model, he looked at two characteristics: the learner and the instructional model. Learner characteristics include (a) engagement, (b) foundations, (c) intuitions, (d) transfer, (e) cultural supports, and (f) student-specific characteristics. Instructional components include (a) meaningfulness, (b) explicit, (c) informal, (d) situational, (e) social, and (f) teacher-specific characteristics. Bottge (2001a) indicated that all of these characteristics must align and fit together for long-term and internal learning to occur.

To help teachers with problem-solving models, general and special educators have to work together to access the knowledge base of each. Maccini and Gagnon (2006) found that secondary special educators used significantly more recommended, researched-based practices than general educators, but special educators still lacked knowledge depth for higher level mathematics instruction.

When examining secondary mathematics, another question to be asked is how special educators and general educators work together to facilitate student progress, given their different strengths (Thompson, Lazarus, & Thurlow, 2003). Educators need to tap knowledge bases and help teachers become successful with secondary students.

Summary of Research

The literature clearly shows that there is much to learn about students with disabilities at the secondary level and developing strategies for problem-solving success. The most promising strategies involve direct instruction or schema building in solving word problems. Both strategies have successfully helped students to understand word problems and develop a process to solve the problems.

Chapter 3: Research Methodology

The purpose of this study was to evaluate the impact of Solve It!, a problem-solving strategy, in a sixth-grade, general education classroom. The efficacy was measured based on math achievement of general education students and students with disabilities. Social validity data were collected to examine how students and staff members thought the Solve It! method worked. The two research questions were:

1. Does the Solve It! method affect the math problem-solving achievement of sixth-grade students?
2. What are teacher and student perceptions of the efficacy of the Solve It! method of teaching word-problem solving?

Research Design

The study used a quasi-experimental design across two groups, a control group and an experimental group. The dependent variable was the accuracy with which the sixth-grade students solved mathematical word problems on the Northwest Evaluation Association (NWEA) mathematics test. The independent variable was the Solve It! instructional approach, which was implemented with sixth-grade students with and without disabilities.

The groups were administered the Mathematics Concepts Test using the computerized NWEA (2009) instrument, with the pre- and posttests focusing on the strand of data analysis and problem solving. A survey was administered to determine social validity of the intervention with the participating students along with teacher interviews.

Setting

The school district where this study was conducted is located in Southwestern Colorado and has approximately 5,000 students enrolled. At the time of the study, the district served approximately 350 sixth graders enrolled in two different middle schools. The middle school chosen for this study had 120 sixth graders assigned to one of two teaching teams. Each teaching team consisted of two teachers who served approximately 60 students. The two teams served a similar number of general and special education students. There were two math classes per team with approximately 30 students per class.

A typical 65-minute math class period occurred daily and consisted of a 20-minute warm-up, a 15-minute homework discussion, and 30 minutes of direct instruction and guided practice. Homework was typically assigned daily based upon the lesson of the day and was designed to take 30–45 minutes for the students to complete. Warm-up exercises consisted of review problems from past chapters, review of concepts from the current chapter, or review of basic computational problems. Homework discussion allowed students to (a) ask questions about specific problems from the homework, (b) ask for clarification, and (c) ask for examples of how to do the problems. Direct instruction on new mathematics concepts was given to students and was typically delivered through lecture, hands-on activities, or examples. Finally, students were given guided-practice examples that were completed along with the teacher to provide immediate feedback to the student. The classroom had 30 desks facing forward with a white board and a smart board at the front of the room.

Students

Students were assigned to a class section based upon a variety of variables that included Colorado Student Assessment Program (CSAP) scores, teacher recommendations, past academic performance, and prior year NWEA scores to determine placement into accelerated classes. The students in the accelerated class did not participate in the study. The remaining students, including those with disabilities, were randomly assigned to one of two math sections by a computer system used to build student schedules. Both sections were taught by the same teacher and covered the same mathematics content and assignments. Both the experimental group and control group had a variety of students including those with disabilities and were taught by the same teacher.

General education students. The general education students' achievement on the CSAP state assessment ranged from unsatisfactory (score of 220–417) to proficient (score of 498–575). The students who scored in the unsatisfactory range did not have any supplemental classes to help address math deficits. The racial composition of students in the sixth-grade classes was 77% White, 13% Hispanic, 6% Native American, 1% Black, 1% Asian, and 2% two or more races. Students who qualified for free or reduced-price lunch for the school represented 24% of the population; 11% of the general education students qualified for free or reduced-price lunch.

The populations of these sixth-grade classrooms were 11- and 12-year-old boys and girls. Forty-seven of the 60 students attained partially proficient to proficient scores on the CSAP and earned scores between 203 and 225 on the NWEA tests, which correlated to high partially proficient to proficient (i.e., 450–575) on the CSAP test. Five students were new to the district this year and did not have CSAP data available.

Students with disabilities. Eight students with learning disabilities, with IQ scores between 91 and 105, participated in this study. They encompassed a variety of diagnostic categories, including two students with emotional disabilities, two with physical disabilities, and four with a specific learning disability. Four of these students had specific Individualized Education Plan goals related to mathematical concepts. The other four scored lower than proficient on the mathematics CSAP. However, they were not in the lower 10th percentile on the NWEA test, which was the point where direct interventions were implemented and specific goals related to mathematics were developed. Seven students were male and one student was female. Four of the students with disabilities qualified for free or reduced-price lunch; the other four students did not.

All of the students received special education services in the form of small-group (i.e., two to three students), direct instruction on specific content or interventions from a special education teacher for at least 2 years. After instruction was given in the elementary general classroom, the four students with specific mathematics goals were pulled out of general education and assigned to a resource room, typically for 30–45 minutes for remedial work on math concepts. In middle school, students remained in the general classroom and were provided additional support from the resource teacher during the 65-minute classroom time. In addition to mathematics class, students received support for reteaching or questions about the math lesson at the end of the day in the resource classroom. This class allowed all students in the middle school to have 35 minutes to work on specific skills, determined by NWEA data, and time to receive answers to questions students had regarding homework for the night.

Three students were age 11 and five were 12 years old. All the students had average intelligence scores as obtained on the Wechsler Intelligence Scale for Children, third edition, where the average range is 85–115 and 100 is the mean. None of the students were retained in elementary school. Seven of the students had an achievement deficit in the area of reading, eight had mathematics achievement deficits, and eight of the students struggled with task completion and organization. An achievement deficit was defined by the school district and state guidelines as falling in the unsatisfactory range on the state achievement test (i.e., CSAP) or falling below the 25th percentile on the subsections of the NWEA tests (i.e., reading, language usage, or mathematics).

The students with disabilities were evenly divided at random between the control and experimental groups. They were achieving at the unsatisfactory to proficient range on CSAP, with most of the students in the low partially proficient range. One student was proficient, with a score of 511, and five students were partially proficient with scores between 436 and 483. Two students scored in the unsatisfactory range (i.e., 383–412) on the state assessment, meaning they did not understand basic mathematics concepts expected at their grade level. These students scored between 184 and 200 on the NWEA test, which was between the 1st and 10th percentiles. These students still needed assistance with basic multiplication and other mathematic processes and had a difficult time keeping up with their peers' mathematics achievement. Their assignments were often shortened or modified within the general classroom in order for them to be successful.

Teacher

The math teacher in the sixth-grade classroom where the study took place was a male teacher with 15 years of experience teaching middle school math. He earned a Bachelor of Arts in Elementary Education with an endorsement in mathematics and a Masters of Arts in the area of reading. He was highly qualified, meeting all the federal guidelines regarding teacher certification in the area of mathematics, and his classroom had been used as an inclusion classroom for the previous 3 years. The teacher and an additional special education teacher helped to facilitate learning and understanding of mathematical concepts and provided support and modifications of assignments for students with disabilities or any student who was struggling.

Curriculum

The Prentice Hall Mathematics curriculum was used throughout the district in general education classrooms. This curriculum was described as a spiraling mathematics curriculum; that is, a "curriculum in which students repeat the study of a subject at different grade levels, each time at a higher level of difficulty and in greater depth" (Pressley & Harris, 2009, p. 81). The sixth-grade text was the first mathematics book in the spiral, with coverage of many mathematical concepts and operations, including addition, subtraction, multiplication, and division, in the areas of (a) decimals, (b) fractions, (c) word problems, and (d) other mathematical concepts. The instructional materials included textbooks, workbooks, practice sheets, cooperative groups, and manipulatives.

Dependent Measures

The NWEA measure is a standardized computer-based testing system that was used by the participating district to collect data on students throughout the year, which were not reported to the state of Colorado. Data, in the form of standard scores, were used to determine whether students were making adequate progress with the curriculum, which should lead to success on the CSAP test. If students were not making adequate progress, changes were made to instruction. The district used this system for 3 years, and students took the tests three times a year in September, January, and May. These scores were used to help place students into advanced classes and to develop goals for Individualized Education Plans. The system provided a detailed printout of student achievement in specific areas (i.e., reading, writing, and a variety of mathematical concepts), which allowed educators to make goals for Individualized Education Plans based on student performance and helped to determine which students should receive enrichment instruction.

This computer-based testing was aligned with the Colorado academic state standards system in use since 1977. In these interactive tests, test questions became easier or more difficult based upon student responses throughout the testing session. As they progressed through the test, students were given a variety of test questions at different levels of difficulty to pinpoint the level at which a student was functioning academically. At the end of the test, students were given an overall standard score and a standard score for specific skills within each content test, which teachers used to develop appropriate academic programming (e.g., remediation or enrichment).

The item pool for the NWEA mathematics test was between 1,500 and 2,500 items. Students cycled through the randomly selected items based upon the questions they correctly answered. For Colorado, Math Survey Aligned With Goals 6+ was taken in the spring of 2007 and the fall of 2007 and had a reliability factor of .92. Thus, it was a good predictor of how students would perform on the CSAP test, based on the reliability between NWEA scores and CSAP proficiency ratings (NWEA, 2009).

The validity of NWEA scores to determine proficiency on the CSAP test was calculated after multiple administrations of the NWEA test. The NWEA results were gathered from Spring 2007, Fall 2007, and Spring 2008 and then compared to the CSAP test results. The number of tests scores used for the concurrent validity analysis was 21,150 during the three testing periods (NWEA, 2009). The goal of the NWEA test was to be able to successfully predict proficiency on the CSAP test. This allowed teachers to make instructional modifications to improve scores of students who were scoring below proficiency. Based on concurrent validity data for the NWEA test and CSAP testing, classification accuracy for proficient or not proficient was .98. The consistency of these predictions was also high at .97, which indicated appropriate concurrent validity (NWEA, 2009).

Additionally, students were given 10 question pre- and posttest quiz from the Solve It! curriculum. The quizzes consisted of one and two-step word problems including the mathematical operations of addition, subtraction, multiplication, and division.

Social Validity

Social validity for this project was measured using student surveys and teacher interviews. The student survey consisted of five questions, and the teachers were interviewed with a five-question survey to gather more detailed information about the Solve It! process. The students were given a survey rated on a Likert scale of 1–5 along with room for open-ended comments, if needed.

Teacher Interviews

The teacher interview focused on the ease of teaching and implementing the Solve It! method. The general education and the special education teacher were interviewed both separately and together. The interview included items to identify (a) the time required to learn the strategy, (b) ease or difficulty implementing the strategy, and (c) outcomes associated within the classroom implementation. It focused on the overall teacher perception, satisfaction with student use, and the perceived effect on student achievement in problem solving. Five teacher interview questions were asked:

1. How easy or difficult was this strategy to teach to students?
2. Did students use this strategy when they encountered word problems in the math curriculum?
3. How effective was this tool in enabling students to solve mathematical word problems?
4. Did this strategy affect students' beliefs about solving word problems?
5. How long did it take to learn about this strategy?

Student Surveys

The student survey focused on similar topics (Appendix A). The survey focused on whether the students felt the tool was effective to use and implement and whether they felt it was time consuming to work through the steps. Students were asked whether they felt they were more successful with word problems using this method and whether it affected their beliefs about mathematics achievement.

Procedures

Experimental Group

The students engaged in the Solve It! problem-solving method for the first 30 minutes of class and used this method every day for 6 weeks during which a 10-question pretest was given along with a 10-question post test at the end of the intervention period. Daily instruction during this time focused on the memorization and application of the seven cognitive processes involved with the Solve It! system.

Each day, students reviewed the steps: (a) reading for understanding, (b) paraphrasing, (c) visualizing, (d) hypothesizing, (e) estimating, (f) computing, and (g) checking. This was done through explicit instruction and scripted lessons provided in the manual. Daily lessons included modeling each step of the problem-solving method to help students understand expectations. Student interaction and involvement in the lesson was mandatory in order to demonstrate their understanding and application of the Solve It! process. Sample problems were modeled each day using the seven-step process, and students engaged in guided and independent practice to show accurate implementation of the strategy. Additionally, students were given two-question quizzes obtained from the Solve It! curriculum weekly to provide additional scores and help evaluate program effectiveness. The success of this strategy was measured through NWEA test scores and by comparing a specific strand called Data Analysis and Problem Solving with January and May data. Trends, such as increase or decrease in scores, were assessed in both the control group and the intervention group.

The intervention was the seven-step problem-solving strategy developed by Montague (1992, 2007) called the Solve It! method. The steps were (a) read the problem, (b) recognize relevant information and ignore irrelevant information, (c) restate the problem, (d) recognize the operation, (e) round and estimate the answer, (f) revise the answer, and (g) review and check. This strategy was taught to students daily. Each student lesson consisted of a 30-minute session and included instruction on a step of the strategy, guided practice using the strategy step, and independent practice. The lesson began with the participating teacher demonstrating (i.e., visual or kinesthetic) and explaining the step of the strategy. The students were asked to demonstrate understanding of the step verbally or kinesthetically for the participating teacher. Next, the participating teacher provided students guided-practice problems that used the steps of the strategy. Students continued to work on problems at a specific step until they were able to solve problems with 80% accuracy. Students spent 30 minutes on each step, with a daily review of each step along with a visual demonstration to remind them of the process and to provide extra practice (Montague, 2007).

The first step of strategy implementation instructed students to read the problem aloud or silently to themselves and identify any words they did not know and any cue words that would help them to solve the problem. During this process, the students were instructed to put a checkmark above any words they did not know and circle any cue words. Cue words were defined as any word that they found in the problem that were critical to understanding how to correctly solve the problem. Identified unknown words were taught to the students as necessary, and strategies were taught to help students decide if the unknown words were relevant to solving the problem. The students were taught the following self-questions: "Are there words I don't know?" and "What are the cue words?"

In the second step, the students were instructed to identify the relevant information, determine if there was irrelevant information, and decide whether a sufficient amount of information was given to solve the problem. The questions to ask themselves were the following: “Do I have all the information I need?” and “What do I need to do to solve the problem?”

The third step involved the students restating the problem in their own words to the participating teacher. They were expected to be able to identify the information from the problem that was needed to solve the problem along with identifying what unit was needed to label the problem after it had been solved. The questions they were asking themselves during self-talk were the following: “What is being asked?” and “What am I looking for?”

The fourth step required the students to identify what operation or operations were needed in order to solve the problem. They were asked to identify the operation (i.e., addition, subtraction, multiplication, or division) for all problems solved. The questions to ask themselves were the following: “What do I need to do first?” and “Is there another step to solve to get to my answer?”

The fifth step involved the students using sample problems that required rounding the numbers in order to get an approximate answer and making the numbers more manageable to work with. Questions they were asking themselves were the following: “What are the numbers after I rounded them?” and “What is the answer after I rounded it?”

The sixth step helped the students to begin the problem-solving process. They worked the problem based on the information they had gathered, using Steps 1–5. Once they solved the problem, the questions they asked themselves were these: “Is the answer in the correct form?” and “Did I label it correctly?”

The final step for the students was to review and check their answer. Students determined whether their solution answered the question correctly, whether it was a reasonable solution, and whether they labeled it correctly. This helped the students review and think through the problem-solving process to keep them cognitively engaged with the problem. The questions they were asking themselves were the following: “Does this solution answer the question?” and “Does it make sense?”

During the intervention stage, the seven steps of the strategy were printed on posters and laminated index cards, which the students could use at any time during the intervention phase. The cards were given out at the beginning of each session to facilitate the memorization of steps.

Control Group

Students in the control group received instruction for problem solving from the district-adopted Prentice Hall curriculum paralleling the time frame of the research group including the administration of the 10-question pre- and posttests. This was completed during 30-minute sessions at the beginning of class and did not exceed the allotted time. The control group participated in taking the NWEA pre- and posttests, along with two-question weekly quizzes given to monitor progress at the same time the research group was taking these assessments.

The Prentice Hall method for teaching problem solving was very basic. It taught students the Pólya (1945) method of problem solving using four steps. The first step was to read and understand the problem. Next, students would make a plan for solving the problem, which could be done through pictures, graphs, or charts.

Then, students were to carry out the plan and complete the computations involved. Finally, students were to check answers computed through the problem-solving process.

The instruction for the problem-solving process moved quickly, and students were given ample time to solve problems. The steps of the problem-solving process were reviewed daily before students were given a problem to solve. Next, the teacher used guided instruction with problems from the Prentice Hall curriculum to demonstrate how to work through a story problem given the four steps of the problem-solving process. Students were encouraged to help the teacher work through the problem and ask questions about the process. Finally, students were given a problem to work independently or with a partner using the four steps. A discussion about the problem and the problem-solving process followed if time allowed. The control group used word problems from the Prentice Hall curriculum and not from the Solve It! curriculum.

Fidelity of Implementation

During implementation of the Solve It! problem-solving strategy, the researcher observed students to ensure accurate implementation of all steps. Observation included a checklist of each of the steps and room to write examples of how the steps were used (Appendix B). This helped to ensure the strategy was being used correctly and to reteach steps missed or used incorrectly. Additionally, the researcher observed the control group classes to monitor for bleed over of information by the teacher, as he was also responsible for teaching the Solve It! curriculum .

When the teacher would begin to provide information related to the Solve It! program, the researcher, sitting at the back of the classroom, would raise her hand in order to signal the teacher he was going too far.

Data Analysis

Data analysis for this project was completed in two steps. The first analysis was conducted using SPSS software with pre- and posttest standard data scores on the NWEA test from January and May to monitor for improvement in the area of problem solving. This was done using the problem-solving strand of data and probability, a subsection of the mathematics concepts test. The control and experimental groups' scores were compared to determine any significant changes. Scores for the pre- and posttest used from the Solve It! curriculum were also analyzed for changes in problem-solving ability. This was conducted through data analysis using SPSS software.

The second part of the data analysis involved the teacher interviews and student surveys. Analyses of the Likert-scale surveys were conducted through the use of descriptive statistics in the SPSS program. The responses were totaled, and the mode for each question was obtained. Additionally, teacher interviews were recorded and coded based on the themes of student use of the strategy, student beliefs about the strategy, and ease of implementation for students and teachers.

Chapter 4: Results

The purpose of the study was to evaluate the efficacy of Solve It!, a problem-solving strategy, using data collected from a sample of 54 sixth-grade students who were divided equally into a control and an experimental group. Efficacy was tested using the number of problems solved correctly on a 10-question word-problem test administered to the students before and after the experimental group used the Solve It! process. NWEA tests were also administered to the sixth graders before (winter scores) and after (spring scores) the experimental group completed the Solve It! strategy intervention. Student surveys and teacher interviews were also conducted to provide social validity and insight about student and teacher perceptions of the Solve It! strategy.

Characteristics of the Sample Population

The characteristics of the sample population are described in this section. Table 1 shows the number of participants with a disability. Thirteen students (24.1%) reported having a disability, with the majority of the sample (75.9%) not having a disability. Table 1 also shows the profile of the sample, control group, and experimental group. The experimental group was taught to use the Solve It! strategy. Table 1 shows that the number of participants in the control group and experimental group were almost equal, with 28 students being in the control group (51.9% of the sample) and 26 students being in the experimental group (48.1% of the sample).

Table 1 also shows the disability profile for the control and experimental groups. As can be observed, the groups had almost the same number of students with a disability, six students (21.4%) in the control group and seven students (26.9%) in the experimental group.

Table 1

Disability Profile of Sample and Groups

Group	Frequency	Percentage
Total sample (*N* = 54)		
No disability	41	75.9
Disability	13	24.1
Control group (*n* = 28)		
No disability	22	78.6
Disability	6	21.4
Experimental group (*n* = 26)		
No disability	19	73.1
Disability	7	26.9

Tables 2 and 3 show the results of the 10-item word-problem test and the NWEA tests, respectively, before and after the experimental group was taught the Solve It! problem-solving strategy. As can be seen in Table 2, before the administration of the Solve It! strategy, the experimental group had a score 0.6401 points lower than the control group on the 10-item word-problem test. After the strategy intervention, the experimental group had an average score 1.3626 points higher than the control group.

Table 2

Ten-Item Word-Problem Pre- and Posttest Results for Both Groups

Group	Minimum	Maximum	*M*	*SD*
Pretest				
Control	0	9	4.179	2.597
Experimental	0	10	3.539	2.702
Posttest				
Control	1	10	4.714	2.291
Experimental	2	10	6.077	1.917

As can be seen in Table 3 with the NWEA test winter and spring scores, before the Solve It! intervention, the control group had an average score of 216.48, 4.1 points greater than the experimental group. On the spring NWEA test, after the intervention, the control group attained an average score of 218.5, which was 3.31 points greater than the experimental group. Table 3 shows ranges, means, and standard deviations.

Table 3

Northwest Evaluation Association (NWEA) Test Results, Winter and Spring, for Both Groups

Group	Minimum	Maximum	*M*	*SD*
Winter NWEA (pretest)				
Control	185	230	216.482	11.440
Experimental	195	221	212.375	6.730
Spring NWEA (posttest)				
Control	186	239	218.500	13.691
Experimental	183	237	215.192	12.436

Research Question 1

Addressing the first research question involved the analysis of the 10-item word-problem test scores and the NWEA test scores of the control and the experimental groups. To address this, means were compared for the 10-item word-problem test scores and the NWEA scores before and after the Solve It! strategy was administered. Paired-sample *t* tests were performed to compare the means of the scores before and after the experiment; however, this assumed normality of the data. As such, normality tests were performed on the pretest and posttest data to determine their normality.

Comparison of 10-Item Word-Problem Test Scores

To test for normality, Shapiro-Wilk's normality tests were performed. Table 4 shows the results of the normality test for the 10-item word-problem scores for the experimental group. As can be observed, both the pretest and posttest scores on the word-problem test had significance values greater than .05, indicating normality. The control group's word-problem scores were also compared, and tests for normality were performed. The 10-item word-problem test scores were normally distributed with Shapiro-Wilk's test significance values greater than .05, as shown in Table 4.

Table 4

Shapiro-Wilk's Test for Normality on 10-Item Word-Problem Test Scores

Group	Statistic	*df*	Sig.
Experimental			
Pretest	.933	26	.092
Posttest	.957	26	.335
Control			
Pretest	.927	28	.051
Posttest	.943	28	.133

Table 5 shows the results of the paired-samples *t* test comparing the pretest and posttest mean scores of the Solve It! experimental group. Table 5 shows that after the Solve It! strategy was taught to students in the experimental group, their score improved on average 2.54 points, with the highest and lowest scores improving as well. The improvement was statistically significant. Teaching the Solve It! strategy might have increased the problem-solving capability of the experimental group; however, further comparisons were required for a more accurate conclusion.

Table 6 shows the *t*-test comparison of pre- and posttest scores of the control group. The posttest scores of the control group were higher, with the increase in scores significant, $p = .016$. This means that the difference between the posttest and pretest mean scores was statistically significant.

Table 5

Experimental Group: Paired-Sample Comparison of Scores on 10-Item Word-Problem Test

Pair	Mean	*SD*	*t*	*df*	Sig. (2-tailed)
Pretest – Posttest	–2.5385	2.21325	–5.848	25	.00

Table 6

Control Group: Paired-Sample Comparison of Scores on 10-Item Word-Problem Test

			95% CI of the difference				
Pair	Mean	*SD*	Lower	Upper	*t*	*df*	Sig. (2-tailed)
Pretest – Posttest	–0.535	1.104	–0.964	–0.107	–2.566	27	.016

A test for normality was performed prior to comparing the differences between the posttest and pretest scores for the control and the experimental groups. As shown in Table 7, the differences for the control group were not normal, with a significance value of .001. As such, a nonparametric comparison of means was performed.

Table 7

Shapiro-Wilk's Test for Normality on Posttest–Pretest Difference on 10-Item Word-Problem Test Scores

Group	Statistic	*df*	Sig.
Control	.856	28	.001
Experimental	.953	26	.272

Tables 8 and 9 present the results of the nonparametric Mann-Whitney U test for comparison of differences in means between posttest and pretest scores for the control and experimental groups. The mean rank and sum of ranks show that the difference between pre- and posttest was higher for the experimental group than for the control group (see Table 8). Table 9 shows the statistical significance of the test, a significance value of .00, which is less than .05 and thus indicated a statistically significant difference.

Table 8

Comparison of Posttest–Pretest Differences of Mean Scores on 10-Item Word-Problem Test

Group	*n*	Mean rank	Sum of ranks
Control	28	20.16	564.50
Experimental	26	35.40	920.50

Table 9

Statistical Significance of Posttest–Pretest Differences on 10-Item Word-Problem Test Between Control and Experimental Groups

Test	Difference statistic
Mann-Whitney U	158.500
Wilcoxon W	564.500
Z	–3.614
Asymp. sig. (2-tailed)	.000

Given these test results, it can be concluded that the experimental group had a significantly higher increase in scores on the word-problem test after learning the

Solve It! strategy as compared to the control group. The data were also broken down to look specifically at the general education students and students with disabilities.

A comparison of means test was performed on the general education students and students with disabilities to test whether there was a significant improvement in each subgroup of students in word-problem test scores of the experimental group over the control group before and after the experiment was performed. General education students (i.e., students without disabilities) in the experimental group showed a greater improvement in scores on the 10-item word-problem test, with a mean rank of 26.05, as compared to the control group, with a mean rank of 16.64 (see Table 10). For students with disabilities, the experimental group also showed greater improvement on the 10-item word-problem test, with a mean rank of 9.93, compared to a mean rank of 3.58 for the control group (see Table 10).

Table 10

Growth Comparison of Means for General Education Students and Students With Disabilities on the 10-Item Word-Problem Test

Group (Posttest – Pretest)	*n*	Mean rank	Sum of ranks
General education			
Control	22	16.64	366.00
Experimental	19	26.05	495.00
With disabilities			
Control	6	3.58	21.50
Experimental	7	9.93	69.50

The test statistics in Table 11 for students identified with and without disabilities indicate a significance value less than .05. This means that the improvement in mean scores on the 10-item word-problem test for the experimental group, both general education students and students with disabilities, was significantly higher after undergoing the intervention as compared to the control group. This indicates that the Solve It! method fostered a significant improvement in the skills solving word problems for general education students and students with disabilities.

Table 11

Pretest–Posttest Differences for Growth Comparison of Means on 10-Item Word-Problem Test

Test	General education students	Students with disabilities
Mann-Whitney U	113.000	0.500
Wilcoxon W	366.000	21.500
Z	–2.563	–3.026
Asymp. sig. (2-tailed)	.010	.002

Given these test results, it can be concluded that the experimental group had a significantly higher increase in word-problem test scores after learning the Solve It! strategy as compared to the control group, who did not learn the strategy. This was shown to be true for both general education students and students with disabilities.

Comparison of NWEA Scores

To test for normality, Shapiro-Wilk normality tests were performed on the data gathered from the NWEA mathematics strand of Data Analysis and Problem

Solving. Table 12 shows the results of the normality test for the experimental group's NWEA test scores. As can be observed, both the NWEA winter and spring scores have significance values greater than .05. As such, these data sets were normal and were compared using the paired-samples *t* test. However, Table 12 shows that the NWEA test scores for winter were not normally distributed for the control group, having a significance value less than .05. Given this, the 10-item word-problem test scores were compared using a paired-samples *t* test, whereas the NWEA test scores for the control group were compared using a nonparametric comparison of means test.

Table 12

Shapiro-Wilk's Test for Normality on Northwest Evaluation Association (NWEA) Test Scores

Group	Statistic	*df*	Sig.
Experimental			
Winter NWEA (pretest)	.943	24	.188
Spring NWEA (posttest)	.977	26	.811
Control			
Winter NWEA (pretest)	.906	27	.019
Spring NWEA (posttest)	.935	28	.081

The experimental group's NWEA test scores were compared. Table 13 shows the paired differences; there was an increase of 1.33 points on average for the NWEA spring scores compared to the winter scores, whereas the lowest NWEA score increased by around 5.46 points from winter to spring. As can be seen in Table 13, the increase was not statistically significant (p = .511). There was no statistically significant difference in the NWEA test scores of the experimental group from winter to spring, which would mean that teaching the Solve It! strategy to the experimental group did not help increase NWEA test scores.

Table 13

Paired-Sample Test for Experimental Group on Northwest Evaluation Association (NWEA) Test Scores

Pair	Mean	*SD*	95% CI of the difference: Lower	95% CI of the difference: Upper	*t*	*df*	Sig. (2-tailed)
Pretest (NWEA winter) – Posttest (NWEA spring)	–1.33	9.77	-5.46	2.79	–.668	23	.511

However, comparing the experimental group's performance on the NWEA tests to that of the control group revealed greater increases for the experimental group. Table 14 shows the comparisons between general education students and students with disabilities on NWEA scores for the experimental group and the control group.

For general education students, the experimental group was found to have a higher improvement in the NWEA test scores, with a mean rank of 19.85, as compared to that of the control group, with a mean rank of 19.21. The test statistics, as shown in Table 15, however, showed a significance of .860, indicating improvement in NWEA test scores for the experimental group over the control group was not statistically significant. The same was true for students with disabilities. The experimental group was found to show improvement on the NWEA test, with a mean rank of 7.57, as compared to that of the control group, which had a mean rank of 6.33. However, the difference was not statistically significant at the .05 level. Thus, there was not enough evidence to conclude that the Solve It! method can significantly improve the problem-solving skills needed for higher NWEA test scores for general education students or students with disabilities.

Table 14

Growth Comparison of Means for General Education Students and Students With Disabilities on the Northwest Evaluation Association (NWEA) Test

Group (Posttest – Pretest)	*n*	Mean rank	Sum of ranks
General education			
Control	21	19.21	403.50
Experimental	17	19.85	337.50
With disabilities			
Control	6	6.33	38.00
Experimental	7	7.57	53.00

Table 15

Pretest–Posttest Differences for Growth Comparison of Means on Northwest Evaluation Association Test

Test	General education students	Students with disabilities
Mann-Whitney U	172.500	17.000
Wilcoxon W	403.500	38.000
Z	–.177	–.575
Asymp. sig. (2-tailed)	.860	.565

Conclusion for Research Question 1

The first research question asked the following: Does the Solve It! method affect the math problem-solving achievement of sixth-grade students? The Solve It! method had a statistically significant, positive effect on student scores on the 10-item word-problem test. However, improvement on the NWEA test was not statistically significant.

Research Question 2

Research Question 2 was the following: What are teacher and student perceptions of the efficacy of the Solve It! method of teaching word-problem solving? The first part of the research question dealt with how effective teaching the Solve It! strategy was to sixth-grade students through the analysis of their problem-solving success before and after they were taught the strategy. The second part of the research question asked how teachers who taught this strategy perceived its usefulness and suggestions for continued use in the classroom.

Student Perceptions

Respondents were 26 students from the experimental group. Data were gathered using a five-item questionnaire, which used a 5-point Likert scale. The survey items can be found in Appendix A.

Student Question 1. Question 1 was used to assess the perceived ease of using the Solve It! strategy. The descriptive statistics for Question 1 are presented in Table 16. The use of the Solve It! strategy was perceived as easy, with a mean of 2.15 and a mode of 2.00, on a scale from 1 (*easy*) to 5 (*difficult*). The breakdown of the statistics is presented in Table 16, showing the frequencies and percentages of the responses. Most students found the Solve It! strategy easy to use, with 30.8% perceiving it to be easy (a rating of 1 on a 5-point scale from *easy* to *difficult*), while another 34.6% gave it a rating of 2 regarding ease of use. Only 11.5% found it at all difficult to use, giving the strategy a rating of 4.

Table 16

Question 1 Response Frequencies and Percentages

Response	Frequency	Percentage
1 (*easy*)	8	30.8
2	9	34.6
3	6	23.1
4	3	11.5
5 (*difficult*)	0	0.0

Student Question 2. Question 2 was used to assess the perceived ease of using the Solve It! strategy when applied specifically applied to word problems. The mean response was 2.69, and the mode was 3.00, on a scale from 1 (*easy*) to 5 (*difficult*). The most frequent response chosen by almost half (46.2%) of students using the Solve It! strategy indicated they found it neither easy nor difficult when solving word problems (see Table 17). Almost all students (84.6%) felt the procedure was easy or neutral in difficulty.

Table 17

Question 2 Response Frequencies and Percentages

Response	Frequency	Percentage
1 (*easy*)	4	15.4
2	6	23.1
3	12	46.2
4	2	7.7
5 (*difficult*)	2	7.7

Student Question 3. Question 3 was used to assess whether students would use the Solve It! strategy in the future when solving word problems. The mean was 3.19, and the mode was 5.00, on a scale from 1 (*not at all*) to 5 (*all the time*). Although the mean was near neutral (3.19), many of the students reported they would use the strategy all the time, with the most frequent response being 5. The breakdown of the statistics is presented in Table 18. As can be observed, 19.2% responded with neutral, and 46.2% indicated they would use the strategy often or all the time.

Table 18

Question 3 Response Frequencies and Percentages

Response	Frequency	Percentage
1 (*not at all*)	6	23.1
2	3	11.5
3	5	19.2
4	4	15.4
5 (*all the time*)	8	30.8

Student Question 4. Question 4 assessed students' perceptions of the effect the Solve It! strategy had on their belief in their ability to solve word problems. The mean was 3.03, and the mode was 4.00, on a scale from 1 (*none*) to 5 (*greatly*). The statistical breakdown presented in Table 19 shows almost half (46.1%) of students felt Solve It! increased their belief that they could solve word problems.

Table 19

Question 4 Response Frequencies and Percentages

Response	Frequency	Percentage
1 (*none*)	5	19.2
2	4	15.4
3	5	19.2
4	9	34.6
5 (*greatly*)	3	11.5

Student Question 5. Question 5 assessed the perception of students related to the effectiveness of the Solve It! strategy for solving word problems. The mean was 3.73, and the mode was 4.00 and 5.00, on a scale from 1 (*not at all effective*) to 5 (*highly effective*). The breakdown of the statistics is presented in Table 20, with 61.6% responding that the Solve It! strategy was effective.

Table 20

Question 5 Response Frequencies and Percentages

Response	Frequency	Percentage
1 (*not at all effective*)	1	3.8
2	3	11.5
3	6	23.1
4	8	30.8
5 (*highly effective*)	8	30.8

Overall, the experimental group believed that Solve It! strategy was an effective and easy strategy to use in word-problem solving. Table 21 shows a summary of the mean responses to each student survey question.

Table 21

Summary of Means and Modes of Student Survey Responses

Student survey question	Mean	Mode
1. Ease of use	2.15	2.00
2. Ease of use with word problems specifically	2.69	3.00
3. Would use strategy in future	3.19	5.00
4. Effect on belief in ability to solve word problems	3.03	4.00
5. Effectiveness of strategy	3.73	4.00, 5.00

Note. Questions 3–5 scored from 1–5, with 5 the most positive score; Questions 1 and 2 reverse scored, with 1 the most positive score.

Teacher Perceptions

The second part of Research Question 2 was the teacher interview. The interview dealt with teachers' perceptions of using the Solve It! strategy in their teaching. The sample included the general education teacher and the special education teacher, who were interviewed independently and together. The interview consisted of five open-ended questions related to (a) ease or difficulty of teaching Solve It!, (b) whether students used the strategy, (c) how effective this tool was for students, (d) whether it affected student beliefs about word-problem solving, and (e) the length of time to learn Solve It! In order to effectively gather the themes of teacher interviews, the researcher recorded the interviews.

General education teacher interview. Question 1 asked the teacher to describe the ease or difficulty of teaching the Solve It! problem-solving strategy to students. Overall, the general education teacher felt the strategy was fairly easy to teach because it was systematic and sequential, allowing him to move from step to step easily. However, he found it difficult to keep the attention of the large group (26 students) due to the detailed steps and the need to teach the students the metacognitive questions of the process. It was also difficult for him to check in with each student to recite or recall the steps and the questions asked, and he found it to be tedious. He had ideas about how to improve the next time he teaches it and to keep students engaged in the process as he checks in with individuals.

Question 2 asked whether the teacher perceived that students used Solve It! when they encountered word problems in the math curriculum. The teacher felt students used it occasionally but not all the time. He felt students who were more concrete thinkers used the process more than the students who were more abstract in their thinking. He indicated this was due to the systematic and step-by-step process that concrete thinkers like to use. He stated,

> Abstract thinkers probably used this process, but much of it took place in their head, so I couldn't tell if they were using it or not, while the concrete thinkers still needed to write it out and do it step by step.

He felt students with a good grasp of problem solving did not need to go through all the steps by writing them out.

The teacher was asked in Interview Question 3 how effective the Solve It! strategy was in helping students solve mathematical word problems. The teacher felt this process gave the students a great framework to think about problem solving. He liked the metacognitive part and teaching students how to talk to themselves during the problem-solving process, which helped them to think more clearly. He said, "When you hear kids talking out loud about their thinking and problem solving, it is much easier to see where their mistakes are, which allowed me to help students more effectively." The teacher also felt the strategy gave students a little more freedom to talk and work through problems, instead of just sitting idly by, because they were expected to talk through the process.

The fourth question in the teacher interview asked whether the teacher felt the Solve It! strategy affected students' beliefs about solving word problems. The general education teacher felt that going through each of the steps so thoroughly and completely, along with exploring both the metacognitive and cognitive processes, helped students understand the problem-solving process more. However, many of the students complained about getting bogged down with following all the steps and felt it was a tedious process. It did seem to increase their beliefs about their own abilities in problem solving as they had a better understanding of how to approach word problems.

The final question asked the teacher about the length of time it took to learn to use the Solve It! strategy. The general education teacher did not feel it took a long time to learn about the strategy or how to teach it. He indicated there were more details to remember, and he often would review the process or steps before teaching to make sure he had all the details. He liked the thoroughness of the process and the access to numerous sample problems to select from for guided problem solving. He said the strategy might have taken him longer to learn due to the addition of the metacognitive processes, which he had not encountered in other problem-solving approaches. He enjoyed learning a new problem-solving process.

Special education teacher interview. Question 1 asked the teacher to describe the ease or difficulty of teaching the Solve It! problem-solving strategy to students. The special education teacher provided support in the classroom while the general education teacher taught the Solve It! process. She did not actually teach the large group the strategy but helped with reinforcing and clarifying as needed with all the students. Her opinion was that it was hard to keep all students on the same page and observed that some students needed to move ahead while others were still struggling with the steps. She felt students were at different levels, creating frustration for students on both ends of the learning curve.

The second question asked whether students used this strategy when encountering word problems in the math curriculum. The special education teacher indicated the students with disabilities used the strategy frequently because of the steps. She stated the strategy gave students guidelines and direction when solving word problems. She thought the general education students would use it on more difficult problems or when they got stuck with a problem. She did not feel the general education students used the strategy consistently, but when they did, they used all the Solve It! steps.

Question 3 asked how effective Solve It! was in helping students when they encountered mathematics word problems. The special education teacher said it was a good process because it was step by step and was easy to follow. She also felt it was effective because it gave her a means to cue students if they got frustrated with problem solving with questions such as, "Which step are you on and what do you need to do next?" or "Have you gone through all the steps?" She felt the most beneficial part of the process for students was that it gave a framework to start the problem-solving process, which they did not seem to have before.

Question 4 asked whether the Solve It! process affected students' beliefs about their abilities in problem solving. The special education teacher responded that it had a positive affect on students' beliefs because they knew how to attack story problems successfully. However, she did not feel the students were more confident in their answers, although they did have more confidence in the process of problem solving. The special education teacher felt students' confidence in getting the right answer would develop as they had more success and exposure to the Solve It! process.

The final interview question probed the length of time it took to learn about the Solve It! strategy. The teacher did not feel it took a long time to learn. She felt the hardest part was learning the language and becoming familiar with the metacognitive questions of the Solve It! process. Overall, she indicated that Solve It! took no more time than learning other strategies.

General education and special education teacher joint interview. After being interviewed separately, the teachers were then asked the same questions together. Both teachers felt like the process was easy to teach but expressed that it was difficult to keep all students on task due to the Solve It! requisite of having everyone understand the steps completely and be able to recite the steps. Students varied in the speed with which they grasped the process. Both teachers felt it would be difficult to utilize Solve It! independently with a large group of students unless there was another person present to help monitor student understanding.

Both of the teachers felt students used the strategy on more difficult questions requiring multiple steps, but students had a tendency to skip some of the steps as they felt they were too time consuming or not helpful. Some students did not use the strategy at all on easy questions. However, the special education teacher noted students with disabilities used the strategy regularly, even on simple problems. Overall, both teachers felt students had a tendency to be lazy problem solvers, because if problems looked hard, they would not attempt to use Solve It! The general education teacher thought this strategy gave all the students a good place to start.

The teachers collectively thought that teaching the Solve It! process had a positive effect on students' beliefs regarding problem solving. They both said students attempted to solve more problems and had more discussions with peers about how to attack a problem. The teachers stated that students were especially interested in how others created visuals for the problem. They agreed that the visualization step seemed to help students the most. Both teachers enjoyed listening to students solve problems because it gave them insight into how students were thinking.

Both teachers thought the Solve It! process did not take longer to learn than any other new program. They both thought it had beneficial components that students had not been exposed to and could see where more conversations with students about metacognition would be beneficial in other core areas, such as science and geography. The special education teacher appreciated the large quantity of problems available in Solve It! to support modification in the classroom. The general education teacher liked having multiple problems also without having to find example problems.

Overall, both teachers responded that the Solve It! process was successful. They indicated it would be easier, more effective, and useful if taught at the beginning of the year when new routines are being developed. They both expressed interest in incorporating it into next year's curriculum if possible.

Chapter 5: Discussion, Conclusions, and Implications

Discussion

The purpose of this study was to investigate whether a direct, cognitive-strategy, problem-solving program (i.e., Solve It!) designed to enhance the word-problem-solving skills of students increased the accuracy with which students with and without disabilities correctly solved word problems. In addition the study was designed to determine whether Solve It! affected students' beliefs about their problem-solving efficacy.

The researcher implemented the Solve It! strategy with 26 middle school students between 11 and 12 years old. These students received instruction from the Solve It! problem-solving curriculum for 6 weeks. Concurrently, a similar group of 28 students received instruction on problem solving using the Pólya (1945) method of understand, plan, execute, and reflect. Distal data were gathered on both groups using the district-mandated NWEA test, which was administered in January and May. Additionally, proximal types of data were gathered on both groups via a 10-item world-problem pretest; four weekly two-question quizzes; and a 10-item posttest containing one- and two-step word problems with a combination of adding, subtracting, multiplying, and dividing. A five-question student survey regarding the use of the Solve It! strategy and a five-question teacher interview were conducted to gather the perceptions of participants on ease, feasibility, and effect on problem-solving abilities with the Solve It! process.

Solve It! provides cognitive-strategy instruction to increase mathematical problem-solving ability; the process was developed by Montague (1992, 2007). It is derived from cognitive theory under the belief that effective problem solving depends on the ability to select and apply cognitive and metacognitive processes in order to understand, represent, and solve problems (Brown, 1978; Flavell, Miller, & Miller, 1993; Mayer, 1985). In this study, the Solve It! process was used to try to improve student problem solving on standardized tests and classroom assignments. Students from both groups were tested throughout the 6-week intervention period to gather data concerning accuracy of problem solving. Problem-solving skill was also examined through the use of a standardized computer test by the NWEA (2009), which is used throughout the school district specifically to measure problem-solving skills. After receiving instruction on the Solve It! process and using it for 6 weeks, students completed a survey to assess the social validity of the problem-solving process. Additionally, teachers who participated in the study were interviewed to learn about their thoughts about the efficacy and the feasibility of implementing the Solve It! strategy in the classroom. These results were coded using a qualitative coding system looking for specific themes throughout the interview.

The data provided mixed results regarding the success of Solve It! with sixth-grade students. Students from both groups showed no significant gains on the problem-solving strand of the standardized NWEA test. However, students who engaged in the Solve It! problem-solving process did obtain a statistically significant increase over students who were not taught to use the process. The results were consistent for both general education students and students with disabilities.

Although students were successful at increasing their problem-solving accuracy using the Solve It! process, student survey results suggested frustration. This was indicated through direct comments from the students on the survey that they were willing to put a limited amount of energy into using the using the Solve It! process. Teacher interviews indicated student frustration while solving problems due to the length of the Solve It! process the students used to get the answer. The general education teacher and special education teacher indicated most students complained about going through all the steps, especially when students could solve the problem easily. However, teachers felt there were positive results for both students and teachers. Teachers indicated they would use this intervention again if allowed as it did have a positive effect on student scores in the short term. Students also indicated they would use the strategy in the future while problem solving.

Using Solve It!

There are several possible reasons why all intervention participant scores increased while using the Solve It! method. One of the reasons could be that the questions on the quizzes were very similar to those taught throughout the Solve It! curriculum. Additionally, students were familiar with the format and style of the Solve It! process, allowing them to solve problems more accurately, as the quiz questions often mirrored or replicated the problems from the class teachings. Another explanation could be that students worked with this strategy consistently for 6 weeks, perhaps not enough time for generalization of skills.

When students encounter problems that are different or inconsistent to what they are used to working with, they can become frustrated and confused. The main reason for this is the lack of exposure students have had to different problem sets along with a lack of concentrated time to work with a strategy to create automaticity. When learning a new skill or strategy, repetition with similar types of problems helps to facilitate and increase accuracy, as students know what is expected and how to attack. However, teachers often spend very little time on word problems and even less on working multiple problems in the same structure (Edens & Potter, 2008). Repetition and exposure are needed to create generalization to other types of word problems. This research project only concentrated on the problem sets in the Solve It! curriculum and did not branch out to lengthier text problems as seen on the NWEA test, which could explain the increase in scores on the Solve It! quizzes and the lack of progress on the NWEA standardized test.

However, the increase in scores for the weekly quizzes was statistically significant for students with and without disabilities. General education students showed an increase of means of 26.05 points from pre- to posttest, as compared to the control group's increase of 16.64 points. The students with disabilities in the Solve It! group increased mean scores from pre- to posttest by 6.35 points more than students with disabilities in the control group. Reasons may include the use of metacognitive strategies helping students to become more cognizant of how they solved problems along with the explicitly taught, sequential steps of the Solve It! process. The strategy appears effective with both general education and students with disabilities.

Metacognition in problem solving is a key factor in teaching strategy use in mathematics, as it teaches students how to think about the steps in the problem-solving process. Although it is frequently used in reading, the transition to using metacognition in mathematics instruction has been slow to develop. This research project has provided evidence that the use of metacognition in problem-solving strategies creates positive results on quizzes along with student beliefs about their problem-solving abilities. Students were interested in learning and applying metacognition to the problem-solving process. The students also stated that it helped them to be more aware of how to solve a problem when using the metacognitive questions provided by the Solve It! strategy.

Another benefit of using metacognition while problem solving was the creation of strategic learners who knew what strategies they had in their repertoire, could determine which strategy would work for the problem, could remember and apply the steps, could evaluate whether the strategy was effective and if not modify, and knew when the problem had been solved (Hughes, 2011). All of these steps were incorporated into the Solve It! process students used. This creation of steps and the incorporation of the metacognitive side of thinking would appear to be extremely important and vital to the continuation of developing effective problem solvers in authentic settings. Metacognitive processes allowed students to select specific strategies by thinking about what they needed to solve the problem, what cognitive resources were needed, and what experiences they had in the past to solve similar problems (Pennequin et al., 2010). Metacognition is an area that deserves further research and examination into the application of mathematics problem solving.

The results of this research provides empirical evidence that students can be taught an explicit problem-solving strategy and increase the accuracy with which they solve word problems. Furthermore, it provides specific evidence that students with disabilities can improve problem-solving abilities in a short amount of time if provided with the right type of instruction and repetition of tasks and sensitive dependent measures.

However, the NWEA standardized computer test did not provide the same results. Students in both groups showed no statistically significant improvement on the posttest after the implementation of the Solve It! strategy. This included the separate data sets of general education students and students with disabilities. General education students showed only a 0.64-point growth on the posttest, and students with disabilities only showed a 1.24-point increase not a significant change.

There was a complication when comparing the NWEA data between the two groups, as students' initial scores showed a large discrepancy. This could be attributed to the wide variety of mathematical abilities among students. Due to the nature of the study using an authentic setting classroom there was no way to create equivalent groups based on NWEA scores between the two participating classes.

Therefore, the control group started out with a higher standard score of 216.49 as compared to the standard score of 212.38 of the Solve It! group.

The results created a dilemma as to why students showed statistically significant growth on the proximal data while showing no growth on the distal data of the study. A few explanations were developed for students' better performance on the 6-week quizzes than on the standardized test: type of math problems presented, reading achievement levels of students, the change in testing format, a pattern of errors, and lack of generalization skills. These areas are explored in more detail.

The NWEA test is a computerized test with multiple tests offered in various academic arenas. For this study, the test called Mathematical Concepts was used, which presented students with multiple types of problems covering a variety of mathematical concepts. During this testing period, students were expected to read a variety of problems, such as data analysis, measurement, proportion and ratios, and so on, from a computer screen; formulate an answer; and pick from the multiple-choice answers listed. The story problems provided for the students were often lengthy, with large amounts of extraneous text that students often would skim through or skip in order to get to the question. This type of problem would be formatted significantly different from the problems the students encountered in the Solve It! process. The large volume of text in a story problem could significantly change a student's ability or desire to try and solve a problem based on the amount of effort needed along with skill repertoire to analyze the problem.

Another complicating factor with the NWEA test was the comprehension of the text coupled with the reading achievement of the students. Although the researcher did not have access to student folders to check reading achievement levels, they could be a determining factor in student achievement on word problems. When working with the Solve It! problems, students were expected to read the problem and circle any unknown words to get clarification before working the problem. However, that was not a strategy that was feasible or allowed when taking the NWEA test. This simple change could have created a significant difference in the performance of students, as they were not allowed to ask questions about the text and could not completely and accurately follow the steps of Solve It! process as dictated by the NWEA testing protocol.

Additionally, taking a computerized test can create unexpected results in that once an answer is chosen, a student cannot go back and change an answer, as can be done when solving problems using paper and pencil. This would mean that strategies students have used, such as waiting to answer a question in case a similar problem comes up that helps them identify what to do, would not be available. This is important in that the Solve It! strategy works on similar problem types each day. Students would not be able to assimilate this to NWEA testing, because they only see one problem at a time rather than multiple problems covering a broader array of problems.

The NWEA test also tested for multiple mathematical concepts, such as computation, data, ratios, probability, and graphing, throughout the testing period.

This forced the student to switch to different processes throughout the testing period and access various parts of the brain to successfully navigate problems throughout the testing session, creating demand on working memory to access information for a variety of mathematical needs. However, the Solve It! process concentrated on one mathematical concept: problem solving. This allowed the students to easily access strategies and working memory because they were solving only word problems, as compared to the multiple mathematical concepts on the NWEA test.

Student and Teacher Feedback

Social validity of a project is important to investigate to determine whether the results coincide with feelings and beliefs of the participants. Social validity is the process of estimating the "importance, effectiveness, appropriateness and/or satisfaction" (Kennedy, 2005, p. 219) of an intervention for different stakeholders. Determining social validity is important in special education as it distinguishes data results from the actual use of the strategy, providing insight into how the strategy or intervention can be used effectively in classroom settings or by the stakeholders (Horner et al., 2005). In accordance with the definition of social validity, the results of the research study indicated that both teachers and students found the *Solve It!* strategy to be effective.

Student survey. The student survey was a five-question survey using a 5-point Likert scale. The survey asked students about applying the strategy, using the strategy, and perceptions about the strategy. The results of the survey provided some valuable insight into the student perspective of using the Solve It! process along with some conflicting answers.

Question 1 of the survey asked students to rate the ease or difficulty of the Solve It! strategy. Whereas the survey results indicated that over 60% of the students found the strategy very easy to use, the anecdotal comments gathered during the intervention and also from the survey suggested differently. Often students commented that the strategy was "too long" or "too tedious" to use. Students often complained that there were "too many steps" and did not want to complete the whole process. Some reasons for these contradictory statements may relate to how students perceived the process as compared to actually using and working through the process. Student beliefs about a process and the actual use of process can be in conflict due to a student's desire to use the strategy or to learn the material. Motivational factors for student learning are important to consider when teaching and using new strategies. Although students may not like to use a strategy, they frequently will see the value in the process and the benefits that can be gained.

Related to the first question, the second survey item questioned students on the ease or difficulty of using the strategy specifically to solve word problems. The results of this question more accurately reflected how the students felt about using this process. A large percentage of the students (46.2%) gave the strategy a neutral rating. This meant that students felt the strategy was neither easy nor hard when solving problems. One potential explanation is that students saw the benefit of using the strategy with the increase in problem-solving accuracy but did not necessarily want to use the strategy for problem solving, due to the time it takes to use.

The third question of the survey asked the students if they would use this strategy in the future to solve word problems. Whereas the previous survey question indicated that students were neutral about the ease or difficulty of using this strategy, 46% of the students said they would use the strategy all or most of the time in the future. This finding suggests that students liked having a process or strategy to use when solving word problems. Research has shown that students, particularly those with disabilities, have a tendency to be inefficient problem solvers due to the lack of strategies they have learned or old and inefficient strategies from the past (Montague et al., 2011). With this in mind, and as expectations for students' problem solving increase, having a large array of strategies to access will become essential for students as they enter higher level mathematics classes.

The next two survey questions examined each student's self-beliefs concerning problem solving. These questions were important because they examined students' perceived ability to solve problems rather than the accuracy with which they solved them. Self-efficacy, defined as the belief in one's ability to organize and execute action to achieve a desired outcome (Bandura, 1986), is a key variable in intervention research. This is a critical aspect, as student beliefs about their performance greatly impact how they will use and integrate a strategy into common practice. These findings were consistent with those of Hoffman and Spatariu (2008), House and Telese (2008), and Metallidou and Vlachou (2007), who reported part of students' success with mathematics and problem solving was due to their beliefs about their abilities. This relates to the current Solve It! research study in that students had a higher self-efficacy about problem solving after learning this strategy. Theoretically, this belief should help students become more efficient problem solvers. The belief that one can perform a task successfully is often a better predictor of success than the intervention that was introduced (Pajares, 2003). With self-belief and better performance, these students may perform even better in the future with the continued use of the Solve It! strategy.

Question 4 asked about the effect the strategy had on students' belief about their ability to solve word problems. The survey results showed that many of the students felt the strategy had a positive effect on their beliefs about problem solving. One reason may be that students understood the processes of cognition and metacognition in the problem-solving process, which helped to solidify the problem-solving process in their strategy repertoire. This has a huge implication for teachers concerning strategy use in that helping students simply believe they can be good problem solvers may increase accuracy as much as the strategy or intervention itself. Students' self-belief, the conviction in one's ability to successfully organize and execute actions for a desired outcome (Bandura, 1986), can be a reliable predictor of mathematics performance (Hoffman & Spatariu, 2008). Building a student's mathematics belief system can lead to extended effort towards problem solving along with persistence in problem-solving activities, leading to an increase in problem-solving accuracy and efficiency (Braten et al., 2004).

The final survey question asked students about their perceived effectiveness of the strategy to solve word problems. This survey question was important when examining the whole child and the results of the quizzes given throughout the intervention. Most of the students (61.2%) perceived this strategy to be effective for solving word problems, even though the students did not know whether or not their test scores were increasing. The power of positive self-talk and a belief that a strategy is helping can have more of an impact than the actual strategy choice. The implications of this finding are tremendous in that teachers may need to focus more on increasing a student's belief systems as compared to teaching multiple strategies for students to access (Klassen, 2002).

General education teacher interview. The general education teacher was responsible for implementing the strategy in the classroom. While the ease of teaching the Solve It! strategy was noted, this teacher also noted that some aspects of the strategy proved challenging. Specifically, keeping the attention of a classroom of middle school students while learning the details and intricacies of the Solve It! process proved difficult. This is an important finding for schools and school districts when examining this strategy as an intervention. A strategy as detailed as Solve It! may be better used as an intervention for a small group than a large class to ensure understanding and effective use.

The second interview question centered on whether the students actually used the strategy when encountering word problems. The general education teacher thought that students used it occasionally but not all the time. This could be related back to the lack of progress on the NWEA test in the area of problem solving; students had not yet achieved mastery on this strategy and were not able to generalize it to a different setting along with the broader array of questions on the standardized test. The Solve It! process focused on the four major operations of mathematics with the use of one- or two-step problems. However, students were responsible for much more than that on the NWEA test, such as data tables, fractions, and conversions like rate or time problems. Because of this difference in problem format, students might have been less inclined to use the Solve It! process, causing smaller gains than were expected and accountability measures may need to align better with instructional strategies.

The third question focused on the effectiveness of the strategy as a tool for students when encountering word problems. The general education teacher felt this strategy provided students with a great framework for problem solving, and the introduction of the metacognitive component helped students verbalize their mathematical thinking. If the students followed all the steps, they were successful at solving the problems. The Solve It! method was sequential and provided students step-by-step instructions for problem solving. This method provided students with cue cards to signal the cognitive and metacognitve processes along with questions the student should discuss for each step. Students were encouraged to have discussions based on the metacognitive questions provided for each step. Additionally, each of the seven steps of the Solve It! strategy began with a verb helping students to determine what they should do next. With this design, if followed correctly, students were successful at problem solving.

Like the questions on the student survey, teachers were also asked about the effect of this strategy on students' beliefs concerning problem solving. The general education teacher felt that the strategy had a positive effect on students' beliefs because students had a good understanding of all the steps needed to solve word problems after learning this strategy. This provided students with the confidence to proceed, due to the extensive understanding of the cognitive and metacognitive processes needed to solve word problems.

The final interview question asked teachers about the length of time it took them to learn the strategy to teach to the students. Although the teacher did not feel this strategy took an extensive amount of time, he did feel pressure and anxiety about making sure he understood all the minute details of the strategy. The Solve It! process has an extensive amount of self-talk that students learn in order to use the metacognitive strategies, and the teacher sometimes struggled with ensuring he had the correct questions matched with the correct step of the seven-step process. An implication from this teacher interview was there can be frustration with implementing another problem-solving strategy without having the time to learn or implement it effectively. A large majority of students with disabilities now receive services in the general education classroom for a significant part of the day (Mercer & Mercer, 2005). Additionally, the number of students without disabilities who have need for extra support is also increasing in the general education classroom

(Stormont, Espinosa, Knipping, & McCathren, 2003); thus, the demand on instructional time in the classroom is extremely high, especially given the emphasis on national and state standards and accountability testing. Strategy implementation for teachers and students needs to be efficient and timely.

Research-based strategies may help to relieve the pressures on instructional time; Solve It! has shown to be research based and effective with middle school students. Research-based strategies, as defined by U.S. Department of Education (2003), are strategies that are supported by rigorous substantiation of effectiveness. There are obvious advantages to using research-based strategies, but these strategies can, in some cases, be difficult for teachers to access and implement. The time teachers have available for implementing interventions within the classroom setting is limited; research-based strategies help counter this because the strategies have been empirically tested over time. Also, teachers need to implement strategies that are most effective and have shown the greatest student success in a short amount of time, especially for those who are already behind academically (Lembke & Stormont, 2005)—thus the need to use research-proven strategies. Finally, research-based strategies provide accountability to parents and the district that strategies that are educationally sound and evidence based are being used to educate students.

Special education teacher interview. The special education teacher was used as a floating teacher in the classroom to help with questions and facilitate learning of the strategy. This teacher did not directly participate in the teaching of the strategy. The first interview question asked the teacher about the ease or difficulty of teaching the Solve It! problem-solving strategy. Although the special education thought the Solve It! strategy was a good strategy, she struggled with keeping everyone engaged, as there were students at both ends of the learning curve. Students with lower mathematical skills showed frustration, while others showed boredom at the pace of the instruction for the strategy. Instruction in the general classroom is much different from that in a resource room, as there are students at many different levels and abilities.

Question 2 asked whether the students actually used the strategy when encountering word problems. The special education teacher felt that students with disabilities consistently tried to use the strategy when solving word problems as it gave them a clear and concrete method for problem solving, which many students with disabilities need when learning a new skill. However, she did not think the general education students used the strategy consistently. She thought these students had other tools that they could access, whereas students with disabilities did not. Students with disabilities often have ineffective or nonexistent problem-solving strategies. These students often fail to take advantage of prior knowledge, which may help them to solve similar problems; they do not manipulate the information given in order to increase personal understanding; and they typically do not use contextual cues to help decipher information (Hughes, 2011). Thus, students with disabilities do not grow cognitively in regards to problem solving as they continually use strategies that are no longer effective or no strategy at all. Finally, as word problems increase in complexity and more steps or operations are added, students with disabilities become disengaged in the problem-solving process altogether, giving up on solving word problems.

The third question focused on the effectiveness of the strategy as a tool for students when encountering word problems. This strategy was deemed effective by the special education teacher for the students as it gave them guidelines and direction for solving word problems. It also gave students structure and a starting point when attacking a word problem.

Question 4 inquired about the effect on student beliefs concerning problem solving. The special educator thought that this strategy had a positive effect on students' beliefs about problem solving but felt 6 weeks was not a long enough time to make a huge difference. Students with disabilities have had years of failure when working word problems, and a short intervention is not going to make an immediate change in a student's belief system. In order to help mediate this problem, a longer intervention period along with a slower instructional pace to allow for mastery of the problem-solving process would be beneficial for students with disabilities and would increase students' self-efficacy as they became more successful with word problems.

The fifth interview question asked teachers about the length of time it took them to learn the strategy to teach to the students. The special educator did not feel that the Solve It! strategy was any different than the other strategies she had learned. Often, special education teachers do not have the content knowledge needed to be effective in the general classroom, whereas general education teachers do not have a background in assessments and strategies to help students access the information.

With the collaboration between the teachers, the special education teacher felt they had a good teaching balance to implement the Solve It! process.

Conclusions and Contributions to the Field

This research expands findings from previous research regarding the use of cognitive-strategy instruction with secondary students, specifically sixth-grade students, providing important new information about the use and transfer of interventions taught to students in authentic classroom settings. In addition, this research provides insight into the relationship between the authentic classroom setting and student behavior as related to practical application of strategies taught.

This study provides evidence that students, with and without disabilities, who were taught using cognitive-strategy instruction increased the accuracy of word-problem solving in a specific context and situation. The teachers and students reported that they appreciated learning the intervention and would use it in the future when problem solving was involved. These results are consistent with previous research studies using cognitive-strategy instruction and provide empirical evidence of its effectiveness with a wide range of students.

A final implication from this research is that cognitive-strategy instruction has proven to be an effective intervention for students with disabilities in the area of problem solving and should be used accordingly (Chung & Tam, 2005; Maccini et al., 2007; Montague et al., 2011). Research has shown teachers need to implement strategies that are most effective and have shown the greatest student success in a short amount of time, especially for those who are already behind academically

(Lembke & Stormont, 2005). Students with disabilities would benefit from cognitive problem-solving strategies that are explicitly taught. This can occur through multiple evidence-based instruction strategies like cueing, modeling, rehearsal, and feedback (Montague et al., 2011), such as used in the Solve It! model. Explicit instruction is typically highly structured and organized, incorporates cues and prompts, provides guided and distributed practice with immediate and corrective feedback, and allows overlearning of the strategy until the point of mastery. Solve It! is an explicitly taught problem-solving strategy that showed positive results with general education students and students with disabilities in word-problem solving. It may be an effective intervention for the school district to adopt and use with students who are having difficulty with the mathematical problem-solving process, as it is a research-based strategy that is educationally sound. However, time must be available to enable teachers to learn to implement strategies with fidelity.

Because the study was limited in time, the results may not indicate the extent that the strategy could have on students' problem-solving abilities. Solve It! could be a strategy that is taught and implemented throughout the entire school for the whole year. There were positive results from the Solve It! implementation with students with and without disabilities, indicating generalization to all learner types. With the implementation throughout the entire school, students would encounter many different problem types along with having constant exposure to the Solve It! process. This could help students begin to generalize the skills learned to a variety of settings, thus possibly leading to an increase of scores on standardized tests such as the NWEA or state accountability tests.

Another important contribution to the field was the results from the student survey and teacher interviews. The student survey provided insight into the beliefs students had about the Solve It! process. Students consistently stated in the surveys that they believed the Solve It! process helped their problem-solving abilities. This is an important part of strategy implementation, because student beliefs about a strategy or process can be the greatest determining factor regarding its implementation and continued use. Although there was no significant change in standardized test scores, the belief that they were better problem solvers could have an effect on standardized scores if students were able to work with the process longer and apply it to other circumstances. An exploration into the beliefs of students and their ability to apply strategies to word problems would be a powerful study, and the results from this study indicate that an increase in beliefs could be correlated to increased accuracy in problem solving.

Limitations of the Study

This study's data showed contrasts with results regarding student achievement and problem solving. The proximal data indicated that students of all abilities could increase problem-solving accuracy, while the distal data showed no change in problem-solving abilities. Caution should be taken when interpreting these results due to these limitations.

First, this study contained a very small sample size of only 54 sixth-grade students. Because of this small sample size, the results could be skewed either way, creating inflated or deflated results.

Second, the students with disabilities were mostly male, with only one participant being a female. This was a limiting factor because male and female students often can be very different learners. Although the data showed growth overall for students with disabilities, it would be difficult to make judgments about gender as there was only one female subject with data. Additionally, not all disability types participated in this study, with the representation of only students with learning disabilities, students with physical disabilities, and students with emotional disabilities. This mix of students, although all were eligible for special education, includes very different behaviors as related to academics. Specifically, students with emotional disorders can create very different results on a daily basis depending on their emotional state. This single fact can create data that are very skewed and misleading as compared to other students with disabilities.

Another limiting factor for this study was that it was conducted during the later part of the academic year so there was only a short time frame in which to conduct the study. In addition, this study took place at the very end of the school year, and students typically have a hard time staying focused during this time. Also, this strategy was introduced late in the academic year and had not been a part of the class routine. Disruption or change in routine can have a dramatic effect on some student behavior and academic achievement, thus impacting the results.

The difference between the two types of data-gathering methods, NWEA testing and weekly quizzes, also was a limiting factor. They were very different types of testing situations. Many circumstances in the NWEA testing setting could not be controlled for, such as reading ability, lack of motivation to perform, the inability to change answers, and lack of clarification of testing information if needed. These factors greatly affect the ability to generalize results to similar situations due to the inability to control.

A final limitation that might have affected the validity of the study was the use of a single cognitive-strategy instruction intervention, specifically the Solve It! strategy, in a very specific setting. Cognitive-strategy instruction is one of the proven effective interventions; another effective intervention is schema-building instruction. It would have been beneficial to see the results of comparing multiple problem-solving strategies instead of only one.

Implications for Future Practice

The findings of this study have several implications for practice. First, the results of the study provide students and teachers with an effective intervention to be used to improve problem-solving accuracy. The Solve It! process provided an explicit method for teaching problem solving that has been found effective for all students with a wide range of abilities. This strategy was flexible and could be used in authentic settings such as an entire classroom or could be tailored for more explicit learners such as those with disabilities or students struggling with problem solving. It also was effective because it was very specific and detailed, providing students with a framework to use when encountering a number of story problems.

With the information about the Solve It! success, implications for future use could include expanding Solve It! into a variety of problem-solving situations to simulate the format of problems, such as those included in state accountability tests. This may include expanding the Solve It! process to multiple-step problems combined with the use of multiple mathematical operations. When students encounter an unfamiliar problem set, they often will shut down. Students do this because they lack experience or background knowledge on how to attack an unfamiliar type of problem. However, if Solve It! were expanded to incorporate many word-problem formats, students would have more experience with applying the strategy, creating a greater success rate in accuracy while increasing the types of problems students attempt to solve. Additionally, the more exposure students have to a wide variety of problems while using Solve It!, the greater the chances of generalization to other word problems. The expansion to other word-problem formats also could increase the chances of success on word problems that have more text such as those students typically encounter on state accountability tests.

Additionally, this study showed positive results for students with disabilities despite a short time frame. However, if the time frame for implementation were extended, student growth may continue in the area of problem solving. The process of problem solving can be very taxing for students with disabilities due to the large number of cognitive processes involved; however, with extended use and practice, students were able to effectively use the Solve It! method. The more exposure and time a student uses a strategy, the greater the chances the student will use it in various settings and testing situations, thus creating greater gains on standardized tests.

This strategy supports the need for collaboration among teachers in order to effectively meet the needs of all students in the classroom. This is important, as students with disabilities are spending more time in the general education classroom, often with support from special education teachers, creating change in teaching behaviors. Students with disabilities often have minimal involvement in the general education classrooms and mathematics curriculum, where rich discussion about problem solving takes place, putting these students at a disadvantage for development of mathematical thinking. Content standards can be used to provide guidelines for general and special education teachers in order to identify key concepts that may help students with disabilities be successful in the general education classroom. General education teachers and special education teachers need to have more collaboration and sharing of responsibilities within the classroom to help students became proficient problem solvers.

Professional development must be content focused to improve teachers' knowledge and practices while also increasing student achievement (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). Teachers in inclusive settings have a tendency to have a better attitude and a greater ability to deal with students with disabilities if there is ongoing consultation and classroom support from special education teachers (Idol, 2006) with newly introduced research-based strategies. Often, special education teachers do not have the content knowledge needed to be effective in the classroom, whereas general education teachers do not have the background in assessments and strategies to help students access the information. Teachers also need to have active professional development to acquire new practices and to implement the strategies in the classroom. For this to be successful, explicit instruction on using research-based strategies in the classroom should be implemented in a collaborative manner between general education teachers and special education teachers (Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2003; Penuel, Fishman, Yamaguchi, & Gallagher, 2007).

Another implication for the future includes incorporating strategies or interventions designed for all students. First, instruction should focus on critical content, which includes concepts, skills, and problem solving to provide a foundation for further learning. Instruction should include preteaching of skills and carefully selected examples so students do not become overwhelmed.

Finally, professional development for teachers regarding effective research-based strategies is paramount for helping students become more efficient and accurate problem solvers. Effective professional development should be coherent and relative to the teacher (Penuel et al., 2007) in that it must align with a teacher's goals and needs within the classroom along with school curricular needs. Although content standards provide guidelines to help general and special education teachers identify key concepts that will help students with disabilities be successful in the general education classroom, professional development also must be content focused to improve teachers' knowledge and practices while increasing achievement among all students (Yoon et al., 2007). Teachers need to be provided active professional development in order to acquire new practices and ongoing support implementing the strategies in the classroom. For this to be successful, explicit instruction on using research-based strategies in the classroom should be implemented in a collaborative manner between general education teachers and special education teachers (Loucks-Horsley et al., 2003; Penuel et al., 2007).

Implications for Future Research

First, to validate the results of this study, a replication is needed with a larger sample size. It is recommended that future research be conducted with more students with varying degrees of disabilities. Such a study would include more students with a variety of disabilities, more female students with disabilities, and different school settings and communities. It would also be useful to examine strategy use in a variety of settings, such as strictly a resource room setting, students older than sixth graders, or only students without disabilities.

Second, the standardized NWEA test did not show the results that were expected from learning this strategy. In order to more accurately measure strategy use on standardized testing, a test should be used that allows students to follow and use the steps of the strategy as taught. An example of this kind of test may be a state accountability test or paper-and-pencil type of test, which seems to be more conducive to the Solve It! strategy methodology. Generalization of a skill, such as a problem-solving strategy, takes many repetitions in order to achieve mastery.

Generalization is described as the “reliable occurrence of a response in the presence of an antecedent” (Skinner & Daly, 2010, p. 108). In this study, the limited amount of time and exposure could have greatly affected the students’ ability to generalize the skill to the computerized NWEA test. Future research may look at the time needed to generalize skills such as problem solving in relation to strategy acquisition. Research has shown that generalization of skills is often hard to determine and even harder to monitor after attainment of strategies. Although most researchers agree generalization of skills to other areas is important and key to successful strategy development, many still struggle with the relationship between skill or strategy proficiency and generalization to other mathematical formats such as accountability testing. Future research should investigate whether the length of time a strategy has been accurately applied to appropriate instructional situations is related to the length of time needed to create transfer to similar skill sets.

Another area for future research would be investigating the effects of a student’s belief system on the proficiency in problem solving. Through the student survey, results suggested that students’ belief about their ability to solve problems increased after learning this strategy. To explore and delve deeper into student beliefs and how they affect student abilities would be an interesting study and could influence and direct strategy and curriculum development if concrete links were developed between beliefs and abilities. Researchers have looked at this area before, but it would be interesting to try to develop a link between students’ beliefs and accuracy of problem solving.

Finally, future research should look at the correlation between a teacher's belief system and student achievement. The teacher interview after the implementation of the intervention indicated that teachers felt good about using the strategy and its effects on student problem solving. This should be explored more thoroughly to determine whether a teacher's beliefs and attitudes correlate to a student's abilities or achievements. The results from this research study could suggest a positive correlation between teacher beliefs and student achievement.

Summary

The research questions addressed in the study asked (a) does the Solve It! method affect the math problem-solving achievement of sixth-grade students, and (b) what are teacher and student perceptions of the efficacy of the Solve It! method of teaching word-problem solving? These research questions guided the researcher in developing the study design and methods, which led to sound and significant analysis. The researcher was able to determine from the comparison of means that while the Solve It! strategy did not statistically significantly improve sixth-grade students' mathematical problem-solving abilities on the standardized NWEA test, it did improve their scores in word-problem solving on the 10-item word-problem test related to the Solve It! curriculum. In addition, the intervention improved the self-perception of the sixth-grade students with regard to their abilities to solve word problems. This may play a part in eventually improving their problem-solving abilities.

Implications of this study include how to effectively design problem-solving strategies and the content that should be included, along with ways to help teachers access research-based strategies. Based on research articles and through the research in this study, cognitive-strategy instruction was shown to be an effective means to help students with disabilities become effective and efficient problem solvers in certain circumstances. Finally, future research should include a larger sample size, more diverse grouping, longer time frame for implementation, and concentration on creating generalization of the strategy to other problem-solving situations. This research study supported past research that indicated the Solve It! method was an effective method for problem solving and showed positive results with increase in scores in certain circumstances. However, questions still remain about the long-term effectiveness of Solve It! for sixth-grade students.

Appendix A: Student Survey Questions

Please answer the following using the rating scales from 1–5.

1. How easy/difficult was it to use this strategy?

1	2	3	4	5
easy				difficult

Comments:

2. How easy/difficult was it to use this strategy to solve word problems?

1	2	3	4	5
easy				difficult

Comments:

3. Will you use this strategy in the future when solving math word problems?

1	2	3	4	5
not at all				all the time

Comments:

4. What effect did this strategy have on your beliefs about your ability to solve math word problems?

1	2	3	4	5
none				greatly

Comments:

5. How effective do you think this strategy is for solving word problems?

1	2	3	4	5
not at all effective				highly effective

Comments:

Appendix B: Problem-Solving Assessment Observation

_______Step 1: Read for Understanding

_____orally ______silently _______struggled with reading

____

____

____

_______Step 2: Paraphrase in own words

_____orally ______silently ____struggled with paraphrasing

____

____

____

_______Step 3: Visualize a picture or diagram

_____picture ______diagram ____struggled with diagram/picture

____

____

____

_______Step 4: Hypothesize a plan

_____orally ______silently ____struggled with plan development

____

____

____

_______Step 5: Estimate an answer

_____orally _____written _______struggled with estimating

____

____

____

_______Step 6: Compute the answer

_____written correctly ____written incorrectly _____struggled with computation

____

____

____

_______Step 7: Check and label

_____written correctly _____written incorrectly _______struggled with answer

____

____

____

Bibliography

Alvermann, D. E., Swafford, J., & Montero, M. K. (2004). *Content area literacy instruction for the elementary grades*. Boston, MA: Pearson.

Baker, S., Gersten, R., & Lee, D. (2002). A synthesis of empirical research on teaching mathematics to low-achieving students. *The Elementary School Journal*, *103*(1), 51-73. doi:10.1086/499715

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Barrouillet, P., & Lépine, R. (2005). Working memory and children's use of retrieval to solve addition problems. *Journal of Experimental Child Psychology*, *91*, 183-204.

Bassok, M., Chase, V. M., & Martin, S. A. (1998). Adding apples and oranges: Alignment of semantic and formal knowledge. *Cognitive Psychology*, *35*, 99-134.

Baxter, J. A., Woodward, J., & Olson, D. (2001). Effects of reform-based mathematics instruction on low achievers in five third-grade classrooms. *The Elementary School Journal*, *101*, 529-548. doi:10.1086/499686

Baxter, J., Woodward, J., Voorhies, J., & Wong, J. (2002). We talk about it, but do they get it? *Learning Disabilities Research and Practice*, *17*, 173-185.

Bender, W. N. (2008). *Learning disabilities: Characteristics, identification, and teaching strategies*. Toronto, Ontario, Canada: Pearson Education.

Bottge, B. A. (2001a). Reconceptualizing mathematics problem solving for low-achieving students. *Remedial and Special Education*, *22*, 102-112. doi:10 .1177/074193250102200204

Bottege, B. A. (2001b). Using intriguing problems to improve math skills. *Educational Leadership*, *58*(6), 68-73.

Bottge, B. A., Heinrichs, M., Chan, S., Mehta, Z. D., & Watson, E. (2003). Effects of video-based and applied problems on the procedural math skills of average and low-achieving adolescents. *Journal of Special Education Technology*, *18*(2), 5-22.

Bottge, B. A., Heinrichs, M., Chan, S., & Serlin, R. C. (2001). Anchoring adolescents' understanding of math concepts in rich problem-solving environments. *Remedial and Special Education*, *22*, 299-314. doi:10 .1177/074193250102200505

Bottge, B. A., Heinrichs, M., Mehta, Z. D., & Hung, Y. (2002). Weighing the benefits of anchored math instruction for students with disabilities in general education classes. *Journal of Special Education*, *35*, 186-200. doi:10.1177/ 002246690203500401

Bottge, B. A., Heinrichs, M., Mehta, Z. D., Rueda, E., Hung, Y., & Danneker, J. (2004). Teaching mathematical problem solving to middle school students in math, technology, education and special education classrooms. *Research in Middle Level Education Online*, *27*(1), 43-68.

Bottge, B. A., Rueda, E., LaRoque, P. T., Serlin, R. C., & Kwon, J. (2007). Integrating reform-oriented math instruction in special education settings. *Learning Disabilities Research & Practice*, *22*, 96-109. doi:10.1111/j.1540-5826.2007.00234.x

Bottge, B. A., Rueda, E., Serlin, R. C., Hung, Y., & Kwon, J. (2007). Shrinking achievement differences with anchored math problems: Challenges and possibilities. *Journal of Special Education*, *41*, 31-49. doi:10.1177/00224669070410010301

Braten, I., Samuelstuen, M. S., & Stromso, H. I. (2004). Do students' self-efficacy beliefs moderate the effects of performance goals on self-regulatory strategy use? *Educational Psychology*, *24*, 231-247. doi:10.1080/0144341032000160164

Brown, A. L. (1978). Knowing when, where, and how to remember: A problem of metacognition. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 1, pp. 77-165). Mahwah, NJ: Erlbaum.

Bryant, D. P., Bryant, B. R., & Hammill, D. D. (2000). Characteristic behaviors of students with LD who have teacher-identified math weaknesses. *Journal of Learning Disabilities*, *33*, 168-179.

Butler, D. L., Beckingham, B., & Lauscher, H. N. (2005). Promoting strategic learning by eighth-grade students struggling in mathematics: A report of three case studies. *Learning Disabilities Research and Practice*, *20*, 156-174. doi:10.1111/j.1540-5826.2005.00130.x

Callister, P. (2009). Thinking like a research expert: Schemata for teaching complex problem-solving skills. *Legal Reference Services Quarterly*, *28*(1), 31-51. doi: 10.1080/02703190902961452

Cawley, J., Parmar, R., Foley, T. E., Salmon, S., & Roy, S. (2001). Arithmetic performance of students: Implications for standards and programming. *Exceptional Children*, *67*, 311-328.

Chung, K., & Tam, Y. H. (2005). Effects of cognitive-based instruction on mathematical problem solving by learners with mild intellectual disabilities. *Journal of Intellectual & Developmental Disability*, *30*, 207-216. doi:10.1080/13668250500349409

Cole, J. E., & Wasburn-Moses, L. H. (2010). Going beyond "the Math Wars." *Teaching Exceptional Children*, *42*(4), 14-20.

Danesi, M. (2007). A conceptual metaphor framework for the teaching of mathematics. *Studies in Philosophy and Education*, *26*, 225-236. doi:10.1007/s11217-007-9035-5

De Corte, E. (2003). Transfer as the productive use of acquired knowledge, skills, and motivations. *Current Directions in Psychological Science*, *12*, 142-146. doi:10.1111/1467-8721.01250

Deshler, D. D., Lenz, K. B., Bulgren, J., Schumaker, J. B., Davis, B., Grossen, B., & Marquis, J. (2004). Adolescents with disabilities in high school setting: Student characteristics and setting dynamics. *Learning Disabilities—A Contemporary Journal*, *2*(2), 30-48.

Deshler, D. D., Schumaker, J. B., Lenz, B. K., Bulgren, J. A., Hock, M. F., Knight, J., & Ehren, B. J. (2001). Ensuring content-area learning by secondary students with learning disabilities. *Learning Disabilities Research and Practice*, *16*, 96-108. doi:10.1111/0938-8982.00011

Deshler, D. D., Schumaker, J. B., Lenz, K., Bulgren, J. A., Hock, M. F., Knight, J., & Ehren, B. J. (2008). Ensuring content-area learning by secondary students with learning disabilities. *Journal of Education*, *189*, 169-181.

Dirks, E., Spyer, G., Van Lieshout, E. M., & De Sonneville, L. (2008). Prevalence of combined reading and arithmetic disabilities. *Journal of Learning Disabilities*, *41*, 460-473. doi:10.1177/0022219408321128

Edens, K., & Potter, E. (2008). How students "unpack" the structure of a word problem: Graphic representations and problem solving. *School Science and Mathematics*, *108,* 184-196. doi:10.1111/j.1949-8594.2008.tb17827.x

Ercikam, K., McCreith, T., & LaPointe, V. (2005). Factors associated with mathematics achievement and participation in advanced mathematics courses: An examination of gender differences from an international perspective. *School Science and Mathematics*, *105*, 5-14.

Farmer, M., Riddick, B., & Sterling, C. M. (2002). *Dyslexia and inclusion: Assessment and support in higher education*. London, England: Whurr.

Ferguson, D. B. (2000). Re-examining at-risk. *Curriculum Administrator*, *36*(9), 79-84.

Flavell, J. H., Miller, P. H., & Miller, S. A. (1993). *Cognitive development*. Englewood, NJ: Prentice Hall.

Fleischman, H. L., Hopstock, P. J., Pelczar, M. P., & Shelley, B. E. (2010). *Highlights from PISA 2009: Performance of U.S. 15 year-old students in reading, mathematics, and science literacy in an international context* (NCES 2011-004). Washington, DC: National Center for Education Statistics.

Foegen, A., & Deno, S. L. (2001). Identifying growth indicators for low-achieving students in middle school mathematics. *Journal of Special Education*, *35*, 4-16. doi:10.1177/002246690103500102

Fuchs, L. S., Compton, D. L., Fuchs, D., Hollenbeck, K. N., Hamlett, C. L., & Seethaler, P. M. (2011). Two-stage screening for math problem-solving difficulty using dynamic assessment of algebraic learning. *Journal of Learning Disabilities*, *44*, 372-380.

Fuchs, L. S., Compton, D. L., Fuchs, D., Paulsen, K., Bryant, J. D., & Hamlett, C. L. (2005). The prevention, identification, and cognitive determinants of math difficulty. *Journal of Educational Psychology*, *97*, 493-513. doi:10.1037/0022-0663.97.3.493

Fuchs, L. S., & Fuchs, D. (2002). Mathematical problem-solving profiles of students with mathematics disabilities with and without comorbid reading disabilities. *Journal of Learning Disabilities*, *35*, 564-574. doi:10.1177/00222194020350060701

Fuchs, L. S., & Fuchs, D. (2005). Enhancing mathematical problem solving for students with disabilities. *Journal of Special Education*, *39*, 45-57. doi:10 .1177/00224669050390010501

Fuchs, L. S., Fuchs, D., Finelli, R., Courey, S. J., & Hamlett, C. L. (2004). Expanding schema-based transfer instruction to help third graders solve real-life mathematical problems. *American Educational Research Journal*, *41*, 419-445. doi:10.3102/00028312041002419

Fuchs, L. S., Fuchs, D., Stuebing, K., Fletcher, J. M., Hamlett, C. L., & Lambert, W. (2008). Problem solving and computational skill: Are they shared or distinct aspects of mathematical cognition? *Journal of Educational Psychology*, *100*, 30-47.

Fuchs, L., Fuchs, D., Yazdian, L., & Powell, S. R. (2002). Enhancing first-grade children's mathematical development with peer-assisted learning strategies. *School Psychology Review*, *31*, 453-458.

Gagnon, J. C., & Maccini, P. (2007). Teacher-reported use of empirically validated and standards-based instructional approaches in secondary mathematics. *Remedial and Special Education*, *28*, 43-56. doi:10.1177/ 074193250702800010501

Garrett, A. J., Mazzocco, M. M., & Baker, L. (2006). Development of the metacognitive skills of prediction and evaluation in children with or without math disability. *Learning Disabilities Research and Practice*, *21*, 77-88. doi: 10.1111/j.1540-5826.2006.00208.x

Geary, D. C. (2004). Mathematics and LD. *Journal of Learning Disabilities*, *37*, 4-15.

Geary, D., Hoard, M. K., Byrd-Craven, J., & DeSoto, C. M. (2004). Strategy choices in simple and complex addition: Contributions of working memory and counting knowledge for children with mathematical disability. *Journal of Experimental Child Psychology*, *88*, 121-151. doi: 10.1016/S0022 -0965(04)00033-5

Gersten, R., Beckmann, S., Clarke, B., Foegen, A., Marsh, L., Star, J. R., & Witzel, B. (2009). *Assisting students struggling with mathematics: Response to Intervention (RtI) for elementary and middle schools* (NCEE 2009-4060). Washington, DC: National Center for Education Evaluation and Regional Assistance. Retrieved from http://ies.ed.gov/ncee/wwc/publications/ practiceguides/

Gonzalez, J., & Espinel, A. I. (2002). Strategy choice in solving arithmetic word problems: Are there differences between students with learning disabilities, G-V poor performance and typical achievement students? *Learning Disability Quarterly*, *25*, 113-123.

Graham, L., Bellert, A., Thomas, J., & Pegg, J. (2007). QuickSmart: A basic academic skills intervention for middle school students with learning disabilities. *Journal of Learning Disabilities*, *40*, 410-419.

Griffin, C. C., & Jitendra, A. K. (2008). Word problem-solving instruction in inclusive third-grade mathematics classrooms. *Journal of Educational Research*, *102*, 187-202. doi:10.3200/JOER.102.3.187-202

Halpern, D. F., & Hakel, M. D. (2003). Applying the science of learning to the university and beyond: Teaching for long-term retention and transfer. *Change*, *35*(4), 36-41. doi:10.1080/00091380309604109

Harper, K. A. (2006). Student problem-solving behaviors. *The Physics Teacher*, *44*, 250-251. doi:10.1119/1.2186244

Harskamp, E., & Suhre, C. (2007). Schoenfeld's problem solving theory in a student controlled learning environment. *Computers & Education*, *49*, 822-839. doi: 10.1016/j.compedu.2005.11.024

Haskell, R. E. (2001). *Transfer of learning: Cognition, instruction, and reasoning*. San Diego, CA: Academic Press.

Helwig, R., Rozek-Tedesco, M. A., Tindal, G., Heath, B., & Almond, P. J. (1999). Reading as an access to mathematics problem solving on multiple-choice tests for sixth-grade students. *Journal of Educational Research*, *93*, 113-125. doi: 10.1080/00220679909597635

Hempenstall, K. (2004). How might a stage model of reading development be helpful in the classroom? *Educational Psychology*, *24*, 727-751.

Henderson, R. (2001). Student mobility: Moving beyond deficit views. *Australian Journal of Guidance and Counseling*, *11*, 121-129.

Hoffman, B., & Spatariu, A. (2008). The influence of self-efficacy and metacognitive prompting on math problem-solving efficiency. *Contemporary Educational Psychology*, *33*, 875-893. doi:10.1016/j.cedpsych.2007.07.002

Horner, R., Carr, E., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children*, *71*, 165-179.

House, J. D., & Telese, J. (2008). Relationships between student and instructional factors and algebra achievement of students in the United States and Japan: An analysis of TIMSS 2003 data. *Educational Research and Evaluation*, *14*(1), 101-112. doi:10.1080/13803610801896679

Hughes, C. A. (2011). Effective instructional design and delivery for teaching task-specific learning strategies to students with learning disabilities. *Focus on Exceptional Children*, *44*(2), 1-16.

Idol, L. (2006). Toward inclusion of special education students in general education: A program evaluation of eight schools. *Remedial and Special Education*, *27*, 77-94. doi:10.1177/07419325060270020601

Individuals With Disabilities Education Improvement Act, Pub. L. No. 108-446 (2004).

Jackson, F. B. (2002). Crossing content: A strategy for students with learning disabilities. *Intervention in School & Clinic*, *37*, 279-283.

Jackson, H. G., & Neel, R. S. (2006). Observing mathematics: Do students with EBD have access to standards-based mathematics instruction? *Education and Treatment of Children*, *29*, 593-614.

Jitendra, A., DiPipi, C. M., & Perron-Jones, N. (2002). An exploratory study of schema-based word-problem solving instruction for middle school students with learning disabilities: An emphasis on conceptual and procedural understanding. *Journal of Special Education*, *36*, 23-38. doi:10.1177/00224669020360010301

Jitendra, A., George, M., Sood, S., & Price, K. (2010). Schema-based instruction: Facilitating mathematical word problem solving for students with emotional and behavioral disorders. *Preventing School Failure: Alternative Education for Children and Youth*, *54*, 145-151.

Jitendra, A., Griffin, C., Deatline-Buchman, A., Dipipi-Hoy, C., Sczesniak, E., Sokol, N., & Xin, Y. (2005). Adherence to mathematics professional standards and instructional design criteria for problem-solving in mathematics. *Council for Exceptional Children*, *71*, 319-337.

Jitendra, A., Griffin, C., Deatline-Buchman, A., & Sczesniak, E. (2007). Mathematical word problem solving in third-grade classrooms. *Journal of Educational Research*, *100*, 283-302. doi:10.3200/JOER.100.5.283-302

Jitendra, A. K., Griffin, C. C., Haria, P., Leh, J., Adams, A., & Kaduvettoor, A. (2007). A comparison of single and multiple strategy instruction on third-grade students' mathematical problem solving. *Journal of Educational Psychology*, *99*, 115-127. doi:10.1037/0022-0663.99.1.115

Jitendra, A. K., Griffin, C. C., McGoey, K., Gardill, M. C., Bhat, P., & Riley, T. (1998). Effects of mathematical word problem solving by students at risk or with mild disabilities. *Journal of Educational Research*, *91*, 345-355. doi:10 .1080/00220679809597564

Jitendra, A. K., & Hoff, K. (1996). The effects of schema-based instruction on the mathematical word-problem-solving performance of students with learning disabilities. *Journal of Learning Disabilities*, *29*, 422-431. doi:10.1177/ 002221949602900410

Jitendra, A. K., Hoff, K., & Beck, M. M. (1999). Teaching middle school students with learning disabilities to solve word problems using a schema-based approach. *Remedial and Special Education*, *20*, 50-64. doi:10.1177/ 074193259902000108

Jitendra, A. K., & Star, J. R. (2011). Meeting the needs of students with learning disabilities in inclusive mathematics classrooms: The role of schema-based instruction on mathematical problem-solving. *Theory Into Practice*, *50*, 12-19. doi:10.1080/00405841.2011.534912

Jordan, N., & Hanich, L. (2000). Mathematical thinking in 2nd grade children with different forms of LD. *Journal of Learning Disabilities*, *33*, 567-578.

Kajamies, A., Vauras, M., & Kinnunen, R. (2010). Instructing low-achievers in mathematical word problem solving. *Scandinavian Journal of Educational Research*, *54*, 335-355. doi:10.1080/00313831.2010.493341

Kennedy, C. H. (2005). *Single-case designs for educational research*. Boston, MA: Pearson.

Kintsch, W. (2004). The construction-integration model of text comprehension and its implications for instruction. In R. B. Ruddell & N. J. Unrau (Eds.), *Theoretical models and processes of reading* (pp. 1270-1328). Newark, DE: International Reading Association.

Kitsantas, A. (2000). The role of self-regulation strategies and self-efficacy perceptions in successful weight loss maintenance. *Psychology & Health*, *15*, 811-820. doi:10.1080/08870440008405583

Klassen, R. (2002). A question of calibration: A review of the self-efficacy beliefs of students with learning disabilities. *Learning Disability Quarterly*, *25*, 88-103.

Koedinger, K. R., & Nathan, M. J. (2004). The real story behind story problems: Effects of representations on quantitative reasoning. *Journal of Learning Sciences*, *13*, 129-164.

Kramarski, B., & Gutman, M. (2006). How can self-regulated learning be supported in mathematical e-learning environments? *Journal of Computer Assisted Learning, 22*, 24-33.

Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and metacognitive training. *American Educational Research Journal*, *40*, 281-310.

Kroesbergen, E. H., & Van Luit, J. E. (2003). Mathematics interventions for children with special educational needs: A meta-analysis. *Remedial and Special Education*, *24*, 97-114. doi:10.1177/07419325030240020501

Kroesbergen, E. H., Van Luit, J., & Maas, C. M. (2004). Effectiveness of explicit and constructivist mathematics instruction for low-achieving students in the

Netherlands. *The Elementary School Journal*, *104*, 233-251. doi:10.1086/ 499751

Lembke, E. S., & Stormont, M. (2005). Using research-based practices to support students with diverse needs in general education settings. *Psychology in the Schools*, *42*, 761-763. doi:10.1002/pits.20110

Lerner, J. W., & Johns, B. H. (2009). *Learning disabilities and related mild disabilities: Characteristics, teaching strategies, and new directions*. Belmont, CA: Wadsworth Cengage Learning.

Lewis, A. C. (2004). Strengthening the high school diploma. *Tech Directions*, *63*(9), 5-6.

Lewis, A. C. (2007). Attention to soft skills. *Tech Directions*, *66*(6), 6.

Loucks-Horsley, S., Love, N., Stiles, K., Mundry, S., & Hewson, P. W. (2003). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.

Maccini, P., & Gagnon, J. C. (2000). Best practices for teaching mathematics to secondary students with special needs. *Focus on Exceptional Children*, *32*(5), 1-23.

Maccini, P., & Gagnon, J. C. (2006). Mathematics instructional practices and assessment accommodations by secondary special and general educators. *Exceptional Children*, *72*, 151-159.

Maccini, P., & Hughes, C. A. (2000). Effects of problem-solving on the introductory algebra performance of secondary students with learning disabilities. *Learning Disabilities Research & Practice*, *15*, 10-21.

Maccini, P., Mulcahy, C. A., & Wilson, M. G. (2007). A follow-up of mathematics interventions for secondary students with learning disabilities. *Learning Disabilities Research & Practice*, *22*, 58-74. doi:10.1111/j.1540-5826.2007.00231.x

Marolda, M., & Davidson, P. (2000). Mathematical learning profiles and differentiated teaching strategies. *Perspectives*, *26*(3), 10-15.

Marshall, S. P. (1995). *Schemas in problem solving*. Cambridge, England: Cambridge University Press.

Martin, S. A., & Bassok, M. (2005). Effects of semantic cues on mathematical modeling: Evidence from word-problem solving and equation construction tasks. *Memory & Cognition*, *33*, 471-478. doi:10.3758/BF03193064

Mayer, R. E. (1985). Mathematical ability. In R. J. Sternberg (Ed.), *Human abilities: An information processing approach* (pp. 127-150). San Francisco, CA: Freeman.

Mazzocco, M. M., & Berch, D. B. (2007). *Why is math so hard for some children? The nature and origins of mathematical learning difficulties and disabilities*. Baltimore, MD: Paul H. Brookes.

Mazzocco, M., Devlin, K., & McKenney, S. (2008). Is it a fact? Timed arithmetic performance of children with mathematical learning disabilities (MLD) varies as a function of how MLD is defined. *Developmental Neuropsychology*, *33*, 318-344.

Mazzocco, M. M., & Myers, G. F. (2003). Complexities in identifying and defining mathematics learning disability in the primary school-age years. *Annals of Dyslexia*, *53*, 218-253. doi:10.1007/s11881-003-0011-7

Mercer, C. D., & Mercer, A. R. (2005). *Teaching students with learning problems* (7th ed.). Upper Saddle River, NJ: Merrill.

Mestre, J. P. (2005). *Transfer of learning from a modern multidisciplinary perspective*. Greenwich, CT: Information Age Press.

Metallidou, P., & Vlachou, A. (2007). Motivational beliefs, cognitive engagement, and achievement in language and mathematics in elementary school children. *International Journal of Psychology*, *42*, 2-15. doi:10.1080/00207590500411179

Miller, S. P., Butler, F. M., & Lee, K. (1998). Validated practices for teaching mathematics to students with learning disabilities: A review of literature. *Focus on Exceptional Children*, *31*(1), 1-25.

Miller, S. P., Stringfellow, J. L., Kaffar, B. J., Ferreira, D., & Mancl, D. B. (2011). Developing computation competence among students who struggle with mathematics. *Teaching Exceptional Children*, *44*(2), 38-46.

Montague, M. (1992). The effects of cognitive and metacognitive strategy instruction on the mathematical problem solving of middle school students with learning disabilities. *Journal of Learning Disabilities*, *25*, 230-248. doi:10.1177/ 002221949202500404

Montague, M. (2007). *Solve It! A practical approach to teaching mathematical problem solving skills*. Reston, VA: Exceptional Innovations.

Montague, M., & Applegate, B. (2000). Middle school students' perceptions, persistence, and performance in mathematical problem solving. *Learning Disabilities Quarterly*, *23*, 215-227.

Montague, M., Applegate, B., & Marquard, K. (1993). Cognitive strategy instruction and mathematical problem-solving performance of students with learning disabilities. *Learning Disabilities Research & Practice*, *8*, 223-232.

Montague, M., & Bos, C. S. (1986). The effect of cognitive strategy training on verbal math problem solving performance of learning disabled adolescents. *Journal of Learning Disabilities*, *19*, 26-33. doi:10.1177/ 002221948601900107

Montague, M., & Dietz, S. (2009). Evaluating the evidence base for cognitive strategy instruction and mathematical problem solving. *Exceptional Children*, *75*, 285-302.

Montague, M., Enders, C., & Dietz, S. (2011). Effects of cognitive strategy instruction on math problem solving of middle school students with learning disabilities. *Learning Disabilities Quarterly*, *34*, 262-272. doi:10.1177/ 0731948711421762

Muir, T., & Beswick, K. (2005). Where did I go wrong? Students' success at various stages of the problem-solving process. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce, & A. Roche (Eds.), *MERGA 28-2005: Building connections: Research, theory and practice*. Sidney, Australia: Mathematics Education Research Group of Australasia.

Muir, T., Beswick, K., & Williamson, J. (2008). "I'm not very good at solving problems": An exploration of students' problem solving behaviors. *Journal of Mathematical Behavior*, *27*, 228-241. doi: 10.1016/j.jmathb.2008.04.003

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*. Washington, DC: U.S. Department of Education.

National Research Council. (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: The National Academies Press.

Nelson, S. D., Teich, A. H., McEnaney, C., & Lita, S. J. (2000). *AAAS: Science and technology policy yearbook.* Washington, DC: American Association for the Advancement of Science.

No Child Left Behind Act of 2001, Pub. Law No. 107-110 (2002).

Northwest Evaluation Association. (2009). *Technical manual for Measures of Academic Progress and Measures of Academic Progress for Primary Grades*. Lake Oswego, OR: Author.

Organisation for Economic Co-operation and Development. (2012). *PISA 2009 technical report*. http://dx.doi.org/10.1787/9789264167872-en

Owen, R. L., & Fuchs, L. S. (2002). Mathematical problem-solving strategy instruction for third-grade students with learning disabilities. *Remedial and Special Education*, *23*, 268-278. doi:10.1177/07419325020230050201

Pajares, F. (2003). Self-efficacy beliefs, motivation, and achievement in writing: A review of the literature. *Reading & Writing Quarterly*, *19*, 139-158. doi:10 .1080/10573560308222

Peled, I., & Segalis, B. (2005). It's not too late to conceptualize: Constructing a generalized subtraction schema by abstracting and connecting procedures. *Mathematical Thinking and Learning*, *7*, 207-230.

Pennequin, V., Sorel, O., & Mainguy, M. (2010). Metacognition, executive functions and aging: The effect of training in the use of metacognitive skills to solve mathematical word problems. *Journal of Adult Development*, *17*, 168-176.

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal*, *44*, 921-958.

Pólya, G. (1945). *How to solve it.* Princeton, NJ: Princeton University Press.

Powell, S. R. (2011). Solving word problems using schemas: A review of the literature. *Learning Disabilities Research & Practice*, *26*, 94-108.

Pressley, M., & Harris, K. R. (2009). Cognitive strategies instruction: From basic research to classroom instruction. *Journal of Educational Psychology*, *189*, 77-94.

Rauschenberger, J. (2001). Finally: A cure for the skills gap. *Connecting Education & Careers*, *76*(6), 46-48.

Reys, R., Reys, B., Lapan, R., Holliday, G., & Wasman, D. (2003). Assessing the impact of standards-based middle grades mathematics curriculum materials on student achievement. *Journal of Research in Mathematics Education*, *34*, 74-95.

Riley, R. W. (1997). In math and college-going, middle school makes all the difference. *Middle School Journal*, *29*(2), 3-7.

Rittle-Johnson, B., & Koedinger, K. R. (2005). Designing knowledge scaffolds to support mathematical problem solving. *Cognition and Instruction*, *23*, 313-349. doi:10.1207/s1532690xci2303_1

Rittle-Johnson, B., Siegler, R. S., & Alibali, M. W. (2001). Developing conceptual understanding and procedural skill in mathematics: An interactive process. *Journal of Educational Psychology*, *93*, 346-362.

Robinson, C. S., Menchetti, B. M., & Torgesen, J. K. (2002). Toward a two-factor theory of one type of mathematics disabilities. *Learning Disabilities Research and Practice*, *17*, 81-89. doi:10.1111/1540-5826.00035

Rowh, M. (2007, January). Multiply your success. *Career World*, *35*(4), 20-22.

Sabornie, E. J., & DeBettencourt, L. U. (2004). *Teaching students with mild and high-incidence disabilities at the secondary level*. Upper Saddle River, NJ: Merrill/Prentice Hall.

Sayeski, K. L., & Paulsen, K. J. (2010). Mathematics reform curricula and special education: Identifying intersections and implications for practice. *Intervention in School and Clinic*, *46*, 13-21. doi:10.1177/1053451210369515

Scheurmann, A. M., Deshler, D. D., & Schumaker, J. B. (2009). The effects of the explicit inquiry routine on the performance of students with learning disabilities on one-variable equations. *Learning Disabilities Quarterly*, *32*, 103-120.

Shiah, R., Mastropieri, M. A., Scruggs, T. E., & Fulk, B. J. (1995). The effects of computer-assisted instruction on the mathematical problem solving of students with learning disabilities. *Exceptionality*, *5*, 131-162.

Skinner, C. H., & Daly, E. J. (2010). Improving generalization of academic skills: Commentary on the special issue. *Journal of Behavioral Education, 19*, 106-115. doi:10.1007/s10864-010-9100-y

Spellings, M. (2005). U.S. Secretary of Education Margaret Spellings. *Harvard Educational Review*, *75*, 364-382.

Stormont, M., Espinosa, L., Knipping, N., & McCathren, R. (2003). Supporting vulnerable learners in the primary grades: Strategies to prevent early school failure. *Early Childhood Research & Practice, 5*(2). Available from http://ecrp.uiuc.edu/v5n2/stormont.html

Swanson, H. L., & Hoskyn, M. (2001). Instructing adolescents with learning disabilities: A component and composite analysis. *Learning Disabilities Research and Practice*, *16*, 109-119. doi:10.1111/0938-8982.00012

Swanson, H. L., Jerman, O., & Zheng, X. (2008). Growth in working memory and mathematical problem solving in children at risk and not at risk for serious math difficulties. *Journal of Educational Psychology*, *100*, 343-379.

Teong, S. K. (2003). The effect of metacognitive training on mathematical word-problem solving. *Journal of Computer Assisted Learning*, *19*, 46-55.

Thompson, S., Lazarus, S., & Thurlow, M. (2003). *Preparing educators to teach students with disabilities in an era of standards-based reform and accountability*. College Park, MD: Institute for the Study of Exceptional Children and Youth.

Tomey, H. A., Steeves, J., & Gilman, D. L. (2003). *Mathematics and dyslexia*. Baltimore, MD: International Dyslexia Association.

U.S. Department of Education. (2003). *25th annual report to Congress on the implementation of the Individuals With Disabilities Education Act*. Washington, DC: Author.

Van Garderen, D., & Montague, M. (2003). Visual-spatial representation, mathematical problem solving, and students of varying abilities. *Learning Disabilities Research & Practice*, *18*, 246-254.

Vaughn, S., & Linan-Thompson, S. (2003). What is special about special education for students with learning disabilities? *Journal of Special Education*, *37*, 140-147. doi:10.1177/00224669030370030301

Vukman, K. B. (2005). Developmental differences in metacognition and their connections with cognitive development in adulthood. *Journal of Adult Development*, *12*, 211-221.

Vukovic, R. K., & Siegel, L. S. (2010). Academic and cognitive characteristics of persistent mathematics difficulty from first through fourth grade. *Learning Disabilities Research & Practice*, *25*, 25-38. doi:10.1111/j.1540-5826.2009.00298.x

Wadlington, E., & Wadlington, P. L. (2008). Helping students with mathematical disabilities to succeed. *Preventing School Failure*, *53*, 2-7.

Wagner, J. (2006). Transfer in pieces. *Cognition and Instruction*, *24*(1), 1-71. doi:10.1207/s1532690xci2401_1

Witzel, B., Riccomini, P., & Schneider, E. (2008). Implementing CRA with secondary students with learning disabilities in mathematics. *Intervention in School & Clinic*, *43*, 270-276.

Woodward, J. (2004). Mathematics education in the United States: Past to present. *Journal of Learning Disabilities*, *37*, 16-31. doi:10.1177/00222194040370010301

Woodward, J. (2006). Developing automaticity in multiplication facts: Integrating strategy instruction with timed practice drills. *Learning Disabilities Quarterly*, *29*, 269-289.

Woodward, J., & Brown, C. (2006). Meeting the curricular needs of academically low-achieving students in middle grade mathematics. *Journal of Special Education*, *40*, 151-159. doi:10.1177/00224669060400030301

Woodward, J., Monroe, K., & Baxter, J. (2001). Enhancing student achievement on performance assessments in mathematics. *Learning Disabilities Quarterly*, *24*, 33-47.

Woodward, J., & Montague, M. (2002). Meeting the challenge of mathematics reform for students with LD. *Journal of Special Education*, *36*, 89-101. doi:10.1177/00224669020360020401

Xin, Y. P. (2003). *A comparison of two instructional approaches on mathematical word problem solving by students with learning problems*. Ann Arbor, MI: ProQuest Information and Learning.

Xin, Y. P., & Jitendra, A. K. (1999). The effects of instruction in solving mathematical word problems for students with learning problems: A meta-analysis. *Journal of Special Education*, *32*, 207-225. doi:10.1177/002246699903200402

Xin, Y. P., Jitendra, A. K., & Deatline-Buchman, A. (2005). Effects of mathematical word problem solving instruction on middle school students with learning problems. *Journal of Special Education*, *39*, 181-192. doi:10.1177/ 00224669050390030501

Xin, Y. P., & Zhang, D. (2009). Exploring a conceptual model-based approach to teaching situated word problems. *Journal of Educational Research*, *102*, 427-442. doi:10.3200/JOER.102.6.427-442

Yoon, K. S., Duncan, T., Lee, S. W., Scarloss, B., & Shapley, K. L. (2007). *Reviewing the evidence on how professional development affects student achievement* (Report No. 033). Washington, DC: National Center for Evaluation and Regional Assistance.

Zakaria, F. (2011, November 14). When will we learn? *Time Magazine*. Available from http://www.time.com/time/magazine/article/0,9171,2098577,00.html

Zawaiza, T. B., & Gerber, M. M. (1993). Effect of explicit instruction on community college students with learning disabilities. *Learning Disabilities Quarterly*, *6*, 64-79.

Vita

Jill Noelle Sampson Choate was born in Marysville, Kansas. She graduated from Marysville High School, Marysville, Kansas, in 1988 where she was a member of the National Honor Society. After graduation, she entered the University of Nebraska–Lincoln, graduating in 1992 with a Bachelors of Science in Education. For three years she was a middle school special education teacher with the Ogallala School District in Ogallala, Nebraska, while taking classes to earn a Masters of Art degree with an emphasis in Behavioral Disorders in 1995. She continued to teach in the Ogallala School District for three more years as a special education teacher and was co-owner of The Mesquite Bean restaurant with her husband, Chris. After six years as a special education teacher in the Ogallala School District, she entered the Educational Administration Graduate School at The University of Texas at Austin. She now teaches in Durango, Colorado.

Permanent address: 132 Metz Lane, Durango, Colorado 81301

This dissertation was typed by the author.