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Investigating the effects of a combined problem-solving strategy for students with learning difficulties in mathematics

Dustin B. Mancl
University of Nevada, Las Vegas

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INVESTIGATING THE EFFECTS OF A COMBINED PROBLEM-SOLVING STRATEGY FOR STUDENTS WITH LEARNING DIFFICULTIES IN MATHEMATICS

by

Dustin Bernard Mancl

Bachelor of Science
University of Nevada, Las Vegas
2001

Master of Education
University of Nevada, Las Vegas
2005

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Department of Special Education
College of Education

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Dustin Bernard Mancl

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be accepted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in Special Education

Susan P. Miller, Committee Chair
Pamela Campbell, Committee Member
Kyle Higgins, Committee Member
Dick Tandy, Graduate Faculty Representative

Ronald Smith, Ph. D., Vice President for Research and Graduate Studies and Dean of the Graduate College

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ABSTRACT

Investigating the Effects of a Combined Problem-Solving Strategy for Students with Learning Difficulties in Mathematics

by

Dustin Bernard Mancl

Dr. Susan P. Miller, Doctoral Committee Chair
Professor of Special Education
University of Nevada, Las Vegas

Many students, specifically those with learning difficulties in mathematics, struggle when presented with word problems to solve. With this in mind, the purpose of this research was to examine the effects of the READER Strategy on word problem performance of students with mathematics disabilities and students who are at-risk to fail in mathematics. There were two parts to this research. Part One was implemented using a single-subject design (i.e., multiple-probe across participants) and Part Two was implemented using a group design (i.e., 2 x 4 factorial design). The single-subject design included three participants identified as having mathematics disabilities. There were two males (i.e., one Hispanic fifth grader and one Black/African-American fifth grader) and one female (i.e., Hispanic fourth grader). The group design included 21 participants who were receiving Tier 2 instruction within a Response-to-Intervention program (i.e., 11 third graders in the treatment group and 10 third graders in the comparison group). Of these 21 participants 2 were Asian, 2 were Biracial, 6 were Black, 9 were Hispanic, 1 was Pacific Islander, and 1 was White. The single-subject participants and the treatment group participants received 17 mathematics researcher-developed lessons that involved the use of a combined problem-solving strategy designed to assist students with mathematical word problems. The instructional method used in these lessons combined
the use of teacher-directed explicit instruction, a graduated word problem sequence, schema-based diagrams, the concrete-representational-abstract sequence, and the use of a math word problem strategy (i.e., READER). The comparison group participants received 17 mathematics lessons from the standard school curricula for students receiving Tier 2 intervention within the Response-to-Intervention Program at the participating school. These lessons were designed to assist students with mathematical word problems and involved the use of teacher-directed explicit instruction, hands-on manipulative devices, student exploration, and whole group discussion and review. The Tier 2 intervention lessons presented to the comparison group were also scripted by the publisher to maintain fidelity of treatment. The results related to Part One of the research (i.e., single-subject design) revealed that students with mathematics disabilities improved their abilities to solve mathematical word problems after receiving the combined problem solving strategy (i.e., READER). The results related to Part Two of the research (i.e., group design) revealed similar findings. Students receiving Tier 2 intervention within a Response-to-Intervention program also improved their abilities to solve mathematical word problems. Additionally, those same students were able to maintain and generalize their abilities to solve mathematical word problems two weeks after receiving the intervention.
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Who would have imagined a Doctor of Philosophy in Special Education? Who would have encouraged a student who struggled? Who would have supported the life-long process of learning? With these questions in mind, I would like to dedicate this dissertation to those who have imagined, encouraged, and supported students with unique ways of learning.
# TABLE OF CONTENTS

ABSTRACT................................................................................................................................. iii

ACKNOWLEDGEMENTS........................................................................................................... v

LIST OF TABLES........................................................................................................................ x

CHAPTER 1 INTRODUCTION ...................................................................................................... 1
  Historical Overview of the Inclusion of Word Problems in Mathematics Curricula .......... 1
  Statement of the Problems ................................................................................................. 5
  Purpose of the Research and Related Questions ............................................................ 9
  Significance of the Research ............................................................................................ 10
  Limitations of the Study .................................................................................................... 14
  Definition of Terms ........................................................................................................... 14
  Summary ............................................................................................................................ 22

CHAPTER 2 REVIEW OF RELATED LITERATURE ................................................................. 24
  Literature Review Search Procedures .............................................................................. 24
  Criteria for Selection ........................................................................................................... 25
  Review and Analysis of Studies Related to Word Problem Instruction ......................... 25
  Review of Literature Summary ........................................................................................ 70

CHAPTER 3 METHODOLOGY .................................................................................................. 73
  Research Designs ................................................................................................................ 74
  Participants .......................................................................................................................... 76
  Setting ................................................................................................................................. 79
  Instructional Materials ....................................................................................................... 80
  Instrumentation .................................................................................................................. 86
  Procedures .......................................................................................................................... 90
  Interscorer Reliability and Fidelity of Treatment ............................................................. 99
  Treatment of Data .............................................................................................................. 101

CHAPTER 4 FINDINGS OF THE STUDY ................................................................................. 106
  Research Questions and Related Findings ....................................................................... 106
  Interscorer Reliability ....................................................................................................... 124
  Fidelity of Treatment ......................................................................................................... 126
  Summary of Findings ........................................................................................................ 128

CHAPTER 5 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS................................. 130
  Discussion of Results ......................................................................................................... 132
  Conclusions ......................................................................................................................... 143
  Practical Implications ........................................................................................................ 144
  Recommendations for Further Study .............................................................................. 145
| APPENDIX A | ADDITION SCHEMATIC DIAGRAM .................................................. | 149 |
| APPENDIX B | SUBTRACTION SCHEMATIC DIAGRAM ............................................ | 150 |
| APPENDIX C | SAMPLE SCRIPTED LESSON ......................................................... | 151 |
| APPENDIX D | GRADUATED WORD PROBLEM SEQUENCE ....................................... | 155 |
| APPENDIX E | READER STRATEGY ................................................................. | 157 |
| APPENDIX F | SAMPLE LEARNING SHEET #1 ...................................................... | 158 |
| APPENDIX G | PROGRESS CHART ................................................................. | 159 |
| APPENDIX H | PERMISSION GRANTED FOR THE USE REQUESTED: A ............... | 160 |
| APPENDIX I | PERMISSION GRANTED FOR THE USE REQUESTED: B ............... | 161 |
| APPENDIX J | LEARNING CONTRACT .............................................................. | 162 |
| APPENDIX K | COMPUTATION REVIEW MINUTE .................................................. | 163 |
| APPENDIX L | READER SCREENER ................................................................. | 164 |
| APPENDIX M | WORD PROBLEM PRETEST .......................................................... | 165 |
| APPENDIX N | WORD PROBLEM POSTTEST .......................................................... | 167 |
| APPENDIX O | WORD PROBLEM MAINTENANCE PROBE ....................................... | 169 |
| APPENDIX P | WORD PROBLEM MAINTENANCE TEST ......................................... | 171 |
| APPENDIX Q | PROBE A .................................................................................. | 173 |
| APPENDIX R | PROBE B .................................................................................. | 175 |
| APPENDIX S | PROBE C .................................................................................. | 177 |
| APPENDIX T | SAMPLE LEARNING SHEET #2 ...................................................... | 179 |
| APPENDIX U | GENERALIZATION TEST .............................................................. | 181 |
| APPENDIX V | SOCIAL VALIDITY QUESTIONNAIRE ............................................. | 183 |
| APPENDIX W | ATTITUDE SURVEY ................................................................. | 184 |
APPENDIX X  ENGLISH PARENT CONSENT FORM.................................185
APPENDIX Y  SPANISH PARENT CONSENT FORM .................................187
APPENDIX Z  STUDENT ASSENT FORM ..................................................189
APPENDIX AA  FIDELITY OF TREATMENT ..............................................190
REFERENCES .................................................................................................191
VITA .................................................................................................................201
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Single-Subject Design: Demographic Information</td>
<td>77</td>
</tr>
<tr>
<td>Table 2</td>
<td>Group Design: Demographic Information</td>
<td>78</td>
</tr>
<tr>
<td>Table 3</td>
<td>Single-Subject Design: Baseline and Intervention Probe Scores</td>
<td>109</td>
</tr>
<tr>
<td>Table 4</td>
<td>Single-Subject Design: Word Problem Pretest and Posttest Scores</td>
<td>111</td>
</tr>
<tr>
<td>Table 5</td>
<td>Group Design: Word Problem Pretest and Posttest Scores</td>
<td>112</td>
</tr>
<tr>
<td>Table 6</td>
<td>Single-Subject Design: Intervention and Maintenance Probe Scores</td>
<td>113</td>
</tr>
<tr>
<td>Table 7</td>
<td>Group Design: Word Problem Posttest and Maintenance Scores</td>
<td>114</td>
</tr>
<tr>
<td>Table 8</td>
<td>Group Design: Word Problem Posttest and Generalization Scores</td>
<td>115</td>
</tr>
<tr>
<td>Table 9</td>
<td>Social Validity Ratings for Participants with Mathematics Disabilities</td>
<td>118</td>
</tr>
<tr>
<td>Table 10</td>
<td>Social Validity Ratings for Treatment Group Participants Receiving Tier 2 Intervention</td>
<td>120</td>
</tr>
<tr>
<td>Table 11</td>
<td>Attitude Survey Ratings for Students with Mathematics Disabilities</td>
<td>122</td>
</tr>
<tr>
<td>Table 12</td>
<td>Attitude Survey Ratings for Treatment Group Participants Receiving Tier 2 Intervention</td>
<td>124</td>
</tr>
<tr>
<td>Table 13</td>
<td>Single-Subject Design: Interscorer Reliability</td>
<td>125</td>
</tr>
<tr>
<td>Table 14</td>
<td>Group Design: Interscorer Reliability</td>
<td>126</td>
</tr>
<tr>
<td>Table 15</td>
<td>Single-Subject Design: Fidelity of Treatment</td>
<td>127</td>
</tr>
<tr>
<td>Table 16</td>
<td>Group Design: Fidelity of Treatment</td>
<td>128</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION

Many students with learning difficulties in the area of mathematics demonstrate specific weaknesses with mathematics reasoning (Griffin & Jitendra, 2009). One aspect of the mathematics curriculum that involves high levels of reasoning is solving word problems. Word problems, sometimes referred to as story problems, are used to give learners a glimpse of how mathematics is used in the real world (Bogomolny, 2009). Word problems consist of a linguistic presentation of hypothetical situations in which problems are posed that can be solved through the use of mathematical equations. Some mathematicians conceptualize word problems as part of a larger problem-solving component of the mathematics curriculum in which students must overcome barriers in order to obtain and explain a solution to a mathematical problem that is not directly apparent (Heddens & Speer, 2001). Based on this conceptualization of solving word problems, the mathematical equations are sometimes hidden within multifarious, complex word usage. Sometimes the numerals and numeric operations are difficult to identify due to unforeseen or unique language structures, especially in the most advanced word problems. This results in high levels of challenge for many students, particularly those with learning difficulties in the area of mathematics.

Historical Overview of the Inclusion of Word Problems in Mathematics Curricula

Although early examples of mathematics can be dated to 30,000 BC (O’Connor & Robertson, 2009), the use of mathematical word problems can be traced roughly to the year 1600 BC, when Babylonians were educated through the use of mathematical tablets
Historians and researchers alike believe Babylonian mathematicians emphasized the importance of word problems and developed problems that challenged their students to solve written tasks through measurement, computation, and critical thinking (Melville, 1999). Similar examples of mathematical word problems have been discovered in early Egyptian writings (Williams, 2008) and in early Roman, Greek, and Hindu artifacts (Eves, Woo-young, & Hang-gyun, 1995). Thus, the idea of valuing the inclusion of word problems within the mathematics curriculum dates back to the beginning of mathematical word problem history. Many great societies and previous generations have valued training of the mind and believed that critically challenging oneself to analyze and solve problems was beneficial (Melville, 1999).

Throughout the late European Renaissance of the 16th and 17th centuries, applied mathematics appeared in the teachings of aristocratic children attending educational institutions. Applied mathematics integrated real life mathematical problem solving while on the Grand Tour (i.e., aristocratic young men traveled around Europe with their tutors exploring life and its endeavors) (Motley, 1990).

The idea of problem solving within the field of mathematics continued to advance throughout the 20th century through the research of George Polya (1945). Polya wrote extensively about mathematics problem solving. He was a strong advocate for introducing mathematics problem solving to primary school-aged children. In 1945, Polya published *How to Solve It*, a four-step strategy for solving mathematics problems. The four steps in his strategy were: (a) understand the problem, (b) make a plan, (c) carry out the plan, and (d) review and respond, or extend (Polya, 1945). Polya continued to develop his plan for teaching students how to solve mathematics word problems by
expanding the four steps of *How to Solve It* to six steps: (a) understand the problem, (b) determine a plan of action, (c) think about possible consequences of carrying out the plan of action, (d) carry out your plan in a thoughtful manner, (e) check to see if the desired goal has been achieved, and (f) reflect on your new knowledge from solving the problem. Polya's word problem strategy laid the foundation for the use of cognitive strategies within the mathematics curriculum.

In the 1980s, at the National Council of Teachers of Mathematics (NCTM) conference, Schimizzi (1988) proposed that mathematics problem solving be the focus of school mathematics. The Council's position, related to the importance of problem solving, received nationwide support within a relatively short amount of time. The support for emphasizing mathematics problem solving has continued through the 21st century.

Today, mathematical word problems are taught, emphasized, and valued greatly in the United States public education system (NCTM, 2009). The emphasis on solving mathematical word problems is supported through local, regional, state, and national mathematics standards. The National Council of Teachers of Mathematics has been at the forefront of establishing these standards and has articulated the importance of problem solving within all of their standards for school mathematics (NCTM, 2009). The NCTM further notes the importance of linking mathematics problems to contexts other than school. Solving mathematical word problems is viewed as one way to promote this type of high-level thinking. Word problem scenarios frequently describe events that occur outside of school and thus have the potential to assist students in understanding that mathematics may be used in a variety of contexts.
Support for the provision of word problem instruction also is evident through various high stakes testing endeavors in the United States. The No Child Left Behind Act (NCLB, 2001) mandates that all students perform proficiently on grade level standards by the year 2014. The proficiency of each student is assessed through criterion-referenced and/or standardized tests in grades 3 through 12; these assessments emphasize mathematical word problem abilities. According to the Center on Education Policy, 28 states currently require high school seniors to pass a high school exit examination (Zhang, 2009). These high school examinations emphasize the ability to think critically and solve mathematical word problems. According to the College Board’s Office of Research and Development (2010), the Scholastic Aptitude Test (SAT Reasoning Test) and American College Testing exam (ACT) strongly emphasize students’ ability to perform proficiently on mathematical word problems. This emphasis has increased substantially over the past several decades and appears to be a continuing trend. Many public four-year institutions consider student performance on challenging word problems when making admittance decisions (Milewski & Camara, 2002). Similarly, graduate college entrance exams (e.g., Graduate Record Examinations) include mathematical word problems. High performance on these examinations is required to enter many graduate programs across the United States. Professional exams for various licensure and certification requirements also incorporate mathematical word problems and are used for entry into the workforce or continuation within one’s current profession (e.g., teaching, military assignments). Thus, it appears that the ability to solve mathematical word problems is an important performance marker at various educational levels (i.e., elementary through adulthood) and that the use of these problems extends beyond the
classroom setting. The current value being placed on the ability to solve word problems is likely to continue for the foreseeable future.

**Statement of the Problem**

The National Institutes of Health (2010) estimates that 15% to 20% of individuals in the United States are affected by specific learning disabilities. Of those cases, estimates specific to mathematics disabilities range from 5% to 13% (Barbaresi, Katusic, Colligan, Weaver, & Jacobsen, 2005; Fuchs, Fuchs, & Hollenbeck, 2007; Garnett, 1998; Geary, 2004; Gross-Tsur, Manor, & Shalev, 1996; Lewis, Hitch, & Walker, 1994). Bryant (2009) suggests that problems related to memory, cognitive development, and visual-spatial ability all contribute to difficulty in mathematics and unfortunately these are common characteristics among students identified as having specific learning disabilities. According to the Individuals with Disabilities Education Improvement Act of 2004 (IDEIA), a learning disability in mathematics is a weakness in mathematical calculations (i.e., arithmetic) and/or mathematical problem solving (i.e., word problems).

A review of research and theoretical literature to identify specific difficulties associated with learning disabilities in mathematics and a subsequent rank ordering of these difficulties from teachers of students with disabilities in mathematics revealed that out of 29 identified difficulties in mathematics, solving word problems was the most problematic for students with learning disabilities and students with mathematics weaknesses (Bryant, Bryant, & Hammill, 2000). Further reviews of the literature revealed that word problem difficulties may include: (a) reading the problem, (b) comprehending the sentences, (c) identifying the question asked in the problem, (d) ignoring extraneous information in the problem, (e) developing and following a plan for
solving the problem, (f) completing multiple steps to solve the problem, and/or (g) using correct calculation skills to obtain the answer (Bryant, Smith, & Bryant, 2008). These findings concurred with and extended earlier research in which it was determined that students with lower performance abilities in reading comprehension, word analysis, decoding, mathematical computation, and mathematics reasoning were apt to struggle with solving word problems (Forsten, 2004). Many students who struggle with mathematical word problems must overcome delays in both mathematics and reading (Cummins, 2010). Unfortunately, many students struggle with solving word problems. Those who struggle with this aspect of the school curriculum in elementary school are likely to encounter continued difficulties as they (a) progress through the secondary grades, (b) attempt to pass high stakes tests (e.g., assessments used to measure Annual Yearly Progress per the No Child Left Behind Act) to graduate from high school, (c) apply for acceptance into university settings, and/or (d) attempt to acquire or maintain professional certifications. Thus, the detrimental effects extend far beyond early mathematics performance within an elementary classroom. Clearly, the cognitive demands placed on students as they attempt to solve word problems are significant and consequently robust instructional interventions are needed to help students meet these demands.

There has been limited research and subsequent curriculum development in the area of mathematics in general and problem solving (i.e., word problems), in particular. This is especially evident when the amount of mathematics research and curriculum development is compared to the amount of research and curriculum development in the area of reading (Gersten, Jordan, & Flojo, 2005; Horowitz, 2007). One cause for this
discrepancy may be the tremendous emphasis on reading instruction in American culture. Researchers and educators note that the importance of literacy has been stressed to a much greater degree than content related to mathematics (Garnett, 1998; Horowitz, 2007). The idea of one academic subject (i.e., reading) faring greater than the other (i.e., mathematics) leads to misdiagnosis or under-representation of individuals with mathematics learning disabilities. Specifically, Garnett notes that many students who only display academic weakness in the area of mathematics are never referred for evaluation or special education services. Horowitz (2007) blames this trend on lack of research, lack of early mathematics intervention and strategies, and the lack of understanding how to teach specific mathematics skills to struggling students. Fuchs (2010) concurs with Horowitz and notes two significant differences between how schools fare while providing support and interventions to students struggling in mathematics as compared to the provision of support to students who struggle with concepts in reading. First, the amount of available reading materials for screening, progress monitoring, and intervention far outweighs the available resources for mathematics. Second, mathematics is a continuously changing curriculum as students move through the grades; whereas reading has five main components (i.e., phonemic awareness, phonics, reading fluency, vocabulary development, and reading comprehension) that continue to develop as one transitions through the school grades (Fuchs, 2010).

The lack of available materials for mathematics intervention also creates problems for teachers who are faced with providing tiered and evidence-based instruction during newly developed Response-to-Intervention (RTI) models (Fennel, 2010; Fuchs, 2010). Response-to-Instruction (RTI) models typically involve 3 tiers of graduated instructional
support to assist students at-risk for failure in particular subjects or specific academic concepts. To date, RTI has been operationalized and primarily researched in the area of reading with little attention devoted to mathematics instruction (Bryant et al., 2008); thus, teachers expected to use RTI models are challenged to identify and implement effective mathematics instruction that provides additional support beyond what students receive in typical first tier instruction (i.e., core instructional curriculum provided to all students within general education classrooms). Limited resources and relevant research makes this particularly challenging especially related to word problem instruction.

Although mathematics has been referred to as the universal language, this hardly seems accurate when considering the diverse learning approaches of the nearly 50 million students enrolled in American public education (Fry, 2006). The idea of one method-fits-all, particularly when teaching complex problem-solving skills to students with learning difficulties, is not an effective approach. In light of this new understanding, strategic instructional approaches have been established that focus on student individuality and stress areas of academic concern. Specific to teaching students how to solve mathematics word problems, preliminary research on a few isolated approaches (e.g., schematic diagrams, cognitive strategies, and graduated problem-solving sequence) seems promising. Although some evidence exists related to the effectiveness of these approaches when used as individual interventions, progress related to solving word problems among students with mathematics difficulties continues to be slow. Perhaps, it is difficult to meet diverse learning needs when teaching complex problem-solving skills when using only one isolated approach. It is possible that a combination of strategies might result in more positive outcomes for students. Thus, research is needed on an
integrated instructional approach that combines what is currently known about best practice approaches for teaching word problem skills. This is particularly true given the emphasis and value being placed on mathematics word problem solving, the current understanding of how important these skills are to student success in school and life beyond school, and the current need to identify varied tiers of evidence-based support related to mathematics instruction.

Purpose of the Research and Related Questions

The purpose of this research was to examine the effects of a combined problem-solving strategy (i.e., READER strategy) on word problem performance of students with mathematics disabilities and students who are at-risk to fail in mathematics. To address this purpose, the following research questions were answered:

- Research Question 1: Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program improve their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

- Research Question 2: Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program maintain their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

- Research Question 3: Do students receiving Tier 2 intervention within a Response-to-Intervention program generalize their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?
• Research Question 4: Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program report high satisfaction levels related to the components of a combined problem-solving strategy and associated instruction?

• Research Question 5: Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program report a positive attitude towards solving mathematics word problems after receiving explicit instruction in a combined problem-solving strategy?

**Significance of the Research**

The ability to solve mathematical word problems is a skill that incorporates higher order thinking and is highly valued within American culture. Those who have mastered the skill of solving mathematical word problems have acquired the ability to conceptualize mathematical problems abstractly. Their capability to think critically and solve mathematical word problems stems from their proficient understanding of number-word representation, mathematical computation, and mathematical reasoning. This combined strength of mathematics skills can bring great success both academically and professionally.

There are many benefits to having the ability to solve mathematical word problems: success in school, graduation from high school, entrance and completion of college. Although some may suggest that solving word problems is an academic or professional task to be completed in school or in the work place, this represents a limited point of view. The ability to solve mathematical word problems plays a significant role in everyday life. Situations addressing time, money, distance, weight, length, and area all
encompass the concept of mathematical word problems. Activities such as shopping, cooking, cleaning, and traveling also revolve around the ability to solve word problems. Thus, students who acquire and generalize strong problem-solving skills are apt to experience greater success related to common everyday tasks.

There is a tremendous need for improved instructional strategies to teach students to solve mathematical word problems, especially students who struggle with this aspect of the curriculum. In spite of the current emphasis on teaching students to solve word problems, this type of instruction typically is addressed near the end of a unit or is used to culminate a mathematics lesson or chapter in a text (Heddens & Speer, 2001). Many mathematics textbooks oversimplify word problems. Rather than challenging a student’s response by exploring the information within the problem, student responses are habituated through repetitive drill of similar word problems with similar operations. These mathematical word problems are often so routine that students can single out numbers and operations without reading the word problem itself (Heddens & Speer, 2001). This lack of critical reflection contradicts the basic understanding of why society values the skill of solving mathematical word problems. It also weakens the idea of teaching students a foundation of linguistic representation of mathematical concepts. The combination of evidence-based instructional strategies (i.e., concrete-representational-abstract sequence, schema-based diagrams, and cognitive strategies) used to develop the intervention lessons for this research, represents a comprehensive and explicit approach for word problem instruction that may have the potential to help students develop critical reflection and deeper understandings related to word problem solutions than traditional textbook approaches.
Educators of students with specific learning disabilities and students receiving Tier 2 intervention within Response-to-Intervention models need additional research-based materials to enhance their instructional methodology when teaching students to solve word problems. This research has the potential to result in a unit of scripted lessons that teachers can use to meet student needs in this area of the curriculum effectively.

These lessons provide enough detail (e.g., what to do and what to say while implementing the instruction) to ensure that teachers will be able to use the materials without specialized training. This research also has the potential to help educators of students without disabilities who are struggling with the concepts involved in solving mathematical word problems. Strategies that are used successfully with students who struggle to understand specific aspects of the curriculum are sometimes recognized as being helpful for all students regardless of academic ability or readiness. Given the increasing trend toward providing instruction to all students within general education classrooms, it is likely that successful strategies will ultimately be adopted across different types of teachers (e.g., general education teachers, special education teachers, mathematics strategists).

The integrated intervention approach used in this research may also result in curricular lessons that can be used during a Response-to-Intervention (RTI) process for identifying individuals with suspected mathematics learning disabilities. Most RTI models require on-going progress monitoring to determine how students respond to a particular intervention over several weeks. This type of progress monitoring is built into the instructional lessons used in this research and will provide useful data related to student needs. Another potential benefit of this research, if shown to be effective, is a
foundation will be established for future research that involves implementation of this combined problem-solving strategy within general education classrooms that include students with multiple ability levels. The strategy used in this research was developed with the recognition that teacher planning time as well as available instructional time related to solving word problems is limited. The scripted lessons offer an explicit instructional plan for teachers to follow. These development characteristics may be particularly valuable if future researchers extend the use of these lessons within typical general education settings.

As noted earlier, a few isolated interventions for instruction of mathematical word problems have emerged in the literature. The effects of combining what are currently viewed as best practice in terms of teaching students with learning difficulties how to successfully solve mathematical word problems has not been studied in a systematic manner. It is possible that combining several evidenced-based practices will offer an efficient approach for teaching students with diverse learning needs and abilities. Thus, this study has the potential to add a research-based intervention to mathematics literature that will enable students become successful mathematicians.

Without improved research-based practices for this complex aspect of the mathematics curriculum (i.e., solving word problems), educators will likely continue to implement practices that result in limited success, ultimately molding a society of individuals unable to understand and solve mathematical word problems successfully. Limited skills in this area effect the quality of life related to advanced schooling, career opportunities, and day-to-day living skills.
Limitations of the Study

This study was limited geographically to one elementary professional development school located on the campus of a large urban university in the southwestern United States. The school population consisted of children from low socio-economic families. Most of these families lived in daily-weekly rental apartments. All students attending the professional development school, including those participating in the study, received free or reduced lunch. According to the district’s accountability report, 45.9% of the students were limited English proficient, and there was a 52.1% transiency rate for the students who attended the professional development school. Thus, caution must be used with regard to generalizing the results from this study to other types of schools, different locations, and students with different demographic characteristics.

Definition of Terms

Abstract Instruction

Abstract Instruction is the act of solving mathematical problems without the use of concrete objects for manipulation and without the use of representational figures for pictorial assistance (Hudson & Miller, 2006).

Advance Organizer

The Advance Organizer refers to the teacher’s dialogue when introducing and preparing students for an upcoming mathematics lesson. Typical components of an advanced organizer include stating the lesson goal, linking new concepts to prior knowledge, reviewing prerequisite skills, building interest and motivation, and providing a rationale for the lesson (Hudson & Miller, 2006).
Algorithms

Algorithms are the step-by-step procedures that are followed to solve computation problems that involve multi-digit numbers (Tucker, Singleton, & Weaver, 2002).

Conceptual Model

The Conceptual Model refers to an object, picture, or drawing that is used to represent a mathematical concept or relationships related to the concept (Van de Walle, 2004).

Concrete Instruction

Concrete Instruction is a research-based instructional approach used to support conceptual understanding of mathematics. Concrete instruction uses concrete objects (i.e., three-dimensional) or manipulative devices during initial lesson delivery, and provides students with visual-manipulation of the task (Witzel & Allsopp, 2007).

Concrete-Representational-Abstract Teaching Sequence

The Concrete-Representation-Abstract Teaching Sequence is a research-based instructional process used to promote conceptual understanding, procedural knowledge, and declarative knowledge. The sequence involves a progression through three stages: (a) concrete level stage which uses three-dimensional objects for manipulation to solve mathematical problems, (b) representational level stage which uses two-dimensional drawings for visual cues, and (c) the abstract level stage which abandons manipulative devices and visual aids while solving mathematical problems (Hudson & Miller, 2006).

Contextualized Problems

Contextualized Problems are used to solve mathematics word problems that involve real-life situations and materials from the environment, and subsequently transfer
into solving a real-life activity (i.e., hands-on projects) through knowledge gained from solving the word problem (Bottge, 1999).

**Describe and Model**

The Describe and Model stage in the explicit teaching cycle, sometimes referred to as the “I do” stage, is where the teacher directly describes and models the thinking process as well as the steps or actions needed for solving a mathematical problem (Hudson & Miller, 2006).

**Explicit Instruction**

Explicit Instruction, also known as teacher-directed instruction, uses a highly structured approach to deliver instruction. Four essential phases are incorporated into explicit instruction: (a) advance organizer, where the teacher prepares the students for the upcoming lesson, (b) demonstration, where the teacher models the steps or process required to solve a problem, (c) guided practice, where the students are provided opportunities to practice the steps or process with the teacher’s guidance or monitoring, and (d) independent practice, where the students independently practice the skill (Hudson, Miller, & Butler, 2006).

**Fluency**

Fluency is the act of being able to recall information with automaticity; having instant, efficient, and accurate recognition of information (e.g., recalling computation facts) (Calhoon, Emerson, Flores, & Houchins, 2007).
**Generalization**

Generalization is the ability to conceptualize abstract ideas and transfer the knowledge or skill from one setting or situation to another. Generalization is essential to successful outcomes in academic, work, and social situations (Wu & Greenan, 2003).

**Graduated Word Problem Sequence**

A Graduated Word Problem Sequence is a series of word problems that sequentially become more difficult: beginning with simple words and numbers and progressing into sentences, then paragraphs, and finally ending with advanced paragraphs with extraneous information. Although some researchers end the graduated word problem sequence with having students write their own problems, the current research did not use this final step (Mercer & Miller, 1991-94; Miller & Mercer, 1993).

**Guided Practice**

Guided Practice is a stage in the explicit teaching cycle sometimes referred to as the “We do” stage, where the teacher uses prompts to assist the students through the process of solving a mathematical problem. During the guided practice stage, the teacher is more of a facilitator of instruction (Hudson & Miller, 2006).

**Independent Practice**

Independent Practice is a stage in the explicit teaching cycle, sometimes referred to as the “You do” stage, where the students independently practice the concept or skill using learning sheets or other materials to demonstrate their knowledge (Hudson & Miller, 2006).
**Learning Disability**

A Learning Disability is defined as “A disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations” (IDEIA, 2004).

**Learning Strategies**

A Learning Strategy is an approach to learning and using information to assist in understanding information and solving problems; the learning strategy is used to assist learners with how to learn and how to use what has been learned (University of Kansas – Center for Research on Learning, 2010).

**Manipulative Device**

Manipulative Devices are three-dimensional or concrete objects (e.g., pattern blocks, base-ten blocks, cubes) used during the concrete instructional stage to introduce new concepts. The concrete objects are physically manipulated to assist as a visual aide during the learning process (Hatfield, 1994).

**Maintenance**

Maintenance is defined as an additional measure(s) used to determine whether students have retained the instruction received previously. In the current research, maintenance measures were administered one or two weeks after instruction had ceased (i.e., one week for students with disabilities and two weeks for students receiving Tier 2 intervention within a Response-to-Intervention program).
Mathematics Disabilities

A mathematics disability is a learning disability in the area of mathematics. For the purpose of this study, students who qualify for learning disability services in mathematics were considered to have mathematics disabilities.

Mnemonic Devices

Mnemonic Devices are learning tools created to assist the memory. Three types of mnemonics are used: (a) mnemonic acronyms that involve a creative combination of letters in which each letter provides a step or action within a series (e.g., RRR = read, remember, recite), (b) mnemonic acrostics or first letter mnemonics in which each letter of the word or invented word(s) provide a step or action within a series, and (c) loci method in which visual aids or drawings are used in familiar locations or patterns to assist with completing tasks (Johnson, 2006).

National Council for Teachers of Mathematics (NCTM)

The National Council for Teachers of Mathematics is a national organization that provides public voice of mathematics education. The NCTM supports teachers and students through vision, leadership, professional development, and research (NCTM, 2010).

Problem Solving

Problem Solving is providing students with real-life mathematical word problems where application of prior knowledge is required in order find a solution (Hudson & Miller, 2006).
**READER Strategy**

The READER Strategy is a first-letter mnemonic tool used to assist students in solving mathematical story problems. The READER Strategy has six steps: (a) read the problem, (b) examine the question, (c) abandon irrelevant (unneeded) information, (d) determine the operation, using the diagrams if needed, (e) enter the numbers, and (f) record the answer.

**Representational Instruction**

Representational Instruction refers to the second stage within the Concrete-Representational-Abstract instructional sequence, in which diagrams or drawings are used to promote conceptual understanding. Within the representational level stage, the two-dimensional drawings serve as visual cues to assist in solving a problem (Hudson & Miller, 2006).

**Response-to-Intervention (RTI)**

Response-to-Intervention is a regulation within the Individuals with Disabilities Education Act (IDEA) that outlines the requirements regarding identification of children with specific learning disabilities. Most RTI models include a three-tiered instructional approach in which students move to progressively greater levels of instructional support when their performance indicates a need to do so. Tier 1 typically involves providing the standard general education curriculum to all students in the general education classroom. Tier 2 typically involves providing a scientific, research-based intervention targeting a specific skill among students who did not master the skills using the standard general education curriculum. Tier 3 typically involves specialized supports for students.
identified as requiring special education services (Office of Special Education Programs, U.S. Department of Education, 2009).

**Scripted Lessons**

Scripted Lessons represent a highly structured lesson plan using explicit language for teachers to follow word for word (Hudson & Miller, 2006).

**Schematic Diagram**

Schematic diagrams, also referred to as schema-based instruction (SBI), involves the use of visual representations or drawings to assist with solving mathematical word problems (Griffin & Jitendra, 2009).

**Tier 2 Intervention**

Tier 2 Intervention is an instructional strategy used during the second tier of the Response-to-Intervention process. Tier 2 involves providing a scientific, research-based intervention targeting a specific skill among students who did not master the skill using the standard general education curriculum. The intervention lasts for a specified duration and progress monitoring occurs to determine its effectiveness (Bryant et al., 2008).

**Word Problems**

Word Problems are mathematical problems presented in text or narrative rather than in number notation. The solving of word problems, also referred to as story problems or mathematics problem-solving, involves combining one’s knowledge of sentence structure, mathematical relations, basic numerical skills, and mathematical strategies in order to solve a mathematics problem presented in sentence or paragraph structure (Griffin & Jitendra, 2009).
Summary

The current trend of high stakes testing, accountability, response to intervention, and the drive for research-based best practices in the area of mathematics, specifically mathematical reasoning and critical thinking, stresses the value of one’s ability to successfully solve mathematical word problems. Limited research on effective interventions to help students solve mathematical word problems has delayed curriculum development in this area. Given the learning diversity among individuals with learning difficulties it may be helpful to develop a more diverse and powerful intervention to use when teaching these students to solve complex word problems.

Although solving word problems is one of the most difficult skills for students to learn, they need to acquire these skills to be successful in school, everyday life, and to reach postsecondary goals upon school completion (e.g., professional or educational) (Zhang, 2009). Without this basic understanding of mathematical reasoning, mathematical calculation, and critical thinking, students will face everyday challenges and struggle to maintain a typical lifestyle. The intervention used in this research involved the use of a combined problem-solving strategy to solve mathematical word problems involving both addition and subtraction. Specifically, the intervention strategy consisted of building student understanding by working through a modified concrete-representational-abstract instructional sequence while using a schema-based instructional approach integrated into a mnemonic device. Specifically, acquisition, maintenance, and generalization of students’ abilities to solve word problems were measured. The results of this research may have direct and immediate practical implications for classroom teachers of mathematics instruction.
Additional features associated with this research are reported in the subsequent chapters. A review of literature related to the topic of mathematical word problems is discussed in Chapter 2. Methodology used to implement the current research is offered in Chapter 3. The results are reported in Chapter 4, and implications of the results are discussed in Chapter 5.
CHAPTER 2
REVIEW OF RELATED LITERATURE

The purpose of this chapter is to summarize and analyze existing professional literature related to instructional strategies and methodologies for teaching individuals with learning difficulties in the area of mathematics to solve word problems. The chapter begins with a discussion of the literature search procedures used to locate potential experimental studies to include in this review. Next, the selection criteria used for research inclusion is reported. Then, a review and analysis of studies related to strategies that have been used, at least in part, for word problem instruction is provided. Next, a review and analysis of studies related to the use of language in word problems is provided. Finally, a summary and synthesis of research related to problem-solving instructional strategies and the use of language in word problem solving is provided.

**Literature Review Search Procedures**

A systematic search through computerized databases was conducted. The databases included (a) Education Resources Information Center, (b) ProQuest - UMI Digital Dissertation Database, (c) H.W. Wilson Company, and (d) Sage Journals Online. The descriptors that were used included: math, word problems, story problems, learning disabilities, math and intervention, math and special education, word problems and special education, word problems and learning disabilities, story problem instruction, word problem instruction, math word problem instruction, problem-based instruction, math problem solving, problem solving and special education, explicit instruction and mathematics, explicit instruction and special education, explicit instruction and learning disabilities, strategic learning and mathematics, strategic learning and special education,
strategic learning and learning disabilities, direct instruction and word problems, direct instruction and mathematics, direct instruction and special education, response-to-intervention and mathematics instruction for at-risk students and mathematics instruction, and strategic instruction model. Also included in the literature review process was an ancestral search through the reference lists of the articles obtained.

Criteria for Selection

Studies were included in this review if (a) the procedures and data-based results were published between 1980 and 2010, (b) the participants were elementary or secondary students with learning difficulties or with learning disabilities in the area of mathematics, (c) the study included at least two subjects, and (d) the purpose of the study was to examine the effectiveness of an instructional intervention or method on students’ mathematics performance or ability to solve mathematical word problems. Studies were excluded from this review if (a) the participants were identified as having disabilities not associated with cognitive development (i.e., health impairments, blindness, deafness), (b) the purpose of the study was to provide instruction on topics other than mathematics, and/or (c) the participants were students identified with learning disabilities in areas other than mathematics.

Review and Analysis of Studies Related to Word Problem Instruction

Concrete-Representational-Abstract Instructional Sequence

The Concrete-Representational-Abstract Sequence is a research-based instructional process used to promote conceptual understanding, procedural knowledge, and declarative knowledge. The sequence moves through three stages: (a) concrete, (b) representational, and (c) abstract. The concrete level stage involves the use of three-
dimensional objects for manipulation to solve mathematical problems, and promotes conceptual understanding and procedural knowledge of the given task. The representational level stage involves the use of two-dimensional drawings for visual cues and promotes both conceptual understanding and procedural knowledge when three-dimensional objects are not readily available. The representational level stage also begins to support the development of declarative knowledge by building automaticity or fluency of the concept. This occurs when the student only uses the drawings when needed. The abstract level stage involves the abandonment of manipulative devices and visual aids while solving mathematical word problems.

Harris, Miller, and Mercer (1995) conducted a study to investigate the effects of teaching initial multiplication skills to students with disabilities in general education classrooms. The researchers focused on the current trends of instructional delivery within the field of special education (i.e., inclusive education services) and future trend of integrating higher levels of effective, direct, and explicit instructional interventions and supports to students who struggle with grade level academic curricula (i.e., Tier 2 instruction and response to intervention).

The study took place at a public elementary school located in north-central Florida. In all, 112 second graders in six second-grade general education classrooms participated in the study. Twelve participants were identified as individuals with learning disabilities, one participant was identified as having emotional disabilities, and 99 participants were general education peers. The instruction took place in the six second-grade classrooms and was delivered by the general education teachers. No special education teacher, paraprofessional, volunteers, or student teacher candidates worked in
the six classrooms during the study. The instructional interventions for multiplication took place during the regularly scheduled mathematics period. Miller and Mercer’s *Multiplication Facts 0 to 81* (1992), a scripted manual from the *Strategic Math Series* (Mercer & Miller, 1991-1994), was implemented as the intervention in the study. Four measurement instruments were used during the study: (a) a one-minute timed multiplication facts sheet, (b) multiplication pretest, (c) multiplication posttest, and (d) the daily learning sheet, which accompanied the 21 scripted lessons. Prior to implementation of the intervention, the six female teachers received a two-hour training session on the procedures of the *Multiplication Facts 0 to 81* program. Baseline procedures continued for several days prior to instruction, measuring the rate of computation on basic multiplication facts. The baseline data were scored through counting the number of correct and number of incorrect digits in the answers to each of the problems completed by students within oneminute. Teachers were instructed to begin with administering the pretest, followed by the intervention lessons, once baseline was established.

A comparison of mean pretest and posttest data indicated a 52.5 % increase among participants identified with learning disabilities. The average pretest scores among participants with learning disabilities ranged from 5% to 50%. The average posttest scores among participants with learning disabilities ranged from 60% to 100%. The researchers also compared the performance of participants with disabilities to their general education peers without identified disabilities. During baseline and pretest data collection phases, both groups began instruction at the same level. During the first 10 lessons (i.e., developing conceptual understanding of multiplication), median scores were
the same for both groups on seven of the nine learning sheets. The difference between
the two groups began to appear after posttest data and when instructional emphasis
changed from conceptual understanding of multiplication facts to requiring the
participants to solve and create their own mathematics word problems. Participants with
disabilities achieved lower scores than their peers without disabilities.

The researchers noted several implications for future practice. These included (a)
effective teaching approaches (i.e., Concrete-Representational-Abstract sequence) benefit
students with and without disabilities while teaching conceptual understanding of
multiplication, (b) pretest data can assist teachers in developing instructional delivery, (c)
mastery levels are critical for teachers to make data-based informed decisions related to
planning instruction and delivering instructional feedback, and (d) students with
disabilities can perform similar to their general education peers, while solving
multiplication, given the instruction involves the use of appropriate curricular materials.

Morin and Miller (1998) conducted a study to evaluate the effectiveness of the
concrete-representational-abstract (CRA) sequence combined with strategy instruction to
teach multiplication skills and related word problems to middle school students with
intellectual disabilities. Although the noted instructional strategy had been successful
with students with learning disabilities and low performers without disabilities (Harris et
al., 1995), Morin and Miller’s study investigated the success of the same instructional
strategy for students with more severe cognitive disabilities (i.e., intellectual disabilities).

The participants for this study were three seventh-grade students with intellectual
disabilities, ranging in age from 15 to 16 years old. The participants’ intelligence
quotients (IQ) ranged between 50 and 64 based on the Wechsler Intelligence Scale for
Children-Revised. Two of the participants also had secondary disabilities. The study involved five weeks of instructional lessons that took place in a location near the special education classroom, within an urban middle school located in the Southeastern region of Alabama. A multiple baseline design across three participants was used. The intervention consisted of 21 scripted lessons. Each lesson included an advance organizer, demonstration, guided practice, independent practice, and feedback. Data, including baseline and intervention scores, and pre- and post-assessment scores, were collected, scored, and plotted on a graph for all three participants. A trained special education teacher implemented the intervention. Eighteen instructional sessions were observed to ensure procedural reliability. Once baseline stability was obtained, Participant 1 began the intervention. When Participant 1 met the 80% accuracy criterion on the first intervention session, the first lesson was introduced to Participant 2. Participant 3 continued the baseline condition until Participant 2 obtained the 80% accuracy criterion, and then Participant 3 began the intervention. Each intervention session lasted 35 minutes. Concrete level instruction was provided in the first three lessons. During concrete level instruction, groups of objects were used to model the multiplication process. Afterwards, three additional lessons using representational level instruction were taught. During representational level instruction, pictures of objects were used to illustrate the multiplication process.

At the end of lesson six, a mnemonic instructional strategy was introduced. The mnemonic device, DRAW (i.e., Discover the sign, Read the problem, Answer or draw and check, and Write the answer), was rehearsed and verbally memorized by each participant. Abstract level instruction was provided in the next three lessons. During
abstract level instruction, the participants were encouraged to memorize the multiplication facts and use the DRAW strategy when needed. During Lesson 11, the teacher introduced the FAST DRAW mnemonic device (i.e., Find what you’re solving for, Ask yourself “what are the parts of the problem?”, Set up the numbers, and Tie down the sign). This lesson set the stage for solving multiplication word problems in subsequent lessons (i.e., Lessons 12 and 13). The remaining lessons (i.e., Lessons 14-21) incorporated both independent practice problems and multiplication word problems. The results between pre-assessment scores (50%, 70%, and 20%) and post-assessment scores (90%, 90%, and 90%) showed gains for all three participants. The gain scores were reported as 40, 20, and 70 percentage points. During the baseline phase, Participant 1 had a mean score of 73.3 and a median score of 70, Participant 2 had a mean score of 67.5 and a median score of 70, and Participant 3 had a mean score of 58 and a median score of 60. During the intervention phase, Participant 1 had a mean score of 90.5 and a median score of 90, Participant 2 had a mean score of 93.5 and a median score of 100, and Participant 3 had a mean score of 91.5 and a median score of 95. The researchers noted that scores for all three participants fell slightly during the advanced problem-solving practice when more complex word problems were solved. The researchers concluded that individuals with intellectual disabilities can learn multiplication facts and related word problems when using a C-R-A sequence and systematic learning procedures. The strengths of this study include (a) the multiple fidelity of treatment checks to determine procedural reliability, and (b) the use of a previously researched intervention. However, the greatest strength of this study was the discovery that the instructional strategy was effective for teaching mathematics skills to individuals with intellectual
disabilities. A limitation related to the study was the failure to include replication with additional students.

Butler, Miller, Crehan, Babbitt, and Pierce (2003) conducted a study to evaluate the effectiveness of two instructional methods: (a) the concrete-representational-abstract instructional sequence, and (b) the representational-abstract (R-A) instructional sequence, for fraction-related instruction. Specifically, the purpose of the study was to compare the effects of the two instructional sequences. The participants in the study were 50 students identified with mild- to moderate disabilities in mathematics. All participants were enrolled in grades 6, 7, and 8 at a public middle school located in a large urban area of the southwestern United States. The students ranged in age from 11 to 15 years and received mathematics instruction in resource room settings. Twenty-six students received the C-R-A instructional sequence and 24 students received the R-A instructional sequence. Additionally, 65 students, without disabilities, enrolled in eighth-grade were administered the post-assessment. To determine what typical students without disabilities know about fractions at the end of eighth-grade, these students served as a comparison group. The instrumentation used in this study included five subtests (three subtests from the Brigance Comprehensive Inventory of Basic Skills-Revised and two subtests designed by the investigator). These instruments were used as pretests and posttests and measured the students’ knowledge of fraction skills. An attitude questionnaire was also administered to each participant to assess the students’ attitude towards mathematics instruction.

Ten scripted lessons were used in the study. Each lesson included an advance organizer, teacher demonstration, guided practice, independent practice, problem-solving
practice (i.e., word problems), and feedback. Each lesson had one accompanying learning sheet for each student. The learning sheets contained problems for guided practice, independent practice, and problem-solving practice. Four investigator-designed cue cards also were used. The concrete materials included fraction circles, dried beans, and fraction squares made of paper. The participants were enrolled in four math classes, two classes were taught the C-R-A sequence and two classes were taught the R-A sequence. Two special education teachers, who were trained in teaching the scripted lessons, delivered the instruction. Both the C-R-A and R-A lessons lasted 45 minutes and followed the same lesson format (i.e., advanced organizer, teacher demonstration, guided practice, problem-solving practice, and feedback routines). Participants in both treatment groups were given notes to assist with lesson understanding.

The key difference between the two treatment groups was evidenced in Lessons 1 through 3. The group receiving the C-R-A instructional sequence was taught fraction equivalence using concrete objects and then proceeded to Lesson 4 that involved the use of representational drawings, whereas the group receiving the R-A instructional sequence used only representational drawings in Lessons 1 through 3. Lessons 4 through 10 were the same for each group.

A post-assessment was administered using the same five subtests and attitude questionnaire used during the pre-assessment. Paired sample $t$-tests were used to measure performance differences between the participants who received C-R-A instruction and those who received R-A instruction. The results of the $t$-tests indicated a significant improvement in all areas of the five subtests (i.e., Area Fractions, Quantity
Fractions, Improper Fractions, Abstract Fractions, Word Problems) for both groups, except the Area Fraction Subtest for the C-R-A group.

To assess the difference between the C-R-A and R-A treatments on the five fraction measures, a MANCOVA was completed. The results indicated a statistically significant difference between the two treatment groups for the set of five subtests ($F_{(1, 43)} = 2.811, p = 0.029$). When a follow-up univariate test was conducted ($F_{(1, 43)} = 14.759, p < 0.0005$), the results revealed a statistically significant difference on the Quality Fractions Subtest favoring C-R-A. When comparing a combined treatment group (C-R-A and R-A) to a comparison group (i.e., general education students who received traditional fraction instruction), the data indicated that the treatment group outperformed comparison students on two subtests (i.e., Improper Fractions and Word Problems). The treatment group of students with disabilities also performed similarly to the comparison group on the other subtests.

The data also revealed similar performance between the C-R-A and R-A groups on the attitude questionnaire. The participants in the C-R-A treatment group demonstrated better conceptual understanding as evidenced through higher mean scores; however, this difference was only statistically significant on the Quantity Fractions Subtest. Researchers suggested that future studies be designed to examine the use of concrete level instruction for a longer period of time.

The strengths of this study include (a) the detailed descriptions of the settings and procedures that provide sufficient detail for replication, (b) the use of scripted intervention lessons to strengthen internal validity, and (c) the social validation of a cost effective intervention designed to teach a skill that must be taught to all students in public
education. However, the demographic data related to the treatment groups did not reveal whether the identified learning disabilities were attributed to factors other than cognitive intelligence (e.g., attention deficit hyperactivity disorder) which could lead to lower pre- and post-assessment scores. Learning disabilities that are specifically attributed to attention deficit hyperactivity disorder can impede the learning process for the individual student, as well as other students in the same classroom. Also, the demographic data do not reveal the age per gender. If this information had been provided, it would be possible to consider the difference in learning readiness between male and female students. A questionnaire could have been administered to determine if the students had been exposed to a concrete level of teaching fractions in prior grades. If all students had previously been exposed to concrete instruction, this could have lead to the similarity between performance levels of the treatment and comparison groups.

Scheuermann, Deshler, and Schumaker (2009) completed a study designed to explore the C-R-A instructional sequence through explicit instruction while solving word problems. The purpose of the study was to examine the effectiveness of this approach in both general education and special education settings. Twenty male and female students, between the ages of 11 and 14 participated in the study. Each participant was diagnosed with a learning disability and scored in the lower 25th percentile on a standardized math assessment. The study was conducted in a charter school that specialized in teaching students with learning disabilities. The procedures for the study included the use of an Explicit Inquiry Routine (EIR) (Scheuermann et al.). The EIR is a teaching routine that combines research-based or validated mathematics practices from general education (i.e., inquiry and dialogue) and mathematics practices from special education (i.e., explicit
instruction). A multiple-probe-across-students design was used. The intervention took place daily during a 55-minute mathematics lesson. Students were provided a lesson using the direct-teaching approach. A follow up worksheet was provided to the students; a score of 75% represented mastery. Data were collected through a pre- and post-assessment, along with maintenance probes. All subjects made significant growth after the intervention was provided. The students’ ability to generalize the skill taught during the intervention was measured and the data indicated students made significant growth in a Far-Generalization Test. Scheuermann et al. concluded that students with math learning disabilities can increase their knowledge of math concepts through the use of direct instruction and the use of a C-R-A instructional sequence.

Maccini and Hughes (2000) conducted a study examining the effects of a problem-solving strategy that involved the use of the C-R-A sequence to introduce algebra to students with learning disabilities. The multiple-probe across subjects design took place over a 168-day period. The participants involved in this study were six secondary school-aged students identified with learning disabilities. The study was designed to answer three questions: (a) can the participants learn the multi-stepped, self-instructional graduated instructional sequence, (b) will the participants improve their word problem-solving abilities after the intervention, and (c) will the participants generalize and maintain their skills when presented with novel mathematic word problems?

The intervention was provided in a school located in central Pennsylvania. The intervention began with concrete application that involved individual manipulation of physical objects to represent mathematical problems. The second step in the instructional
sequence was semi-concrete applications in which participants were taught to draw pictures to represent the previously used physical objects. The abstract application step was the final step in the instructional process. During this step, the participants were taught to use mathematical symbols combined with written numbers to solve math problems. A first letter mnemonic, STAR, was also introduced to the participants to assist in the process for solving mathematics word problems. The STAR mnemonic device steps were (a) Search the word problem, (b) Translate the problem, (c) Answer the problem, and (d) Review the solution. Each of the C-R-A and strategy lessons included phases adapted from the Strategic Math Series (Mercer & Miller as cited in Maccini & Hughes, 2000): (a) provide advance organizer, (b) describe and model, (c) conduct guided practice, (d) conduct independent practice, (e) give a posttest, and (f) provide feedback.

Data were collected for each participant’s correct problem solution, answer percentage, and strategy-use abilities. A holistic scoring guide and scale was established to provide points per component. A visual analysis of multiple probe data and an analysis of the pretest and posttest results indicated an improvement in the percentage of strategy use with all participants (23% at baseline, 80% near-transfer generalization, 54% far-transfer generalization, and 69% for maintenance). All participants also increased their accuracy on problem solving (addition baseline M = 33.38% to instructional M = 94.12%, subtraction baseline M = 26.88% to instructional M = 93%, multiplication baseline M = 13.88% to instructional M = 93%, and division baseline M = 10.04% to instructional M = 97%). Participants also demonstrated accuracy on problem solutions, ranging from 38.87% to 57.89% on the baseline measure to 89.4% to 100% on the
instructional measures. Similar results were obtained for percentage accuracy on generalization measures. Using a Likert-scale questionnaire, the subjects responded positively to the strategy and the teachers. Results obtained from three open-ended questions were also positive. Thus, the social validity was very high.

In another study, Maccini and Ruhl (2000) used the C-R-A and STAR mnemonic strategy to examine the effectiveness with solving algebraic subtraction problems. A multiple probe design across three subjects was used. The participants were three eighth-grade students ranging in age from 14 to 15 years old. Each subject was diagnosed as having a learning disability and demonstrated deficits in subtraction tasks. All three participants received specialized education in the area of mathematics. The study was conducted in a public middle school located in central Pennsylvania. The intervention lessons were taught in one of two conference rooms within the school.

The study used instructional procedures adapted from the Strategic Math Series (Mercer & Miller cited in Maccini & Ruhl, 2000). The students increased their percentage of strategy use and increased their operation abilities within algebraic problemsolving. The Likert-scale social validity questionnaire was used, but the participants in this study rated the strategy higher than the previous study with a mean satisfaction of 4.67, using a five-point scale (5 being the greatest satisfaction).

Based on the previously reviewed studies, the concrete-representational-abstract instructional sequence appears to be an effective instructional strategy for teaching mathematical computation and word problems involving fractions, basic multiplication facts, and algebra. Additionally, the C-R-A instructional sequence was cited as an effective instructional strategy for educating diverse populations (i.e., students with and
without identified learning disabilities and individuals with intellectual disabilities). However, what appears to be missing from the literature is research in the use of a C-R-A instructional sequence for teaching mathematics problem solving that requires students to discriminate between multiple operations (e.g., addition and subtraction) to accurately solve word problems. This requires higher levels of analysis and reasoning than solving only one type of word problem.

Schema-Based Strategies

Schema-based strategies involve the use of visual representations or drawings to assist with solving mathematical word problems (Griffin & Jitendra, 2009). Often referred to as schema-based instruction (SBI), schema-based strategies assist with developing conceptual understanding, procedural knowledge, and declarative knowledge.

Willis and Fuson (1988) conducted a study to examine whether teaching elementary-aged children to use schematic drawings would improve addition and subtraction word problem abilities. The researchers identified multiple questions to be answered through this research: (a) can the participants make schematic drawings, (b) can the participants determine the appropriate schematic drawing to use to solve the problem, (c) do participants use the correct numbers in the appropriate location of the schematic drawing, (d) are participants able to select the correct solution strategy, (e) how do participants relate the problem to their choice of solution strategy, (f) do the participants carry out the solution strategy correctly, and (g) do participants record the correct answer?

The participants in the study were second-grade students from two public schools in the Chicago area with varying socio-economic statuses. The participants were
assigned to their respective mathematics classes based on teacher-determined mathematics abilities. The first class had 24 students whose mathematics abilities were categorized as high achieving, whereas the second class had 19 students whose mathematics abilities were categorized as average. The intervention took place in the students’ regularly scheduled mathematics classes.

The procedures of the study began with administering a pretest to all students. The assessment measured the students’ ability to solve word problems. The students were able to solve the mathematics word problems using any strategy or idea currently known to them. After the pretest, the first class (high achieving) received instruction on the schematic drawings. Four schematic drawings were used: (a) compare diagram, (b) put together diagram, (c) change-get-more diagram, and (d) change-get-less diagram. The students received instruction on each type of schematic drawing one at a time. Following the instruction, a two-to-four day practice period was provided to the students to develop a greater understanding and performance level for each schematic drawing.

At the end of the fourth schematic drawing instructional activity, a posttest was given and the second class (average ability) began the intervention. Due to time constraints, the second class did not receive the total amount of time allotted to practice each schematic drawing, nor was time provided to review questions on the compare strategy. Also, based on the performance of the high-achieving class, some instructional activities were excluded from the average-ability class, which ultimately had to be taught to the students at the end of the intervention lessons due to gaps in the teaching and learning process.

Data were collected through assessments to determine the ability of each participant while drawing the schematic drawing and based on the solution strategy
performed. The results indicated significant gains in some areas (i.e., change-get-more, compare, and put together within the high achieving group; put together and change-get-more within the average ability group) while completing addition and subtraction word problems after receiving the schematic drawings intervention. The results of the high performing class can be used to show the effects of the schematic drawings because the intervention was administered in its entirety without time, procedural, instructional, or practice flaws. The findings of this study would be stronger if a control group had been included.

Jitendra and Hoff (1996) conducted a study examining the effects of a schema-based instructional approach on solving mathematical word problems for students with learning disabilities. The researchers used a multiple-probe-across-students design and provided a schema-based learning strategy to three participants. The strategy focused on teaching students a method to distinguish word problem operations based on three classifications of problem type (i.e., change, group, and compare). A different schemata diagram was used to represent each of the three problem types. The diagrams were used as visual cues or thinking maps to help students solve the three types of word problems. The diagrams also incorporated important word references that cued the students to the process of solving the problem, be it addition or subtraction. The three participants ranged in age from 8 to 10 years old and were enrolled in either third or fourth grade. The study was conducted at a small private school for students with learning disabilities. With the use of probes, worksheets, and student interviews, the data were analyzed within and between conditions. The results indicate that all three subjects improved their word problem solving abilities after receiving the intervention. The interview results also were
positive, with all subjects agreeing they would recommend the schema-based strategy to a friend who may struggle with solving mathematical word problems.

Jitendra et al. (1998) conducted a study to investigate and compare the effects of a schema-based instructional strategy and a traditional basal strategy to teach basic addition and subtraction word problems to students with mild learning disabilities and students without identified learning disabilities but categorized as at-risk for failure in mathematics. Data were collected in four public school classrooms located in the southeastern United States. The participants included 34 students from grades two through five. Ten participants in the treatment group were identified as having a learning disability. Twenty-four typically achieving third graders were used as a comparison group.

Two phases were implemented in this study. The first phase examined the effects of the schematic strategy and the traditional basal strategy on the acquisition of basic addition and subtraction problems and the second phase examined maintenance and generalization related to the two instructional strategies. The study began with administration of a pretest. Participants were instructed to read the word problems and complete them to the best of their ability. The pretest contained a variety of story problems that required the students to add and subtract basic numbers. Seventeen to 20 45-minute instructional sessions were provided to small groups (i.e., 3 to 6 students). The instructional sessions were delivered by doctoral and master’s degree students who were enrolled in the special education and school psychology programs. Scripted lesson formats were provided to all instructors. The students receiving the schema-based strategy were taught three schema-diagrams to assist with solving the word problems: (a)
change story situation, (b) group story situation, and (c) compare story situation drawings. Students were taught the schema-diagrams, practiced identifying and drawing the schema-diagrams, and reviewed problems using each schema-based diagram. The students who were instructed using the traditional basal instructional strategy were taught using the school textbook. A posttest was administered after the treatment along with a generalization assessment one day later.

Additionally, participants were again assessed one to two weeks after the posttest to examine the maintenance of the strategies. A strategy questionnaire was individually administered to each participant at the end of the study. The results of the study indicated no significant difference between the traditional and schema-based conditions while comparing the pretests using an analysis of variance ($F_{(1,23)} = 0.29$, $p = 0.59$). With the use of an Analysis of Covariance, a statistically significant difference was found between both the posttest and maintenance scores (i.e., for schema-based strategy 77% and 81% correct and for traditional basal strategy 65% and 64% correct). Although both groups demonstrated an increase in word problem-solving abilities (i.e., 26% increase in schema-based group performance and 16% increase in traditional basal group performance), students in the schema-based strategy group demonstrated the greatest effect. They performed at a level commensurate to the comparative sample group of third-grade students without disabilities. This success was relative to the maintenance assessment in which the schema-based instructional strategy group scored a mean of 81% and the comparison group scored a mean of 82%. The traditional basal strategy group scored a mean of 64% on the maintenance assessment. The data indicated that the use of schema-
based instructional approaches helps students with disabilities perform similarly to students without disabilities.

Jitendra, Hoff, and Beck (1999) conducted a study to replicate the earlier research (Jitendra et al., 1998) on the effects of schema-based instructional strategies, and also investigate the generalization from one-step addition and subtraction word problems to two-step word problems. The study was conducted in a middle school classroom setting located in the northeastern United States. The participants were four middle school students with learning disabilities, ranging in age from 12 to 14 years old. Twenty-one typically achieving students were used as a comparison group for testing only. The instruction took place in a special education resource room during a 45-minute period.

A multiple baseline across subjects and across behaviors design was used to evaluate the effects of the schema-based instructional strategy while teaching mathematical word problem-solving abilities. The phases included within the study were baseline, two instructional levels (schema-based instruction on one-step and two-step word problems), posttests, setting and behavior generalization, and maintenance. Instruction was provided to the participants on the procedures of solving one-step addition and subtraction word problems while using the schema-based instructional strategy. The participants had to reach 90% criterion over a two-day period to progress to solving two-step addition and subtraction word problems with the use of the schema-based instructional strategy. Three schema-based diagrams were used: (a) change diagram, (b) group diagram, and (c) compare diagram.

The results of the study indicated an increase in word problem solving abilities after the intervention of schema-based instruction was taught in all areas measured (i.e.,
drawing the diagram, mapping the diagram, and writing the answer). When examining the data after the instruction for one-step word problems, the researchers found that the participants increased their abilities to solve the problems by 26%. After receiving instruction on solving two-step word problems with the schema-based instructional strategy, the participants increased their ability by 71% when comparing the pre- and post-test scores. The average performance on generalization and maintenance also increased 39% when compared to the baseline data.

Overall, the data indicated that the schema-based instructional strategy was effective when teaching middle school-aged students with learning disabilities how to solve one- and two-step addition and subtraction word problems. Questionnaire interviews also indicated that the students found the schema-based diagrams to be useful for mapping and solving mathematic word problems. The researchers noted that future researchers should examine whether the participants would generalize their skill to novel mathematics word problems (i.e., three- or four-step word problems). The strength of this study included the rigor in which the study was conducted. Procedures were put in place and executed with precision and routinely checked through observation, fidelity checklists, and reliability procedures.

Owen and Fuchs (2002) completed a study designed to examine the effects of strategy instruction on solving mathematical problems with 24 third-grade students. The three-week study involved instruction on a six-step sequence to solving word problems. The six-step strategy taught to the participants followed the sequence (a) read the problem, (b) draw individual circles representing each number used, (c) draw a rectangle divided in half, (d) cross out the first circle and draw it in the left box, do the same for the
second circle but place it in the right box—continuing the process until you run out of circles, (e) count the circles in each box, make sure each box has the same number of circles, and (f) count the circles in one box and record the number as your answer. The researchers used a pretest and posttest to collect data on the effect of the strategy. Student surveys and teacher surveys also were used to measure social validity. The results of the study indicated that students who received the instructional strategy did significantly better on the post-assessment than students in the control group. Similar to the participants in Jitendra’s (2002) study, students in the Owen and Fuchs (2002) study enjoyed the instructional experience and were happy with their results.

Jitendra, DiPipi, and Perron-Jones (2002) conducted a study to replicate the effects of earlier research on schema-based strategy instruction. The purpose of this study was to continue the investigation related to the use of schema-based diagrams to improve the mathematic problem-solving abilities of middle school students with learning disabilities and at-risk for failure in mathematics. Three research questions were asked: (a) is a schema-based instructional strategy effective while teaching middle school students to solve one-step multiplication and division word problems, (b) will the students be able to maintain their word problem-solving skill, and (c) will the skill to solve one-step multiplication problems be generalized to solve multi-step multiplication and division word problems?

A multiple-probe-across-participants design was used with four eighth-grade students. There were two boys and two girls, who received learning support for mathematics instruction and all who were 13 years of age. The study took place at a middle school in a northeastern suburban area of the United States. Specifically, the
intervention took place at a table in the students’ typical mathematics class. Each participant received instruction independently at different times. The classroom teacher was responsible for providing the intervention and the instructional aide monitored the other students in the class while the teacher provided the word problem instruction to each of the four study participants. Materials included in the study were scripted lessons for teaching the word problems, worksheets, and practice probes. The worksheets used in the study also included the problem schemata diagrams and examples of the two problem types explored in the study: multiplicative comparison and vary problems. Prior to the implementation of the study, the teacher was trained in the procedures for the experimental conditions and was provided with all instructional materials required for implementation.

Four experimental phases were implemented in the study. First, during the baseline phase, the participants were assessed on their word problem-solving abilities. Second, during the intervention phase, participants were provided 35- to 40-minute lessons on mathematical word problem-solving strategies for multiplication and division problems. Schema-based training was administered, and participants were required to obtain 100% correct on two training sessions in order to progress to the next lesson. Explicit modeling, interactive discussion, guided practice, monitoring and corrective feedback, and independent practice were combined during each intervention lesson.

The intervention began with the easier of the two problem types, and progressed into the more difficult algorithms. During the third and fourth phases of the study, (i.e., generalization and maintenance), the participants completed assessments involving novel word problems, and completed strategy assessments at the end of weeks 4, 8, 9, and 10 to
assess the maintenance of the skill. Data were collected through word-problem tests provided by the classroom teacher. Prior to intervention, the baseline scores for drawing diagrams to compute the word problem consisted of 20%, 0%, 0%, and 0% for the four participants. Post-treatment, the scores for the same factor increased to 83%, 100%, 100%, and 100%, respectively. Similarly, the ability to write the number sentence correctly also increased after the intervention, from 0%, 100%, 0%, and 17% to 100%, 100%, 100%, and 53%. Although the researchers believed the study results to be positive, two participants had high mathematical reasoning scores and the researchers questioned whether these students had a true disability in mathematics. Ultimately, this may have elevated the performance effects related to teaching schema-based instructional strategies to students with mathematics learning disabilities. The researchers also noted that the results may not generalize to other populations because the study was conducted as a single-subject design. The strengths of this study were (a) validation of the idea of using a schema-based instructional approach to assist students while solving mathematical word-problems, (b) provision of additional social validity related to using schema-based instruction in typical classroom settings, and (c) expansion of research in assisting students at-risk for failure in mathematical story problem solving.

Xin, Jitendra, and Deatline-Buchman (2005) conducted a study to compare the effects of two mathematical problem-solving instructional approaches. The first approach was a schema-based instructional method that consisted of two steps: (a) identify the problem type, and (b) determine the structure of the problem to be used in a schematic diagram. This method was used in an earlier study conducted by Jitendra (1996). The second approach involved the use of a general strategy. The approach was
adapted from a commercial mathematics textbook. The approach had four steps: (a) read to understand, (b) develop a plan, (c) solve, and (d) look back.

The participants in the study were 22 students who struggled with academics, 18 who were identified as having a learning disability, one with emotional disturbance, and three were at risk for mathematics failure. The study took place at a middle school located in the northeast region of the United States. Word problem assessments were used to determine whether students acquired, maintained, and transferred the skill from either learning method. The results of the study indicated that students who participated in the first approach (schema-based instruction) performed significantly better than students who participated in the general strategy instruction. There were statistically significant differences between groups on posttest, maintenance, follow-up, and generalization test results. Findings from this study support findings from other studies examining the effects that a schema-based instructional approach has on solving mathematical word problems.

Van Garderen (2007) examined the use of diagrams to solve one- and two-step mathematical word problems by students with learning disabilities. The design used in this study was a multiple-probe-across-participants design. The three participants, all of whom were in eighth grade and had been diagnosed with a learning disability, were taught a diagram strategy to solve mathematical word problems. Four research questions were used to guide this research: (a) can students with learning disabilities improve their ability to generate diagrams to represent mathematical word problems, (b) can those students improve their word problem performance while incorporating the diagram strategy, (c) will the students generalize the acquired skills to authentic, real-world
problems, and (d) how will the subjects evaluate the effectiveness and acceptability of the strategy? The study took place at a junior high school in the mid-Hudson region of New York. The experimental phases included baseline, intervention, generalization, and maintenance. A pretest and posttest were used to analyze the effectiveness of the diagram strategy.

The data from the study indicated improved mathematical word problem performance for all participants. Although the researchers did find some inconsistencies between participants’ performances, Van Garderen stressed the importance of supporting any diagram-based instructional method with a few lessons to teach the participants about what a diagram is and how it can be used to assist in solving problems. Van Garderen also noted that researchers and educators should begin instruction with an emphasis on the use and conceptualization of diagrams and how to generate diagrams.

Based on this review of literature, the use of schema-based diagrams helps students who struggle with mathematics improve their ability to solve word problems. Among this literature only three studies were found that involved elementary students and no studies were found that investigated the use of schema-based diagrams within the context of the concrete-representational-abstract (CRA) instructional sequence. Also, no studies were found in which researchers attempted to decrease students’ use of the schematic diagrams over time.

**Cognitive Strategies**

Cognitive strategies involve the use of written cues or prompts to assist in solving mathematical word problems. Typically written in a mnemonic format, cognitive
strategies guide students through the process or steps to solving mathematical problems, assisting with the development of procedural knowledge.

Case, Harris, and Graham (1992) examined the effect of a self-regulated strategy developed to improve mathematical word problem abilities in students with learning disabilities. The purpose of this study was to investigate the effects of a cognitive strategy to assist with solving simple addition and subtraction word problems. The subjects were four fifth- and sixth-grade students identified as having a learning disability. All of the participants received mathematics instruction in a self-contained special education classroom located in a large metropolitan area in the northeastern United States. Each participant was able to score 80% or higher on a simple addition and subtraction computation test; however, each participant scored between 40% and 70% on the baseline word problem test. Two undergraduate students enrolled in the special education program administered the intervention during a five-week treatment period.

The instruction was delivered one-on-one in a small classroom at the participants’ school. Twenty-five probes with seven addition problems and seven subtraction problems were used. Also, each probe contained six different word problem types (i.e., addition-joining, addition-combining, subtraction-separate, subtraction-comparison, subtraction-joining missing addend, and subtraction-combining). The self-regulated strategy involved the use of cognitive strategies in which the participant took on an active collaborator role that included scaffolding and Socratic dialogue. The self-regulation also involved self-assessment, self-recording, and self-instruction.

The instructional sessions were criterion-based and the subjects did not progress through the lessons until mastery in the current lesson was obtained. Each intervention
lesson was approximately 35-minutes in length and was administered two or three times per week. The procedures included (a) conferencing, (b) discussion of the problem-solving strategy, (c) modeling the strategy and self-instruction, (d) mastery of strategy steps, (e) collaborative practice of the strategy and self-instruction, (f) independent practice, and (g) generalization and maintenance components. Data collection involved three components: (a) word problems that were scored in two categories: number of correctly written equations and number of correctly written equations with correct answers, (b) strategy usage, and (c) social validation in which the students and their special education teachers provided perspectives about the intervention through interviews. The researchers used a multiple-baseline-across-subject and across two behaviors design to complete the study. During baseline data collection, the participants averaged 56% of their problems written correctly followed by the correct answer. Directly after learning the strategy, the participants scored an average of 95% accuracy on writing and correctly solving addition problems.

During the second phase of the intervention, the participants scored an average of 82% accuracy on writing and correctly solving subtraction problems. The data also indicated a successful effect during the generalization probes in which the participants scored an average of 88% accuracy on writing and correctly solving mixed addition and subtraction problems. The researchers noted that, although accuracy on solving word problems increased after the intervention, the participants were more apt to write the problem and circle words during the strategy than draw pictures. When measuring social validity through interviews, both participants and their teachers reported positive remarks.
Montague (1992) conducted a study that integrated cognitive and metacognitive strategies to assist individuals while solving mathematics word problems. Six middle school-aged students participated in the study. Their ages ranged from 12 to 14 years old. Each participant had been identified as having a learning disability and was enrolled in grades 6 through 8. The study followed a multiple-baseline-across-subjects design.

The participants received individual instruction during their regularly scheduled 55-minute special education period. The study continued for a period of four months; however, generalization took place during two independent months in the following school year. The intervention materials included scripted lessons, wall charts that listed (a) seven cognitive strategy steps, (b) a metacognitive strategy, and (c) the combined seven cognitive strategy steps and metacognitive strategy. The materials also included strategy study cards, 50 practice probes, and graphs to record both individual and group scores.

Baseline data were collected prior to the intervention and consisted of test scores and the time it took for each participant to complete the test. The first treatment focused on teaching the subjects the seven cognitive strategy steps and the metacognitive strategy. This treatment took place during three 55-minute sessions. The second treatment focused on using the strategies to solve mathematical problems with missing components. Both setting and temporal generalization followed the two levels of treatment.

Although the researcher noted the results to be effective for mathematics instruction during the middle school years for students with learning disabilities, replication of this study may be quite difficult. The Montague (1992) study took place over two academic school years. Although this was one of the strengths of the study, it
would not be possible at many urban schools due to high transiency rates among their students. Also, with the current high demands of the No Child Left Behind Act (2002), curriculum mandates, benchmarking periods, and accountably for mastering the curriculum, the length of the Montague study would likely be unrealistic in today’s educational context.

Montague, Applegate, and Marquard (1993) conducted a study to investigate the effects of a cognitive strategy to assist students with learning disabilities while solving mathematical word problems. The overall purpose of the investigation was to determine the effects of the strategy on the performance related to solving mathematics word problems among junior high school students with learning disabilities. The researchers noted that students with disabilities had not improved in mathematics problem solving as a result of typical classroom instruction in past investigations; therefore, an effective cognitive strategy was deemed to be necessary.

Seventy-two students with learning disabilities from four schools in the southeastern part of the United States of America participated in the study. Three treatment conditions were included within the study: (a) cognitive instruction only (COG), (b) metacognitive instruction (MET), and (c) a combined cognitive and metacognitive instruction (COG-MET). The participants were randomly assigned to one of the treatment conditions. The mean age within each treatment was 14.5 years (COG), 14.3 years (MET), and 13.9 years (COG-MET). Participants ranged from seventh to ninth grade. Nineteen participants were female, and 53 participants were male. Among the participants, 35 identified as Anglo, seven identified as African American, and 30 identified as Hispanic.
Two cycles of treatment were provided to the participants: (a) a seven-day unit of instruction incorporating a 10-problem test of mathematical word problems each day, and (b) a five-day unit of instruction incorporating one of the condition groups (i.e., COG, MET, or COG-MET). A posttest and a final maintenance test were administered after the two cycles of treatment. A repeated-measures design was used to test the effects of the treatment over time. The study took place during the last semester of the academic school year and lasted four months.

The COG treatment consisted of direct instruction of the seven processes used in the cognitive strategy: (a) Read, (b) Paraphrase, (c) Visualize, (d) Hypothesize, (e) Estimate, (f) Compute, and (g) Check. The MET treatment consisted of only the metacognitive process of the cognitive strategy. The COG-MET treatment consisted of both the COG treatment and the MET treatment.

Although all participants improved from pretest to posttest, the data indicated that only the COG treatment group reported a statistically significant higher posttest score when compared to the pretest score. The data also revealed that all participants scored significantly lower on the second maintenance measure compared to the first maintenance measure, which was administered five weeks after the posttest. The researchers concluded that students with learning disabilities (a) can benefit from strategy instruction for solving mathematical word problems, (b) may become more confident about their ability to solve mathematics after mastering a strategy, and (c) may increase self-esteem and motivation to solve mathematics word problems in the future.

Based on the review of literature, the use of cognitive strategies helps students who struggle with mathematics improve their ability to solve word problems. Among
this literature, students in elementary and middle school levels have shown positive gains in their readiness for mathematics problem solving, with the assistance of cognitive strategies alone. However, no study within the context of the cognitive strategies literature also involved the use of the CRA instructional sequence or a schematic-based diagram to assist students with mathematics problem solving.

**Contextualized Instruction**

Contextualized instruction is a teaching approach that incorporates real world examples (i.e., hands-on projects). More specifically to mathematical problem solving, the approach involves word problems developed from real-life situations and materials from the environment, and subsequently transfers the problem solving to a real-life activity (Bottge, 1999).

Bottge (1999) conducted a study to examine the difference in student outcomes between basal textbook instruction and contextualized mathematics instruction when teaching mathematical problem-solving skills. The researcher of this pretest-posttest experimental design sought to answer two questions: (a) does contextualized video instruction improve the skills of students while solving computation, word, and contextualized problems, and does the instructional method foster transfer of task, and (b) does word problem instruction improve the skills of students while solving computation, word, and contextualized problems, and does the instructional method foster transfer of task?

Sixty-six eighth-grade students who attended a middle school in the rural upper-Midwest participated in the study. Seventeen students attended remedial math, seven qualified for special education services in the area of mathematics, and the remaining
students were recommended to attend the remedial mathematics class the following year. Two licensed teachers were trained to implement the intervention. One middle school mathematics teacher provided the word problem basal instruction, and one special education teacher provided the contextualized word problem instruction. The intervention lessons took place in the regularly scheduled classrooms.

To collect data, three measures were used: (a) a fraction computation test, (b) a word problem test, and (c) a contextualized problem test. These assessments were administered immediately following instruction. Also, a transfer test was conducted 10 days after the posttests.

The experimental group treatment consisted of two video-based, contextualized mathematics problems. The participants viewed the video as a whole group and completed assigned problem-solving tasks that were identified in a folder provided by the classroom teacher. Students worked in groups to solve the given problems and discuss their methodology and results to the class. After the successful completion of the two video lessons (on the tenth day), the teacher asked a series of what if questions to continue the thinking process of solving mathematics word problems. The control group treatment involved the provision of word-problem instruction through a basal mathematics textbook design. The instructional approach involved a series of standard single- and multistep word problems that corresponded with the questions in the video-based instructional approach. The methodology for both instructional approaches followed the same pattern: review, presentation of new skill, guided practice, feedback, independent practice, and review.
A qualitative measure was also used in this study. The students were provided an inquiry problem to be solved. After the formal instruction was provided and posttest administered, each group was asked to complete the same task (i.e., use your skills to plan and build a skateboard ramp). Students then used their skills from the instructional lessons to build a real skateboard ramp with wood using power tools located in the industrial technology room. To ensure fidelity of treatment, scripted lessons were provided to both teachers, a two-hour training session was conducted prior to instruction, procedures and instruction were reviewed twice a day with each teacher, and the researcher observed 26 of the 40 lessons. Also, the student work folders where designed by the researcher for the purpose of helping students focus on the skill of the day. Additionally, six class sessions were videotaped for analysis.

Three two-way analyses of covariance tests were conducted to identify differences on computation, word problem, and contextualized posttests, with each pretest serving as the covariate. The types of instruction (i.e., word problem and contextualized problem) were the factors being investigated. A two-way analysis of variance was used to assess the difference in means between the instruction type and class groups on the transfer task. A qualitative inquiry design was used to collect information on the skateboard ramp activity.

The results, although mixed, indicated that the practice of situating problems in a contextualized manner supports instruction of solving word problems. Significant differences were found on both the contextualized problem test and the transfer task for conceptualized problem solving. However, there were no significant differences between groups when comparing the computation and word problem tests. Bottge (1999) noted
that although the data support contextualized instruction, the results may have been influenced by the non-random assignment of participants in the two groups. Also, the students in the contextualized problem group did not begin their transfer activity the first day due to constant arguing and unwillingness to work together. The researcher noted that contextualized problem solving is important, and most students benefit from real-life examples when solving mathematical word problems. Although the results did not indicate a significant difference between all explored areas, the researcher was accurate by noting this may be due to the unbalanced or non-random design of the study. This flaw represents a typical challenge encountered when working with public schools during instructional hours. One of the study strengths is its focus on ensuring that classroom teachers recognize the importance of contextualized mathematical word problems while teaching students to solve these problems. Teachers who understand the rationale for instructional procedures are more apt to implement them with fidelity.

Bottge, Rued, Grant, Stephens, and Baroque (2010) conducted a study to examine the effects of incorporating anchored problem solving and computation instruction in middle school context-rich learning environments. Two versions of anchored instruction were used to teach students with learning disabilities in mathematics how to solve mathematical word problems (i.e., teacher-delivered anchored instruction and a computer-based instructional module). The researchers of this pretest-posttest cluster randomized experiment investigated whether combining an Enhanced Anchored Instructional (EAI) method with formal computation instruction would improve a students' ability to solve fraction computation compared to using a computer-based instructional module.
Fifty-four sixth through eighth graders who attended three middle schools near a large urban area in the Pacific Northwest participated in the study. All participants received their mathematics instruction in self-contained special education settings. Each school had one special education teacher providing the interventions. Two experimental interventions were provided at each school: (a) informal instruction and EAI and (b) formal instruction (i.e., teacher directed instruction) and EAI. The intervention took place for 24 days during class periods that lasted approximately 50 minutes.

The informal instruction consisted of three Enhanced Anchored Instruction (EAI) units for adding and subtracting fractions. The units included (a) watching an introductory EIA video called *Bart's Pet Project*, where students were provided eight days to complete the same challenge Bart faced in the video, (b) *Fractions of the Cost*, where students used EIA information to build a skateboard ramp over a six-day time period, and (c) *Hovercraft Challenge*, where students again used EIA (i.e., hands-on activity) to create a roll-over cage and PVC pipe to construct a hovercraft. The additional computer-based instructional program provided additional instructional activities and scaffolds or visual cues to assist the students with completing their projects.

The formal instruction also consisted of three units. The first two units were the same as the informal instruction (i.e., *Fraction of the Cost* and *Hovercraft Challenge*). However, *Bart's Pet Project* was replaced with teacher provided explicit instruction on addition and subtraction fraction problems. The teacher directed instruction was paired with a computer-based program called *Fractions at Work*.

To collect data, four measures were used: (a) two researcher-developed criterion-referenced tests (i.e., Fraction Computation Test and Problem Solving Test) and (b) two
standardized norm-referenced achievement measures (i.e., Iowa Test of Basic Skills Computation Measure and Iowa Test of basic Skills Problem Solving and Data interpretation Measure). These measures were administered pre- and post- intervention. The measures were used to assess participant ability to solve fraction computation problems and mathematical problem solving.

A series of analyses of variance with repeated measures was conducted to determine the conditions of the pre- and posttest design. There was no significant difference between the formal group ($M = 3.17$) and informal group ($M = 1.67$) on the Fraction Computation Pretest. However, the analysis revealed that the students in the informal group scored significantly higher on the posttest, whereas the students in the formal group did not demonstrate a significant difference from pre- to posttest (i.e., formal $M = 30.24$ and informal $M = 17.72$).

The data also revealed there was no difference between the formal group and informal group on the Problem Solving Pretest. Although both groups showed growth between pretest and posttest scores, the informal group showed a significant improvement.

There was no significant difference between scores on either Iowa Test of Basic Skills subtest. There was also no significant gain on either pre- to posttest score. Additionally, there was no additional benefit from participating in either group (i.e., formal and informal).

There were a few challenges with this study. First, all three teachers taught both interventions, which may have resulted in an unintentional carry-over effect. It is possible that part of one intervention protocol was used in the other because it was part of
the teacher’s repertoire. Second, although student scores improved from pretest to posttest, the researchers note that the improvement on the posttest was only half of the possible points earned. Additionally, it may be difficult to generalize the findings of this study to students with mathematics disabilities who received instruction outside of a self-contained special education classroom.

Hasselbring and Moore (1996) conducted a study to examine the development of mathematical literacy through the use of contextualized learning environments. Thirty-two students in first through third grade participated in the study. All participants were enrolled in two inner city schools located in Nashville, Tennessee. Each student received specialized education services for mathematics instruction. Participants were eligible for special education services under Serious Emotional Challenges, Specific Learning Disability, and Mild Intellectual Disability categories. Students in the comparison group received mathematics instruction as defined by the Tennessee Basic Skills Curriculum. Both groups (i.e., treatment and comparison) received instruction during 30-minute class sessions.

Three different contextualized learning environments (i.e., anchored instruction) were used to teach students with learning challenges how to solve mathematical problems. The first anchor video was about a boy named Jeff who was newly enrolled in school. In the video, Jeff is seen wandering around the school and stated that he was afraid he would get lost. Participants were asked to create a school map with several subtasks (i.e., counting the number of classrooms, creating a computer-based map of the school, measuring the school and classrooms, and creating a map of the school on grid paper – to scale). The second anchor video was an extension of the first video; however,
in this video Jeff faced a new problem – struggling with his daily class schedule. Participants were asked to create a new daily schedule by recording current class schedules throughout the school. The third anchor video was about a girl named Michelle who ordered a toy she saw on TV; however, Michelle was disappointed when the toy arrived. Participants were asked to create their own video discussing money handling skills in correlation to consumer reports.

To collect data, five measures were used: (a) the Test of Early Mathematical Ability (2nd ed.), (b) the Culture Free Self-Esteem Inventory, (c) Developmental Problem-Solving Assessment Time-telling Skills and Handling Money Skills, (d) measurement and Counting Performance-based Assessment Task, and (e) a student interview. The measures were administered pre- and post- intervention. Mean raw score at pretest and posttest, along with level of significant change within group from pre- to posttest was recorded for each measure.

Hasselbring and Moore (1996) found that there was a significant difference between pre-intervention scores (M = 69.61, SD = 6.11) and post-intervention scores (M = 80.33, SD = 5.86) using the Test of Early Mathematical Ability (2nd ed.), noting that participant math quotient scores following contextualized learning environments instruction improves student ability to problem solve (t17 = -10.73, p < .0001). However, participants who did not receive the contextualized learning environments (i.e., comparison group) also obtained a significant difference (t5 = -6.50, p = .01) between pre-intervention scores (M = 79.17, SD = 5.85) and post-intervention scores (M = 83.50, SD = 6.25).
A paired $t$-test was used to determine the degree of difference between participant perceptions on their ability of mathematics within the treatment group. Pre- and post-scores from the Culture-Free Self-Esteem Inventory (2nd ed.) was used for this measure. Four subgroups were assessed within this measure: (a) general ability, (b) social skills, (c) academic skills, and (b) parental perceptions. On two measures (i.e., general and academic) there was a significant increase from pre- to post- intervention. On the other hand, there was no significant difference on the social and parental pre- and post-intervention measures.

Similar to the Test of Early Mathematical Ability (2nd ed.) measure, both groups (i.e., treatment and comparison) demonstrated a significant increase from pre- to post-intervention related to student abilities to solve problems related to time and money (i.e., Developmental Problem-Solving Assessment Time-telling Skills and Handling Money Skills). Hasselbring and Moore noted that the findings of this study support the use of anchored instruction to assist students with both formal and informal mathematical knowledge. Additionally, contextualized learning environments support real-world examples of problem-solving to assist in future mathematical situations.

**The Use of Language in Word Problem Instruction**

Mathematical problem solving or word problems are presented in text or narrative rather than in number notation. Word problems, also referred to as story problems, involve combining one’s knowledge of the five essentials of literacy (i.e., phonemic awareness, phonics, vocabulary, fluency, and comprehension), mathematical relations, basic numerical skills, and mathematical strategies in order to solve a mathematics problem presented in sentence or paragraph structure (Griffin & Jitendra, 2009).
Mathematical problem solving also incorporates real-life mathematical situations where application of prior knowledge and vocabulary development is required in order to find a solution (Hudson & Miller, 2006).

Stein (1998) conducted a study to examine the importance of language development and the use of language during mathematics word problem instruction. Specifically, she examined the difference between two teaching approaches: (a) a task specific, procedural method, and (b) a teacher-directed, explicit strategies method. The participants of the study included fourth graders enrolled in an urban public school located in the Mid-Atlantic region of the United States. The procedures began with the administration of a pretest to assess the students’ ability to solve grade-level math facts, along with a pretest to assess the students’ ability to solve mathematics word problems.

Then, explicit strategy instruction lessons were provided daily. The lessons consisted of solving mathematics word problems, rewriting math word problems to be more concise, using simpler number facts, and using a part-whole relationship. During the lessons, a four-step problem-solving plan was put in place: (a) tell the information, (b) show the algorithm, (c) solve the problem, and (d) check the answer. The strategy was used with teacher-made materials for 20 days. At the conclusion of the 20th lesson, a post-test was administered to assess the students’ ability to solve mathematics computation and word problems.

The results of the study revealed that students scored considerably higher on the computation assessments when compared to the assessment that used language. Stein (1998) also found students’ abilities to solve word problems increased after the use of the teacher-directed explicit lessons in which teacher language was consistent. Although
Stein obtained positive results in the study, the overall discussion of procedures was weak. The narrative related to research procedures only informed the reader of the use of teacher-made materials. However, details about the materials were not discussed or explained. Thus, replicating this study would be very difficult.

Leong and Jerred (2001) conducted a study to examine how children understand and solve mathematics word problems. Specifically, they inspected the effects of three characteristics of word problems as well as related features needed to solve them: (a) consistency and/or inconsistency in elementary mathematics word problems, (b) adequacy or inadequacy of linguistic information within the mathematics word problems, and (c) cognitive and memory tasks of the participants as they performed the mathematics word problems. They also interviewed 12 students to understand the verbal strategies students use to solve the mathematics word problems.

Ninety-one students enrolled in grades three, four, and five participated in the study. The students attended school in western Canada. Twenty-four mathematical word problems that involved 12 consistent and 12 inconsistent problems were used. Leong and Jerred defined word problem consistency as information in the word problem being presented in the order that problem-solvers prefer, in other words, accessible in the order in which the problem must be written in numeric sense to be solved. Inconsistency was defined as information presented in random patterns that conflict with the order of operation.

The students were administered the 24 problems in a quiet room within the school. Students were asked to solve each problem. Correct responses and incorrect responses were scored. The study assessment also involved 36 mathematics problems
using adequate language and inadequate language. The students were asked to classify each problem with three codes: (a) JE for just enough information, (b) NE for not enough information, and (c) NN for having not needed information. If the students classified a problem as having just enough information, they were to solve the mathematical word problem and record an answer. If the students classified a problem as not having enough information, they were asked to write down a few words that would make the mathematical word problem complete. If the student classified a problem as having non-needed information, the student was asked to cross out the excess information.

Prior to the study, the students were assigned to math ability groups: (a) less able and (b) more able. Groups were compared using various assessment tools that were used to measure reading, comprehension, vocabulary, mathematics concepts, and working memory skills and abilities. With these data, an analysis of variance and an analysis of covariance were run.

The results indicated that although consistency of language within mathematical word problems plays an important function within the learning process, adequacy of information had a greater effect on whether students had the ability to solve word problems. Also, the data indicated that students considered less able did more poorly than their more able peers on both types of mathematical word problems (i.e., not having enough information and having non-needed information) at each grade level.

These data supported building language consistency and adequacy through scaffolding. Leong and Jerred (2001) suggested that consistency in language information is important for learners of mathematics word problem-solving abilities. They also maintained that when language within a word problem is inconsistent, many students will
struggle with performing the task. The researchers also stressed the idea of language adequacy while teaching mathematical word problem skills.

When the language within the mathematic word problem is adequate, the information needed to solve the word problem is easily available to the solver. Problems that are classified as inadequate are those with too much or not needed information. This inadequacy within the mathematical word problem creates additional barriers that students who are just learning the solving process, should not encounter. Leong and Jerred (2001) also noted that if students still require schema-based instructional strategies for solving word problems, the language used should be consistent and adequate. Hence, when teaching students with identified mathematics learning disabilities or those at-risk for mathematics failure, it may be beneficial to use instructional approaches that take into consideration the language within the mathematical word problems.

Xin, Wiles, and Lin (2008) conducted a study to examine the concept of story grammar and the effect of reading comprehension on the solving process of mathematical word problems. Five fourth- and fifth-grade students participated in the study. All participants had or were at-risk for having an identified learning disability in the area of mathematics. The two male and three female participants ranged in age from 10 years 3 months to 11 years. All five participants were Caucasian. The students received the intervention after their classroom teachers referred them for an after-school academic program. The intervention sessions for the study took place after school hours in either a vacant conference room or classroom.

An adapted multiple-probe-design-across-participants was used to conduct the study. The intervention sessions were conducted three times a week and lasted for
approximately 20 to 35 minutes. Although students had to compute mathematical equations after determining the necessary information from the word problem, calculators were provided to the participants to accommodate for computation deficits. A teaching script was provided to the implementer of the strategy to decrease any threat to the integrity of the independent variable. Forty percent of the instruction was observed by two research assistants using a checklist to measure fidelity of the treatment (95% agreement across all observed sessions). Four problem types were addressed in the intervention: part-part-whole (PPW), additive compare (AC), equal group (EG), and multiplicative compare (MC). Two parts of instruction were also provided: (a) problem structure instruction and (b) problem solution instruction. The instructional method began with word problems that contained no unknown information to provide the participants ample learning time to build complete representation of problem structure and type. This also created a bridge between the presented problem schema and the visualization of mathematical relations.

Students were taught and instructed to use a researcher-developed checklist that included the mnemonic device DOTS to represent the order of operations for solving mathematical word-problems. The steps of DOTS include (a) detect the problem type, (b) organize the information to express mathematical expressions, (c) transform the diagram into a mathematical equation, and (d) solve the equation. Story grammar questions were also designed to assist participants in understanding the word problem. The researchers’ theory behind teaching story grammar was that doing so assists students in retelling the stories and identifying the elements embedded within those stories. The researchers also noted that when elements and patterns of story are taught, key
information is more easily identified. To assist with the identification of elements, prompt cards were also constructed and used during the intervention. Hence, although the primary purpose of the study was to examine the use of teaching story grammar to assist in solving word problems, cue cards, a first letter mnemonic (DOTS), and schema-based instructional approaches were also incorporated into the study.

The results showed positive growth in problem-solving skills for all participants. During baseline performance, the mean for solving addition and subtraction word problems across three of the participants was 21%, 28%, and 28% accuracy. After the first intervention, all three participants scored 100% correct. At the end of the intervention and during post-intervention criterion testing, the results indicated a 15%, 58%, and 58% increase from baseline scores. Data from the last two participants who engaged in multiplication and division word problem solving also reflect a positive trend. During baseline performance, the median correct for the two participants was zero. During post-intervention tests, Participant One scored 100% representing a 42% increase from instructional probes and a 97% increase from baseline. Participant Two also demonstrated similar improvement (i.e., 100% correct on post-intervention test and 100% increase from baseline). While teaching pre-algebraic concepts and skills, the intervention continued to result in an increase of performance; Participant One increased from 33% to 67%, Participants Two and Five increased from 0% to 100%, and Participants Three and Four increased from 0% to 67%.

The overall gradual increase of skill from baseline performances to post-intervention assessments reflects positive results. Other positive aspects to the study included the limited amount of time needed to provide the intervention, the idea of
reinforcing story grammar in word problem-solving, and the combined use of previous researched-based best practices for teaching mathematics (i.e., schema-based instruction and mnemonic devices).

**Review of Literature Summary**

The trend of providing research-based instruction to students with disabilities has gained momentum over the past few years. Support for this trend is evidenced in both the No Child Left Behind Act (NCLB, 2001) and the Individuals with Disabilities Education Improvement Act (IDEIA, 2004). The No Child Left Behind Act mandates that all students will perform proficiently at grade level on academic standards by 2014. The Individuals with Disabilities Education Improvement Act (IDEIA) mandates that students with disabilities have access to and progress through the general education curriculum. IDEA also requires the use of research-based instructional practices for teaching students with disabilities. Thus, educators are challenged to provide high quality instruction within their respective academic settings.

One of the most challenging and important areas of the mathematics curriculum for many students is solving word problems. Based on this review of literature, several instructional practices emerged as having positive effects on students’ ability to solve these complex problems. These effective practices included the C-R-A instructional sequence, schema-based diagrams, and cognitive strategies. The C-R-A instructional sequence focuses on moving students through three stages of mathematical development: (a) concrete or three-dimensional hands-on manipulation, (b) representational or the use of two-dimensional drawings, and (c) abstract. Schema-based diagrams are two-dimensional drawings that assist students in the problem-solving process. Cognitive
strategies stress the importance of language development and the process (i.e., procedural steps) to solve mathematical problems. It is interesting to note that in many of the studies included in this review, explicit-direct instruction was identified as an effective approach for teaching students with learning disabilities or those who were struggling with mathematics curricula. Specifically, explicit instructional procedures were used to teach students how to use the C-R-A sequence, schema-based diagrams, and cognitive strategies. In spite of the documented benefits noted in the literature for use of the C-R-A sequence, schema-based diagrams, and cognitive strategy instruction, reports related to student performance with word problems clearly indicate a need for continued work in this area. Additional research is needed to improve and build upon existing knowledge related to this challenging aspect of the school curriculum.

Only four studies (Harris et al., 1995; Maccini & Hughes, 2000; Maccini & Ruhl, 2000; Morin & Miller, 1995) were identified that combined the use of C-R-A and cognitive strategies and only one study (Xin et al., 2008) was identified that combined the use of schema-based diagrams and a cognitive based strategy. The remaining studies in this review of literature investigated the effectiveness of word problem interventions in isolation. Thus, it appears that no one has developed and investigated a word problem intervention that integrates C-R-A, schema-based diagrams, and cognitive strategies. It is possible that combining these three best practices will result in a robust intervention in terms of student learning.

The current research involved the integration of the three interventions that emerged from this review of literature as being especially beneficial (i.e., C-R-A, schema-based diagrams, and cognitive strategies), for teaching students with learning
difficulties to successfully solve mathematical word problems. A researcher-constructed first letter mnemonic strategy was used to facilitate the integration of these interventions. Thus, the current study built upon past research and may add new knowledge related to word problem instruction. The goal of this study was to create and implement an effective and efficient intervention to assist elementary students with learning disabilities and elementary students receiving Tier 2 intervention within a Response-to-Instruction service model in solving mathematical word problems. The goal was to serve as a springboard for additional research related to use of the intervention in elementary settings to decrease the continuation of poor word problem performance in middle and high school settings as was evidenced in many of the studies included in this review of literature.
CHAPTER 3

METHODOLOGY

The purpose of this research was to examine the effects of a combined problem-solving strategy (i.e., READER strategy) on word problem performance of students with disabilities in mathematics and students who are at-risk to fail in mathematics. To address this purpose, the following research questions will be answered:

- Research Question 1: Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program improve their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

- Research Question 2: Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program maintain their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

- Research Question 3: Do students receiving Tier 2 intervention within a Response-to-Intervention program generalize their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

- Research Question 4: Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program report high satisfaction levels related to the components of a combined problem-solving strategy and associated instruction?
• Research Question 5: Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program report a positive attitude towards solving mathematics word problems after receiving explicit instruction in a combined problem-solving strategy?

In this chapter, an outline of the methodology used in this research is discussed. There were two parts to this research. Part One involved the use of a single subject design to answer the research questions relevant to students with mathematics learning disabilities. Part Two involved the use of a group design to answer the research questions relevant to students receiving Tier 2 intervention within a Response-to-Intervention program.

This chapter is organized into eight sections. First, the two designs used in this research are discussed. Second a summarization of research participants is provided. Third, the setting of the research is discussed. Fourth, the measures and related instrumentation are presented. Fifth, the research materials are discussed. Sixth, the procedures for both parts of the research are summarized in detail. Seventh, interscorer reliability and fidelity of treatment are discussed. Finally, the treatment of data is described.

**Research Designs**

**Part One: Single Subject Design**

A multiple-probe-across-participants design (Gast, Skouge, & Tawney, 1984) was used to examine the effects of the combined problem-solving strategy on word problem performance of students with disabilities in mathematics. The independent variable was methodically and consecutively introduced to one participant at a time per the parameters
of a multiple probe design. Baseline data were collected through ongoing probes to ensure the participants were not improving their word problem skills prior to introducing the independent variable (Gast, Skouge, & Tawney, 1984). Once a stable pre-intervention baseline level was achieved, the intervention lessons began with the first participant. The remaining participants continued to receive intermittent baseline probes. After the first participant reached mastery on the first three intervention lessons (i.e., 80% or higher), the second participant began to receive the intervention lessons while the remaining participant continued receiving intermittent baseline probes. This sequence of instructing and probing continued until all participants had been introduced to the independent variable.

**Part Two: Group Design**

A group design was used to measure the effectiveness of the combined problem-solving strategy for students at-risk for failure in mathematics. These students were receiving Tier 2 intervention in mathematics from the school’s math strategist. In this design, two groups participated: (a) the treatment group and (b) the comparison group. Both groups received a pretest. Once pre-testing had been administered, the treatment group received 17 mathematics lessons lasting approximately 30-minutes each, using researcher-developed problem solving lessons. The comparison group received 17 mathematics lessons lasting approximately 30-minutes using the core curriculum intervention (i.e., *Investigations*) used at the school. At the completion of the 17 lessons, both groups took a posttest. Two weeks after the posttest was administered a maintenance test and generalization test was provided to participants in both groups. A two-by-four factorial ANOVA with repeated measures on time was used to determine if
there was a significant difference between the two groups (i.e., treatment and comparison) over time (i.e., pretest, posttest, generalization, and maintenance). This allowed the researcher to determine the effectiveness of the combined problem-solving strategy instruction in comparison to the core curriculum intervention used at the school.

**Participants**

There were three elementary school-aged participants involved in Part One (i.e., single subject design) of this research and 21 elementary school-age participants in Part Two (i.e., group design) of this research. There were two instructional implementers who delivered the word problem lessons to the participants (i.e., learning disability teacher implemented Part One of the research and mathematics strategist implemented Part Two of the research).

**Part One: Single Subject Design**

There were two males and one female involved in Part One of this research. The ages of the participants ranged from 10.3 to 11.10. Of the three participants, one was enrolled in fourth grade and two were enrolled in fifth grade. Participant ethnicities included one Black/African-American and two Hispanic/Latino. All three participants had specific learning disabilities in mathematics as determined by the school’s Multi-disciplinary Team (MDT). Standard Scores (SS) in mathematics ranged from 61 to 74, using the Wechsler Independent Achievement Test (WIAT-2) and from 70 to 76 using the Kaufman Test of Educational Achievement. All three participants received a free or reduced lunch indicating low socio-economic status. Table 1 displays a detailed summary of these demographic data for each participant.
Table 1

Single-Subject Design: Demographic Information

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One</td>
</tr>
<tr>
<td>Gender</td>
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</tr>
<tr>
<td>Age</td>
<td>10.3</td>
</tr>
<tr>
<td>Grade</td>
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</tr>
<tr>
<td>Ethnicity</td>
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</tr>
<tr>
<td>Disability</td>
<td>SLD</td>
</tr>
<tr>
<td>Mathematic Achievement Score</td>
<td>76(^a)</td>
</tr>
<tr>
<td>Language Assessment Score (LAS)</td>
<td>---</td>
</tr>
</tbody>
</table>

Note: \(^a\)Kaufman Test of Education Achievement Test (2\(^{nd}\) ed.); \(^b\) Wechsler Independent Achievement Test (2\(^{nd}\) ed.); \(^c\) overall English proficiency score.

The specific learning disabilities teacher implemented all instructional lessons.

The specific learning disabilities teacher was White/Caucasian and female. The specific learning disabilities teacher holds a Masters degree in special education. During the time of the study, the specific learning disabilities teacher was beginning her first year of teaching experience.

Part Two: Group Design

There were 21 participants involved in Part Two of the research: (a) 11 participants in the treatment group and (b) 10 participants in the comparison group.

There were 14 males and seven females. The ages of the participants ranged from 8.2 to 10.10, with a mean age of 8.9. All 21 participants were enrolled in the third grade.

Participant ethnicities included six Black/African-American, nine Hispanic, one White/Caucasian, two Asian, one Pacific Islander, and two Biracial. All 21 student
participants were eligible for Tier 2 interventions within the Response-to-Intervention program in mathematics. All 21 students received a free or reduced lunch indicating low socio-economic status. Table 2 displays a detailed summary of the demographic information for the treatment group and comparison group.

Table 2

*Group Design: Demographic Information*

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Treatment</th>
<th>Comparison</th>
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</thead>
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<td>Male</td>
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<tr>
<td>Female</td>
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<tr>
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<td>1</td>
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<tr>
<td>Biracial</td>
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<tr>
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<tr>
<td>White</td>
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<td>0</td>
</tr>
<tr>
<td>Mean Age</td>
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<td>8.6</td>
</tr>
<tr>
<td>Mean State Assessment Results</td>
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<td>65.00</td>
</tr>
</tbody>
</table>

*Note:* Mean State Assessment Results report third trimester mathematics performance from 2009-2010 on state mathematics curriculum benchmarks.
The mathematics strategist at the participating school administered all instructional lessons for the treatment group. The mathematics strategist is a White/Caucasian, female teacher with eight years experience in elementary education. She holds a Bachelors Degree in K-8 education, a Masters Degree in K-12 special education, along with an endorsement in teaching English as a second language.

Setting

The research took place within an elementary professional development school (PDS) located in a large metropolitan school district in the southwestern region of the United States. At the time of the study, the elementary school was located on the campus of a large public university and served students from a wide range of backgrounds and educational experiences. Designated as a Title I school, 88.1% of the student body qualified for Free or Reduced Lunch (FRL) and all students zoned to attend the neighborhood-elementary PDS resided in neighborhood apartment complexes. These latter variables related to economic status, may have contributed to the school’s 52.1% transiency rate. Approximately 46% of the students attending the elementary school were classified as Limited English Proficient (LEP), and 4.6% of the students had been identified as requiring special education services. The prekindergarten through fifth-grade elementary school served an ethnically diverse student population that included Asian/Pacific Islander (6.5%), Hispanic (58.6%), Black/African American (21.0%), and White/Caucasian (13.6%).

Part One: Single Subject Design

Part One of the research took place in the special education resource room, located in the interior hallway of the school. The interior hallway connected two sections
(i.e., north and south) of the school. Each section housed three grade levels. A kidney-shaped table was located near the front of the classroom and was used for instructional delivery. The table was positioned so that participants could easily view the classroom whiteboard and the adjacent bulletin board. Participants sat at the table during all instructional lessons. The special education teacher either sat at the table or stood at the whiteboard or bulletin board depending on the specified instructional endeavor. Only participants in the study were in the special education resource room at the time of lesson delivery to avoid distractions associated with other students engaged in other instructional activities.

**Part Two: Group Design**

Part Two of the research took place in a third-grade classroom located in the north section of the school. Each student participant sat at a desk. The desks were positioned so that participants could easily view the classroom whiteboard and the adjacent bulletin board. The math strategist stood near the whiteboard or bulletin board depending on the specified instructional endeavor. Only participants in the study were in the classroom at the time of the lessons to avoid distractions associated with other students engaged in other instructional activities. An ELMO projector and screen was used to project the word problems used during the describe and model component of the instructional lessons.

**Instructional Materials**

**Scripted Instructional Lessons**

The same researcher-constructed instructional lessons were used for both Part One (i.e., single subject design) and Part Two (i.e., group design) of this study. The 17
lessons were formatted using the Strategic Math Series as a model (Mercer & Miller, 1991-1994). The lessons were scripted to minimize the possibility of teacher effect and to gain greater internal validity, and the readability level. Specifically, each scripted lesson included five instructional components: (a) advance organizer, (b) describe and model, (c) guided practice, (d) independent practice, and (e) fluency practice. Schema-based diagrams (i.e., addition and subtraction) were incorporated into the first five lessons to assist students with conceptual understanding. The schema-based diagrams are pictorial representations of an addition problem (see Appendix A) and a subtraction problem (see Appendix B). Student participants used concrete objects (i.e., manipulative devices) to represent the addends or subtrahends of each problem presented on the learning sheets. Manipulation of the concrete objects based on the computation process served as visual cues for solving addition and subtraction problems.

The advanced organizer component of the scripted lesson included (a) lesson goal, (b) rationale for the lesson, (c) review of past lesson performance (after the first lesson), and (d) a few words of encouragement. The describe and model component of the lesson included a description of what the teacher says and does while demonstrating how to solve word problems. The guided practice component of the scripted lessons included a description of how the teacher provides graduated levels of support related to solving the problems. The independent practice component of the lesson included a description of what the teacher says as the students begin independent practice. The fluency practice component of the lesson included directions for administering the Computation Review Minute (see Appendix C for sample lesson).
A graduated word problem sequence (Mercer & Miller, 1991-1994; Miller & Mercer, 1993) was used as an over arching structure for the word problem lessons. During the first five lessons, minimal linguistic representation or words were used. See Appendix D for a display of the increasingly complex stages in the sequence. Each of the first five lessons focused on one concept; Lessons 1 and 2 focused on addition, Lessons 3 and 4 focused on subtraction, and Lesson 5 focused on discriminating between addition and subtraction problems.

A concrete-representational-abstract instructional approach was incorporated into the instruction. During Lessons 1 through 5, students used three-dimensional figures or manipulative devices and schema-based diagrams (i.e., drawing) for the concrete and representational levels of instruction. Lessons 2 and 4 initiated the use of the words in problems, but only included one word following each number (see Appendix D). These lessons also included a mix of horizontal and vertically written problems that used both addition and subtraction.

Lessons 6 and 7 incorporated basic numeric facts embedded into simple sentences. Some sentences followed a vertically written math problem; whereas, other sentences were written in a horizontal sentence format (see Appendix D). Again, these lessons used a mix of both addition and subtraction problems. Lessons 1 through 7 also integrated the use of a schema-based instructional approach. The schema-based diagrams (see Appendices A and B) were used as a visual cue to assist students with determining whether to use addition or subtraction while solving mathematical word problems.

Lesson 8 included an introduction of the READER Strategy (see Appendix E). Students were taught the mnemonic device steps that were designed to assist in solving
mathematical word problems. Lessons 9, 10, and 11 included a combination of
linguistically written word problems with a combination of standard form numerals and
numerals written in word form embedded within the problem. The READER Strategy
was used and displayed during each of these lessons. During this phase of the
instructional sequence, students began the abstract level instruction, using the schema-
based strategy for guidance, only if needed.

Lessons 12, 13, and 14 included only linguistically written word problems. These
lessons also contained extraneous information (i.e., additional information that is not
relevant to solving the problem). Both addition and subtraction problems were integrated
through these lessons. Additionally, during lessons 12 through 14, the teacher continued
to fade out the use of the schematic diagrams and encouraged students to rely on the use
of the mnemonic strategy for assistance in solving mathematical word problems.

Lessons 15, 16, and 17 involved the use of word problems written only in
paragraph format. Similar to Lessons 12 through 14, Lessons 15 through 17 contained
extraneous information. However, the length of each word problem varied (i.e. three to
seven sentences) and the amount of extraneous information became more in-depth (see
Appendix D). Additionally, each lesson incorporated different instructional
methodologies, which included (a) schematic diagrams, (b) concrete-representational-
abstract sequence, (c) addition or subtraction, and (d) a mnemonic device (see Appendix
D).

**Learning Sheets**

There were 17 researcher-constructed learning sheets. Each learning sheet
included 15 problems: three describe and model problems, three guided practice
problems, and nine independent practice problems. Each lesson component was identified with the appropriate heading on the learning sheet. The readability level of the included problems was controlled at the 3.5 to 4.5 grade levels per the flesh Kinkaid measure even though the problems were read aloud to the participants. See Appendix F for a sample learning sheet.

**Student Progress Chart**

There were two graphs included on the Student Progress Chart (see Appendix G). The top graph was the Percentage Graph. It included vertical lines to represent the pretest, learning sheets, posttest, and maintenance measures. The horizontal lines represented percentage scores from 0% to 100%. The top graph was used to display the student’s percentage scores earned throughout the instructional process. The bottom graph was the Rate Graph. It included vertical lines to represent one Computation Review Minute per lesson. The horizontal lines represented the number of digits written per minute ranging from 0 to 50. The bottom graph was used to display the number of correct digits and number of incorrect digits earned on a one-minute facts review probe. The bottom graph was used to display the student’s rate performance throughout the instructional process. At the end of each lesson, the teacher and student participant recorded both scores together on the appropriate progress chart. Immediate scoring took place throughout the lessons. The Student Progress Chart was adapted from Mercer and Miller’s (1991-1994) *Strategic Math Series*. Permission was granted to use this chart (see Appendix H and I).
READER Strategy Cue Card

The READER Strategy Cue Card was a sheet of paper that contained the mnemonic device for solving mathematical word problems. The mnemonic device steps were written down the center of the page (see Appendix E). The READER Strategy Cue Card was provided to the student participants during Lesson 8. Student participants were allowed to use the READER Strategy Cue Card as a reference throughout the completion of the learning sheets.

Learning Contract

A Learning Contract was provided to each student participant prior to lesson one. The contract was used to formulate an agreement between the student participant and the teacher. The teacher section of the contract focused on the teacher maintaining high standards, providing quality instruction, and displaying a positive attitude during instruction. The student participant section of the contract focused on coming to class ready to learn, willing to try a new strategy to assist in solving mathematical word problems, and displaying a positive attitude during instruction (see Appendix J). The Learning Contract was adapted from Mercer and Miller’s (1991-1994) Strategic Math Series. Permission was granted to use this chart (see Appendix H and I).

Computation Review Minute

The researcher-constructed Computation Review Minute was used for fluency practice, and was administered at the end of each lesson. The Computation Review Minute was designed to help students maintain accuracy and fluency related to solving computation facts. Forty-two addition and subtraction problems were included on the Computation Review Minute. The problems were written in vertical format. These
Computation Review Minutes, or practice minutes, were used to reinforce the computation skills needed to solve the mathematical word problems accurately (see Appendix K).

Instrumentation

Screening Test

The researcher-constructed Addition and Subtraction Screening Test was administered prior to implementation of the intervention. The screening test was designed to measured students’ addition and subtraction skills. Twenty addition and subtraction problems were included on the Addition and Subtraction Screening Test (see Appendix L). The problems were written vertically. Student scores from the Addition and Subtraction Screening Test assisted the researcher in determining student eligibility to participate in the study. Participants met a criterion of 70% on the screening test to participate in the study.

Word Problem Pretest and Posttest

The Word Problem Pretest (see Appendix M) and Word Problem Posttest (see Appendix N) consisted of 12 mathematical word problems written in paragraph format. Six of the problems required the use of addition to solve and six problems required the use of subtraction. Three of the problems that required addition to solve included extraneous information and three of the problems that required the use of subtraction included extraneous information. The pretest and posttest were identical to provide an accurate measure of improvement related to solving mathematical word problems. The Word Problem Pretest and Posttest were administered to all participants included in both parts of this research (i.e., single subject design and group design).
**Word Problem Maintenance Probe**

The Word Problem Maintenance Probe (see Appendix O) consisted of 10 mathematics word problems written in paragraph format. Five of the problems required the use of addition to solve and five problems required the use of subtraction. Two of the problems that required addition to solve included extraneous information and two of the problems that required the use of subtraction included extraneous information. The Word Problem Maintenance Probe was administered to the participants in Part One of the research study (i.e., single subject design) one week after receiving the Word Problem Posttest. The special education teacher administered the Word Problem Maintenance Probes individually to each participant in the single subject design part of this research.

**Word Problem Maintenance Test**

The Word Problem Maintenance Test (see Appendix P) consisted of 12 mathematics word problems written in paragraph format. Six of the problems required the use of addition to solve and six problems required the use of subtraction. Three of the problems that required addition to solve included extraneous information and three of the problems that required the use of subtraction included extraneous information. The Word Problem Maintenance Test was administered to all the participants in Part Two of the research study (i.e., group design) two weeks after receiving the Word Problem Posttest. The mathematics strategist administered the Maintenance Tests as a whole group to each participant in the group design part of this research.

**Curriculum-Based Baseline Probes**

The curriculum-based baseline probes were used in Part One of this research (i.e., single subject design) to measure ongoing participant performance related to solving
word problems. There were three distinct baseline probes (i.e., Probe A, Probe B, and Probe C). Administration of the baseline probes was rotated to prevent potential practice effect related to the individual word problems. Each baseline probe consisted of ten mathematics word problems. The format for baseline Probes A, B, and C was the same, but the word problems were different (see Appendices Q, R, and S). The baseline probes consisted of ten mathematics word problems written in paragraph format. Five of the problems required the use of addition to solve and 5 problems required the use of subtraction. Three of the problems that required addition to solve included extraneous information and three of the problems that required the use of subtraction included extraneous information. The baseline probes were administered to all participants in the single subject design.

**Curriculum-Based Intervention Probes**

The curriculum-based intervention probes were used in Part One of this research (i.e., single subject design) to measure ongoing participant performance related to solving word problems. There were 17 distinct curriculum-based intervention probes (i.e., Learning Sheets). Each curriculum-based intervention probe consisted of 15 mathematics word problems (see Appendix T). The curriculum-based intervention probes consisted of three problems described and modeled by the specific learning disabilities teacher, three problems used as guided practice, and nine problems used as independent practice. The last ten problems on each probe were scored and recorded to measure participant problem-solving abilities. The curriculum-based intervention probes followed the graduated word problem sequence.
Word Problem Generalization Test

The Word Problem Generalization Test consisted of 12 mathematics word problems written in paragraph format. Six of the problems required the use of addition to solve and six problems required the use of subtraction. Three of the problems that required addition to solve included extraneous information and three of the problems that required the use of subtraction included extraneous information. The generalization test was similar to the pretest and posttest in design (see Appendix U). The Word Problem Generalization Test was administered to all participants included in Part Two of this research (i.e., group design) to determine the participants’ ability to generalize their newly acquired skills. The research assistant administered the assessment in the Great Room located outside of the intervention classroom. The generalization test was used to determine whether participants could generalize their ability to solve word problems to a different setting with a different instructor.

Social Validity Questionnaire

The Social Validity Questionnaire was provided to all student participants in each part of the study (i.e., single subject design and group design) at the end of the intervention to gather student perceptions about the READER strategy and solving word problems (see Appendix V). The ten-question questionnaire was read aloud to the participants. The questions focused on the intervention lessons, schematic-based diagrams, and mnemonic strategy. Students rated each question using a four-point Likert scale.
Attitude Survey

The Attitude Survey was administered both prior to and after the intervention to all participants in both parts of the study (i.e., single subject design and group design) to determine participant perceptions about mathematics and solving word problems (see Appendix W). The five-question survey was read aloud to the participants. Students rated each question using a four-point Likert scale.

Procedures

The implementation of both Part One (i.e., single subject design) and Part Two (i.e., group design) of this research involved five phases: (a) research preparation and teacher training, (b) screening and pre-assessment, (c) implementation of the treatment, (d) post-assessment, and (e) reporting of progress and data to the participants and their parents. All five phases were completed within one school year.

Phase One: Research Preparation and Teacher Training

Development of the READER strategy and instructional materials. The READER Strategy was developed using a first letter mnemonic device to help students solve mathematical word problems. The sequential steps in the READER strategy were (a) Read the problem, (b) Examine the questions, (c) Abandon irrelevant (unneeded) information, (d) Determine the operation using diagrams, (e) Enter numbers, and (f) Record answer. A total of 17 lessons with accompanying learning sheets, designed to teach elementary students how to solve word problems, were developed. The lessons were scripted and used an explicit teaching approach to increase the accuracy of implementation and to promote language consistency across lessons. The lessons were structured using a graduated word problem sequence that began with number
representation and single words and slowly progressed to problems written in paragraph format (Miller & Mercer, 1993). The complexity of the paragraph-formatted problems continued to increase and ultimately included irrelevant information that had to be filtered out, based on the question posed in each problem. Additionally, the lessons included the concrete, representational, and abstract levels of instruction.

For the purpose of providing representational level instruction, the researcher developed two schema-based diagrams: one for word problems involving addition and one for word problems involving subtraction (see Appendices A and B). The diagrams were constructed with elementary students in mind (i.e., simple in design).

**Research approval.** Approval to conduct the research was acquired from the university, school district, and professional development school institutional review boards and research committees prior to implementation of the research. After approval was obtained, letters explaining the research were sent home along with parent consent and student assent forms. Parent permission and student assent was obtained prior to initiation of the research (see Appendices X, Y, and Z). After all forms had been submitted to the researcher, implementation began.

**Single subject participant selection.** The participants for Part One of this research were selected from a sample of convenience. Specifically, the participants were selected from the total population of students with learning disabilities that were enrolled in the participating school. A selection criterion was applied to identify eligible participants from the pool of students with learning disabilities. Specifically, each participant: (a) met the State of Nevada Administrative Code eligibility criteria for specific learning disabilities in the area of mathematics, (b) was enrolled in at least one
period of specialized support for mathematics instruction, (c) met the criteria for participation in the READER strategy lessons (i.e., scored at least 70% on screening instrument and less than 70% on the Word Problem Pretest) and, (d) returned the signed parent permission form and signed student assent form indicating consent to participate in the research.

**Group design participant selection.** The participants for Part Two of this research were selected from a sample of convenience. Specifically, the participants were selected from third-grade students participating in classes identified to receive Tier 2 intervention within the school’s Response-to-Intervention program (RTI) in the area of mathematics. The students were enrolled in the same participating school as the Part One participants. A specific selection criterion was applied to identify eligible student participants for Part Two of this research (i.e., group design). Each participant: (a) met the school’s criteria to receive Tier 2 intervention in the area of mathematics, (b) was enrolled in at least one period of Tier 2 intervention for mathematics instruction, (c) met the criteria for participation in the READER strategy lessons (i.e., scored at least 70% on screening instrument and less than 70% on the Word Problem Pretest), and (d) returned the signed parent permission form and signed student assent form indicating consent to participate in the research.

**Teacher training.** The elementary math strategist (group design) and the special education teacher (single-subject design) who participated in the study as the instructors participated in one two-hour training session. The training session began with a brief overview related to the difficulties students with learning disabilities have related to solving word problems. Next, lesson materials were given to the math strategist and
special education teacher. Lesson components (i.e., Describe and Model, Guided Practice, Independent Practice, and Review Minute) were described and the lesson sequence (i.e., concrete-representational-abstract, schema-based diagrams, and mnemonic) was modeled. The application of the READER Strategy was modeled, including the use of the schematic diagrams. The math strategist and special education teacher practiced demonstrating the READER steps until 100% accuracy with the strategy steps was achieved. Accuracy was measured through informal observations, practicing each lesson component, and discussing the sequence of each lesson.

The next part of the training session involved learning how to score and graph the learning sheets and computation review minutes. The math strategist and special education teacher were given an opportunity to score and graph learning sheets and computation review minutes until 100% accuracy was achieved two times in a row.

Each teacher was provided a FLIP digital video camera to record their lessons. Time was allocated to practice using the digital video cameras. Examples of where to place the video camera, out of student sight, were also provided.

A copy of the Treatment of Fidelity Checklist (see Appendix AA) was provided to the math strategist and special education teacher. The purpose of this checklist was explained to ensure that both implementers understood the importance of delivering the instructional lessons with fidelity. The teachers were told that the researcher and the research assistant would view the videos of the lessons to determine implementation fidelity.
Phase Two: Screening and Pretesting

A pre-assessment session was held to determine whether potential participants were eligible to participate in the research. The Word Problem Pretest (i.e., 12 word problems, requiring addition and subtraction of double-digit numbers without regrouping) (see Appendix M) and the Reader Screener (i.e., screening test) (see Appendix L) were administered to all potential participants. The mathematics strategist administered the pretest and the screening test as a whole group in the general education classrooms. The special education teacher administered the pretest and the screening test to students who participated in the special education classroom.

The Attitude Survey was administered at the beginning of the intervention to collect information about participant attitudes towards mathematics and mathematical problem solving (see Appendix V) prior to receiving the word problem lessons. The five-question survey was read aloud, whole group to all participants receiving the intervention lessons. Participants rated each question using a four-point Likert scale.

Phase Three: Implementation of the Word Problem Lessons

Single subject and treatment group lessons. The instructional treatment was the same in both Part One (i.e., single subject design) and Part Two (i.e., group design) of this research. The participants involved in Part One received the researcher-developed word problem lessons adhering to the previously discussed parameters of a single-subject-multiple-probe design (i.e., baseline probe data collected until stability reached followed by staggered implementation of the treatment to participants). The participants involved in Part Two of the study also received the researcher-developed word problem lessons immediately following the collection of screening and pretest data.
There were 17 thirty-minute lessons focusing on solving mathematical word problems. In Lesson 1, students solved 15 single-digit addition problems written both horizontally and vertically. The 15 addition problems did not consist of written words, but rather each problem was written using numeric digits (see Appendix F). During Lesson 1, students used the addition schema-based diagram (see Appendix A) and manipulative devices (i.e., cubes) to assist with conceptual understanding at the concrete instructional approach.

In Lesson 2, students solved 15 single-digit addition problems written both horizontally and vertically. The 15 addition problems consisted of mathematics digits and a label (i.e., boats, dogs, stars). During Lesson 2, students used the addition schema-based diagram and manipulative devices. Thus, Lesson 2 included the concrete schema instructional approach.

In Lesson 3, the students solved 15 single-digit subtraction problems written both horizontally and vertically. The 15 subtraction problems did not consist of written words, but rather each problem was written using mathematics digits. During Lesson 3, students used the subtraction schema-based diagram (see Appendix B) and manipulative devices (i.e., cubes) to assist with conceptual understanding within the concrete instructional approach.

Lesson 4 consisted of 15 single-digit addition problems written both horizontally and vertically. The 15 subtraction problems consisted of mathematics digits and a label (i.e., boats, dogs, stars). During Lesson 4, students used the subtraction schema-based diagram and manipulative devices. Thus, Lesson 4 included the concrete schema instructional approach.
In Lesson 5, students solved 15 single-digit addition or subtraction problems. The addition and subtraction problems were written both horizontally and vertically. Each problem consisted of both mathematics digits and a label (i.e., boats, dogs, stars). During Lesson 5, students had to discriminate between addition and subtraction, select the appropriate schema-based diagram, manipulate the process for solving the problem using the concrete schema instructional approach, and record their answer.

In Lessons 6 and 7, students solved 15 mathematics problems. Each problem was written using mathematics digits, along with a label (i.e., boats, dogs) or a phrase (i.e., boats were in the river, dogs were eating). Mathematics problems were written both horizontally and vertically. Students had to determine the appropriate operation (addition or subtraction) for each problem. A representational schema instructional approach was used. During this instructional approach, students selected the appropriate schema-based diagram to use during problem solving. Students recorded the correct digits in the diagram as a representation of the problem, prior to recording their response.

In Lesson 8, students were introduced to the READER Strategy (see Appendix E). During this lesson, the teacher and students verbally rehearsed the strategy. Students had to recall the steps of the READER Strategy to demonstrate mastery.

In Lessons 9, 10, and 11, students solved 15 mathematics word problems. Each word problem was written in sentence form using a combination of words and mathematics digits. Within each word problem, the mathematics digits represented the numbers students used for solving each problem. The students used the READER Strategy to assist with procedural knowledge during this abstract instructional approach.
There was no extraneous or irrelevant information embedded within the mathematics word problems.

In Lessons 12, 13, and 14, students solved 15 mathematics word problems. Each word problem was written in sentence form only. The key difference between Lessons 12, 13, and 14 and the previous lessons was each number was written in word form, rather than in digits. Again, the students continued to use the READER Strategy to assist with procedural knowledge during this abstract instructional approach. Similar to Lessons 9 through 11, Lessons 12 through 14 did not contain extraneous or irrelevant information.

In Lessons 15, 16, and 17, students solved 15 mathematics word problems written in sentence format. No numeric digits were used. Each number was represented in word form. Additionally, each problem consisted of one or two extraneous details, unneeded to solve each problem. Students continued to use the READER Strategy to assist with this abstract level of problem solving.

**Comparison group lessons.** Participants assigned to the comparison group in Part Two of this research received the core curriculum intervention. The intervention curriculum is based on the *Investigations* (Pearson Scott Foresman, 2008) intervention activities outlined in the textbook. The core curriculum intervention took place in the general education classroom, located in the same hallway as the treatment group. Additionally, the comparison group’s instruction was provided at the same time as the treatment group’s instruction. For 17 days, the comparison group was taught *Investigations* intervention lessons that pertained to solving mathematical word problems. Similar to the treatment group’s instruction, the comparison group received 30 minutes of
instruction each day. The instruction followed the scripted lessons outlined in the
*Investigations* series. Each lesson began with the teacher describing and modeling how
to solve an addition or subtraction word problem. Next, students worked in groups to
solve a number of addition and subtraction word problems using manipulative devices,
drawings, or abstract thought. Finally, at the end of each lesson, the teacher brought the
participants back as a whole group to review the day’s lesson. The research assistant
observed 30% of the comparison group’s lessons. The observations were randomly
scheduled to guarantee mathematical word problem instruction was taking place during
the Tier 2 intervention time.

**Phase Four: Post-Assessments**

At the end of the intervention periods, a post-assessment was administered to each
participant. The posttest assessment included twelve word problems (same as the
pretest), requiring addition and subtraction of double-digit numbers without regrouping
(see Appendix N). The posttest was scored and plotted on the problem solving progress
chart. The mathematics strategist administered the posttest to both the treatment group
and comparison group. The posttest was administered as a whole group in the general
education classrooms. The special education teacher administered the same posttest to
the participants in the single-subject design. The special education teacher scored and
plotted participant performance on the problem solving progress chart.

The Social Validity Questionnaire was administered at the end of the intervention
to determine participant perceptions about the READER strategy and solving word
problems (see Appendix V). The 10-question questionnaire was read aloud, whole
group, to all participants that received the intervention lessons. Participants rated each question using a four-point Likert scale.

The Attitude Survey was also administered at the end of the intervention to determined participant attitudes about mathematics and mathematical problem solving (see Appendix W). The five-question survey was read aloud, whole group to all participants that received the intervention lessons. Participants rated each question using a four-point Likert scale.

The Maintenance Probe was administered by the special education teacher to the participants in Part One of this research (i.e., single subject design). The Maintenance Probe was administered one week after the posttest assessment (see Appendix O).

The Maintenance Test was administered by the mathematics strategist to Part Two of this research (i.e., group design). The Maintenance Test was administered two weeks after the posttest assessment (see Appendix P).

The Generalization Test was administered by the research assistant to the participants in Part Two of this research (i.e., group design). The generalization test was administered two weeks after the posttest assessment. It was administered in the Great Room, which is located outside the intervention classroom door (see Appendix U).

**Phase Five: Reporting of Progress to Participants and Parents**

Progress was reported to participants daily after each assessment, intervention lesson, and Computation Review Minute. Student scores were recorded on the Student Progress Chart. Both pretest and posttest assessments were also reported on the participants’ Student Progress Charts. A copy of each participant’s Student Progress Chart was provided to each student to take home and share with their parent/guardian.
Interscorer Reliability and Fidelity of Treatment

Interscorer Reliability

The researcher and implementer (i.e., mathematics strategist or special education teacher) scored 100% of the student baseline probes, pretests, posttests, maintenance probes, maintenance tests, and generalization tests. The researcher served as the primary scorer and the implementerserved as the secondary scorer. An agreement was considered when both scorers (i.e., researcher and implementer) obtained the same response for an answer. The formula agreements ÷ (agreements + disagreements) X 100 was used to determine reliability levels (Tawney & Gast, 1984). In addition to the single subject implementer (i.e., special education teacher) scoring each intervention lesson, the researcher scored 100% of the intervention lessons. An agreement was considered when both the researcher and the implementer recorded the same score for an answer. The formula agreements ÷ (agreements + disagreements) X 100 was used to determine reliability levels (Tawney & Gast, 1984).

Fidelity of Treatment

Both the elementary math strategist and special education teacher used digital video cameras to record each lesson. To determine interobserver agreement related to fidelity of treatment, the researcher and the research assistant completed the fidelity of treatment checklist while viewing the lessons recorded by the digital video cameras (see Appendix AA). Items on the fidelity of treatment checklist were marked appropriately to indicate compliance with the READER Strategy scripted lessons. The formula agreements ÷ (agreements + disagreements) X 100 was used to establish the fidelity of treatment level (Tawney & Gast, 1984). The researcher and research assistant completed
the fidelity of treatment checklist for 30% of the lessons recorded by the digital video cameras for both parts of this research.

**Treatment of Data**

Specific data sets used and analysis procedures are discussed following each research question.

**Research Question 1**

Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention (RTI) program improve their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

**Part one: Single-subject design (students with mathematics disabilities).**

Visual analysis of multiple probe data displayed in line graph format (i.e., baseline and treatment probe scores) was used to determine whether the word problem performance of students with mathematics disabilities improved after receiving explicit instruction using the READER strategy. This analysis included determining differences in level between baseline and treatment conditions for each participant. Visual analysis also included examining variability and trends of the graphed data. To further analyze the data obtained from the ongoing baseline and treatment probes, the percentage of non-overlapping data (PND) (i.e., nonparametric approach to determining treatment effects in single subject design studies) was calculated by (a) identifying the highest baseline probe among all participants), (b) identifying the number of treatment probes from all participants that were greater than the highest baseline probe), and (c) dividing the
number of treatment probes greater than the highest baseline probe by the total number of
treatment probes and multiplying by 100.

The Word Problem Pretest scores and Word Problem Posttest scores were used to
provide additional descriptive data related to the performance of participants with
mathematics disabilities. Although not required in single subject research, these data
provide supplemental information related to each of the individual participants.

Part two: Group design (students receiving RTI). A 2 x 2 (i.e., group and
time) factorial ANOVA with repeated measures on pretest and posttest analysis was used.
The mean Word Problem Pretest scores and mean Word Problem Posttest scores were
used to determine if the groups (i.e., treatment and comparison) increased mathematical
word problem-solving skills. Additionally, an Independent \( t \)-test was used to determine if
the mean pretest and mean posttest scores between groups (i.e., treatment and control)
were different from each other.

Research Question 2

Do students with mathematics disabilities and students receiving Tier 2
intervention within a Response-to-Intervention program maintain their abilities to solve
word problems after receiving explicit instruction in a combined problem-solving
strategy?

Part one: Single-subject design (students with mathematics disabilities).
Visual analysis of maintenance probe data displayed in line graph format along with the
multiple probe baseline and treatment probe data were used to determine whether the
word problem performance of students with mathematics disabilities was maintained
one week after receiving word problem instruction. This analysis included determining
differences in level between baseline, treatment, and maintenance conditions for each participant.

**Part two: Group design (students receiving RTI).** A 2 x 2 (i.e., group and time) factorial ANOVA with repeated measures on posttest and maintenance was used. The mean Word Problem Posttest scores and mean Word Problem Maintenance scores were used to determine if the groups (i.e., treatment and comparison) maintained mathematical word problem-solving skills. Additionally, an Independent $t$-test was used to determine if the mean maintenance scores between groups (i.e., treatment and comparison) were different from each other. This analysis was used to determine whether a change in performance occurred two weeks after receiving word problem instruction.

**Research Question 3**

Do students receiving Tier 2 intervention within a Response-to-Intervention program generalize their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

A 2 x 2 (i.e., group and time) factorial ANOVA with repeated measures on posttest and generalization was used. The mean Word Problem Posttest scores and mean Word Problem Generalization scores were used to determine if the groups (i.e., treatment and comparison) generalized mathematical word problem-solving skills. Additionally, an Independent $t$-test was used to determine if the mean generalization scores between groups (i.e., treatment and comparison) were different from each other. This analysis was conducted to determine whether a change in participant performance occurred when the setting and teacher changed.
Research Question 4

Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program report high satisfaction levels related to the components of a combined problem-solving strategy and associated instruction?

Part one: Single-subject design (students with mathematics disabilities). The data obtained from the Social Validity Questionnaire were used to determine the level of satisfaction from students with mathematics disabilities. Likert-scale ratings from the three participants for each of the 10 questions were reported using a frequency count format. These data will be used to inform future implementation of the instruction and to provide information related to potential improvements to the intervention.

Part two: Group design (students receiving RTI). The data obtained from the Social Validity Questionnaire were used to determine the level of indicated satisfaction from students receiving Tier 2 instruction within a Response-to-Intervention program for mathematics problem solving. Frequency counts and mean scores for each of the 10 questions were reported. These data will be used to inform future implementation of the instruction and to provide information related to potential improvements to the intervention.

Research Question 5

Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program report a positive attitude towards solving mathematics word problems after receiving explicit instruction in a combined problem-solving strategy?
Part one: Single-subject design (students with mathematics disabilities). The data obtained from the Attitude Survey were used to determine the attitude towards mathematics from students with mathematics disabilities. Scores for each of the 5 questions were reported for both the pre-attitude survey and post-attitude survey. These data were used to determine whether student attitudes toward learning mathematics changed as a result of the instruction they received.

Part two: Group design (students receiving RTI). The data obtained from the Attitude Survey were used to determine the attitude towards mathematics from students receiving Tier 2 intervention within a Response-to-Intervention program. Mean scores and individual scores for each of the 5 questions were reported for both the pre-attitude survey and post-attitude survey. These data were used to determine whether student attitudes toward learning mathematics changed as a result of the instruction they received.
CHAPTER 4

FINDINGS OF THE STUDY

The purpose of this research was to investigate the effects of a combined problem-solving strategy for students with learning difficulties in mathematics. There were two parts to this research. Part One involved the use of a multiple-probe-across-participants design to assess the intervention effects on students with mathematics disabilities. Part Two of this research involved the use of a group design to assess the intervention effects on students who were receiving Tier 2 intervention within a Response-to-Intervention program. Data were collected to answer five research questions. This chapter begins with a sequential presentation of results related to each of these questions for each part of the study (i.e., single-subject design and group design). Additionally, interscorer reliability and fidelity of treatment data are provided for each part of the study (i.e., single-subject design and group design). The chapter concludes with a brief summary of the results obtained.

Research Questions and Related Findings

Part One: Single-Subject Design

Visual analysis was used to determine level changes between mean baseline probe scores and mean intervention probe scores. Visual analysis also was used to assess trend and variability of intervention probe scores for each participant in response to receiving the combined problem-solving strategy instruction. Additionally, the Percentage of Non-Overlapping Data (PND) was used to measure effect size. Calculating the PND involved: (a) identifying the highest baseline probe among all participants (i.e., 90%, Participant 3), (b) identifying the number of treatment probes from all participants that were greater than
the highest baseline probe (i.e. 35), and (c) dividing the number of treatment probes greater than the highest baseline probe by the total number of treatment probes (i.e., 51) and multiplying by 100. Thus, the PND for these three participants was 69%, which represents a moderate to large effect size (Mathur, 2009; Mathur, Kavale, Quinn, Forness, & Rutherford, 1998).

Part Two: Group Design

A 2 (group) x 4 (time) factorial ANOVA with repeated measures on time was used to determine if there was a significant change between pretest, posttest, maintenance, and generalization scores. Alpha = .05 served as the significance level. The analysis revealed a significant group x time interaction ($F_{(3, 27)} = 2.87$, $p = .044$), indicating the presence of inconsistent differences between groups across time. Next, simple main effects analysis was conducted and consisted of one-way repeated measures (RM) ANOVAs for time (i.e., pretest, posttest, maintenance, and generalization) for each group. Additionally, Independent $t$-tests were used to determine if group differences were significant at pretest, posttest, maintenance, and generalization.

Research Question 1

Research Question 1: Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program improve their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

Part one: Single-subject design. There were two data sets (i.e., ongoing probes and pre-posttests) used to determine whether the word problem performance of students with mathematics disabilities improved after receiving explicit instruction in a combined
problem-solving strategy. The first data set consisted of the curriculum-based probes that were collected throughout the baseline and intervention conditions (see Figure 1). Visual analysis was used to analyze these data (i.e., level, trend, and variability) per the parameters of the multiple probe design. Additionally, the percentage of non-overlapping data (PND) was calculated to determine the magnitude of the treatment effects (i.e. 69%).

Figure 1

*Single-Subject Design Data Set*
Visual inspection of Figure 1 reveals that all three participants demonstrated improvement in performance level upon the initiation of the combined problem-solving instruction. The mean baseline probe scores for the three participants ranged from 47.5% to 76.6% ($M = 65.83$, $SD = 17.81$). The mean intervention probe scores for the three participants ranged from 95.29% to 95.88% ($M = 95.68$, $SD = 7.00$). This represents a mean percentage point improvement of 29.85. See Table 3 for a summary of individual baseline and intervention probe percentage scores.

Table 3

*Single Subject Design: Baseline and Intervention Probe Scores*

<table>
<thead>
<tr>
<th>Participants</th>
<th>Baseline Probes M / SD</th>
<th>Intervention Probes M / SD</th>
<th>Percentage Point Increase from Baseline to Intervention Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>76.60 / 5.77</td>
<td>95.29 / 7.99</td>
<td>18.69%</td>
</tr>
<tr>
<td>Participant 2</td>
<td>47.50 / 12.58</td>
<td>95.88 / 6.18</td>
<td>48.38%</td>
</tr>
<tr>
<td>Participant 3</td>
<td>74.00 / 15.16</td>
<td>95.88 / 7.12</td>
<td>21.88%</td>
</tr>
</tbody>
</table>

With regard to trend all three participants demonstrated relatively stable baseline performance and consistently high performance after the initiation of the combined problem-solving strategy instruction. With regard to variability, Participant 1
demonstrated baseline variability that ranged from 70% to 80%, which meant a
difference of only one problem. Participant 2 demonstrated baseline variability that
ranged from 30% to 60%, which translates to a difference of three problems. Participant
3 demonstrated baseline variability that ranged from 50% to 90%. Less variability was
demonstrated during the intervention condition. Participant 1 demonstrated intervention
variability that ranged from 80% to 100% which meant a difference of 2 problems.
Participant 2 demonstrated intervention variability that ranged from 80% to 100% which
meant a difference of 2 problems. Participant 3 demonstrated intervention variability that
ranged from 80% to 100% which meant a difference of 2 problems. Thus, intervention
variability for all three participants ranged from 80% to 100%, which translates to a
difference of only two problems.

The second data set used to assess the performance of students with mathematics
disabilities consisted of the *Word Problem Pretest* scores and the *Word Problem Posttest*
scores. All three participants increased their scores from pre- to posttest. The pretest
scores for the three participants ranged from 42% to 58% (*M* = 52.60%, *SD* = 9.23). The
posttest scores for all participants ranged from 83% to 100% (*M* = 94.30%, *SD* = 9.81).
This represents a mean percentage point improvement of 41.70. See Table 4 for a
summary of individual Word Problem Pretest and Posttest Scores.
Table 4

*Single Subject Design: Word Problem Pretest and Posttest Scores*

<table>
<thead>
<tr>
<th>Participants</th>
<th>Pretest Score</th>
<th>Posttest Score</th>
<th>Percentage Point Increase from Pretest to Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>58%</td>
<td>100%</td>
<td>42%</td>
</tr>
<tr>
<td>Participant 2</td>
<td>42%</td>
<td>83%</td>
<td>41%</td>
</tr>
<tr>
<td>Participant 3</td>
<td>58%</td>
<td>100%</td>
<td>42%</td>
</tr>
</tbody>
</table>

**Part two: Group design.** Per previous discussion related to the analysis, both the treatment group (i.e., $M_{\text{pretest score}}$ of 47.55% and $M_{\text{posttest score}}$ of 87.27%) and comparison group (i.e., $M_{\text{pretest score}}$ of 53.40% and $M_{\text{posttest score}}$ of 74.40%) demonstrated a significant change from pre- to posttest. Thus, both groups improved their problem-solving skills significantly. Independent $t$-tests were conducted to determine if group differences were significant at both pretest and posttest. There was no significant difference between the groups on the pretest measure ($t_{19} = -0.56$, $p = .581$). Similarly, there was no significant difference between the groups on the posttest measure ($t_{19} = -1.94$, $p = .066$), but the difference did approach significance. Means and standard deviations for pretest and posttest measures scores can be found in Table 5.
Table 5

*Group Design: Word Problem Pretest and Posttest Scores*

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pretest Score</th>
<th>Posttest Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M / SD</td>
<td>M / SD</td>
</tr>
<tr>
<td>Comparison</td>
<td>53.40 / 20.19</td>
<td>74.70 / 18.21</td>
</tr>
<tr>
<td>Treatment</td>
<td>47.55 / 26.79</td>
<td>87.27 / 10.80</td>
</tr>
</tbody>
</table>

Research Question 2

Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program maintain their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

**Part one: Single-subject design.** There was one data set (i.e., ongoing probes) used to determine whether the word problem performance of students with mathematics disabilities was maintained after receiving explicit instruction in a combined problem-solving strategy. Intervention probes were administered throughout the intervention condition within the multiple probe design. The mean scores for each participant on these intervention probes were compared to their respective maintenance probe scores. Participant 1 demonstrated a mean score of 95.29% on the intervention probes and a maintenance probe score of 100%. Participant 2 demonstrated a mean score of 95.88% on the intervention probes and a maintenance probe score of 90%. Participant 3 demonstrated a mean score of 95.88% on the intervention probes and a maintenance probe score of 60%. Thus, Participant 1 maintained and actually increased his
performance after a week of no word problem instruction, whereas Participant 2 and Participant 3 demonstrated a decline in performance after a week of no word problem instruction (see Table 6).

Table 6

*Single Subject Design: Intervention and Maintenance Probe Scores*

<table>
<thead>
<tr>
<th>Participants</th>
<th>Intervention Probe $M$</th>
<th>Maintenance Probes</th>
<th>Percentage Point Change from Posttest to Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>95.29%</td>
<td>100%</td>
<td>4.71%</td>
</tr>
<tr>
<td>Participant 2</td>
<td>95.88%</td>
<td>90%</td>
<td>-5.88%</td>
</tr>
<tr>
<td>Participant 3</td>
<td>95.88%</td>
<td>60%</td>
<td>-35.88%</td>
</tr>
</tbody>
</table>

**Part two: Group design.** The analysis revealed there was no significant difference from pretest to maintenance for the treatment group (i.e., $M$ posttest score of 87.27% and $M$ maintenance score of 85.64%) or the comparison group (i.e., $M$ posttest score of 74.70% and $M$ maintenance score of 69.00%). Thus, both groups maintained their ability to solve word problems two weeks after the posttest. Independent $t$-tests were conducted to determine if group differences were significant at both posttest and maintenance. There was no significant difference between the groups on the posttest measure ($t_{19} = -1.94$, $p = .066$). There was, however, a significant difference between groups on the maintenance measure favoring the treatment group ($t_{19} = -2.34$, $p = .040$).
### Table 7

*Group Design: Word Problem Posttest and Maintenance Scores*

<table>
<thead>
<tr>
<th>Groups</th>
<th>Posttest Score</th>
<th>Maintenance Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M / SD</td>
<td>M / SD</td>
</tr>
<tr>
<td>Comparison</td>
<td>74.70 / 18.21</td>
<td>69.00 / 20.79</td>
</tr>
<tr>
<td>Treatment</td>
<td>87.27 / 10.80</td>
<td>85.64 / 10.62</td>
</tr>
</tbody>
</table>

### Research Question 3

Do students receiving Tier 2 instruction within a Response-to-Intervention program generalize their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

This analysis revealed there was no significant difference from posttest to generalization for the treatment group (i.e., $M_{\text{posttest}}$ score of 87.27% and $M_{\text{generalization}}$ score of 78.09%) or the comparison group (i.e., $M_{\text{posttest}}$ score of 74.70% and $M_{\text{generalization}}$ score of 67.50%). Thus, both groups generalized their ability to solve word problems two weeks after the posttest in a different setting with a different teacher. Independent $t$-tests were conducted to determine if group differences were significant at both the posttest and generalization. As noted previously, there was no significant difference between the groups on the posttest measure ($t_{19} = -1.94$, $p = .066$). Moreover, there was no significant difference between groups on the generalization measure ($t_{19} = -0.944$, $p = .357$). See Figure 2 for simple main effects.
analysis results from each measure (i.e., pretest, posttest, maintenance, and generalization) used in the group design.

Table 8

*Group Design: Word Problem Posttest and Generalization Scores*

<table>
<thead>
<tr>
<th>Groups</th>
<th>Posttest Score M / SD</th>
<th>Generalization Score M / SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison</td>
<td>74.70 / 18.21</td>
<td>67.50 / 29.05</td>
</tr>
<tr>
<td>Treatment</td>
<td>87.27 / 10.80</td>
<td>78.09 / 22.20</td>
</tr>
</tbody>
</table>

**Research Question 4**

Do students with mathematics disabilities and students receiving Tier 2 instruction within a Response-to-Intervention program report high satisfaction levels related to the components of a combined problem-solving strategy and associated instruction?

**Part one: Single-subject design.** The Social Validity Questionnaire (see Appendix V) was administered to each participant immediately after completing the intervention posttest. The purpose of the Social Validity Questionnaire was to assess the satisfaction levels, of each participant, in regard to the READER Strategy and solving
word problems. The 10 statement Social Validity Questionnaire was designed using a four-point Likert scale: (a) circling the number 1 indicated that the participant strongly disagreed with the statement, (b) circling the number 2 indicated that the participant somewhat disagreed with the statement, (c) circling the number 3 indicated that the participant somewhat agreed with the statement, and (d) circling the number 4 indicated that the participant strongly agreed with the statement.

Participants 1 and 3 strongly agreed with statement one (i.e., The READER Strategy helped me solve math word problems), while Participant 2 strongly disagreed.
with the statement. Participants 1 and 3 also strongly agreed with statement two (i.e., I will be able to use the READER Strategy in math class while solving math word problems), while Participant 2 agreed somewhat. All three participants strongly agreed with statements three (i.e., The READER Strategy was easy to use.) and four (i.e., I enjoyed learning how to use the READER Strategy.)

Participants 2 and 3 strongly agreed with statement five (i.e., I enjoyed solving the word problems on the learning sheets.), while Participant 1 agreed somewhat with the statement. Participants 1 and 3 strongly agreed with statement six (i.e., the READER Strategy lessons were easy to understand.), while Participant 2 strongly disagreed with the statement.

Participants 1 and 3 strongly agreed to statement seven (i.e., I enjoyed using the READER Strategy diagrams), statement eight (i.e., I will be able to use the READER Strategy diagrams in math class), statement nine (i.e., the READER Strategy diagrams helped me solve math word problems), and statement ten (i.e., I would recommend the READER Strategy to my friends who struggle with solving math word problems; while participant 2 agreed somewhat to each statement, seven through ten). See Table 9 for a summary of each participant’s responses.
Table 9

*Social Validity Ratings for Participants with Mathematics Disabilities*

<table>
<thead>
<tr>
<th>Statements</th>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The READER Strategy helped me solve math word problems.</td>
<td>P2</td>
<td></td>
<td></td>
<td>P1, P3</td>
</tr>
<tr>
<td>2. I will be able to use the READER Strategy in math class while solving math word problems.</td>
<td></td>
<td>P2</td>
<td></td>
<td>P1, P3</td>
</tr>
<tr>
<td>3. I enjoyed learning how to use the READER Strategy.</td>
<td></td>
<td>P1, P2, P3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I enjoyed learning how to use the READER Strategy.</td>
<td></td>
<td>P1, P2, P3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I enjoyed solving the word problems on the learning sheets.</td>
<td>P1</td>
<td>P2, P3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. The READER Strategy lessons were easy to understand.</td>
<td>P2</td>
<td></td>
<td></td>
<td>P1, P3</td>
</tr>
<tr>
<td>7. I enjoyed using the READER Strategy diagrams.</td>
<td>P2</td>
<td></td>
<td>P1, P3</td>
<td></td>
</tr>
<tr>
<td>8. I will be able to use the READER Strategy diagrams in math class.</td>
<td>P2</td>
<td></td>
<td>P1, P3</td>
<td></td>
</tr>
<tr>
<td>9. The READER Strategy diagrams helped me solve math word problems.</td>
<td>P2</td>
<td></td>
<td>P1, P3</td>
<td></td>
</tr>
<tr>
<td>10. I would recommend the READER Strategy to my friends who struggle with solving math word problems.</td>
<td>P2</td>
<td></td>
<td>P1, P3</td>
<td></td>
</tr>
</tbody>
</table>

*Note: P1 = Participant 1; P2 = Participant 2; P3 = Participant 3*
**Part two: Group design.** The Social Validity Questionnaire (see Appendix V) was administered to each participant immediately after completing the intervention posttest. The purpose of the Social Validity Questionnaire was to assess the satisfaction levels, of each participant, in regard to the READER Strategy. The ten statement Social Validity Questionnaire was designed using a four-point Likert scale: (a) circling the number 1 indicated that the participant strongly disagreed with the statement, (b) circling the number 2 indicated that the participant somewhat disagreed with the statement, (c) circling the number 3 indicated that the participant somewhat agreed with the statement, and (d) circling the number 4 indicated that the participant strongly agreed with the statement. The frequencies of student responses for each question along with the mean scores were calculated. These data are displayed in Table 10. When rounded to the nearest whole number, the mean scores for the first nine statements on the Social Validity Questionnaire indicate student participants somewhat agree that the READER Strategy was beneficial, enjoyable, and assisted with solving mathematical word problems. When rounded to the nearest whole number, the mean score for the last statement (i.e., I would recommend the READER strategy for my friends who struggle with solving math word problems) indicated the participants strongly agreed.
Table 10

*Social Validity Ratings for Participants Receiving Tier 2 Intervention (N = 11)*

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Did Not Respond</th>
<th>Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The READER Strategy helped me solve math word problems.</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td>2. I will be able to use the READER Strategy in math class while solving math word problems.</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>3. I enjoyed learning how to use the READER Strategy.</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3.2</td>
</tr>
<tr>
<td>4. I enjoyed learning how to use the READER Strategy.</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>3.4</td>
</tr>
<tr>
<td>5. I enjoyed solving the word problems on the learning sheets.</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>6. The READER Strategy lessons were easy to understand.</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2.9</td>
</tr>
<tr>
<td>7. I enjoyed using the READER Strategy diagrams.</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3.2</td>
</tr>
<tr>
<td>8. I will be able to use the READER Strategy diagrams in math class.</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>3.2</td>
</tr>
<tr>
<td>9. The READER Strategy diagrams helped me solve math word problems.</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td>10. I would recommend the READER Strategy to my friends who struggle with solving math word problems.</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>3.6</td>
</tr>
</tbody>
</table>

*Note:* 1 = Strongly Disagree; 2 = Somewhat Disagree; 3 = Somewhat Agree; 4 = Strongly Agree
Research Question 5

Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program report a positive attitude towards solving mathematics word problems after receiving explicit instruction in a combined problem-solving strategy?

Part one: Single-subject design. The Attitude Survey (i.e., pre- and post-survey) evaluating each participant’s opinion towards mathematics and mathematical word problems was administered immediately after the pretest and posttest measures (see Appendix W). The directions of the Attitude Survey required participants to indicate the extent to which they agreed or disagreed with five statements.

Participants 1 and 3 strongly agreed on both the pre- and post-survey with statement one (i.e., I am good at addition word problems), while Participant 2 agreed somewhat on the pre-survey and strongly disagreed on the post-survey. Participant 1 strongly disagreed on the pre-survey and strongly agreed on the post-survey with statement two (i.e., I am good at subtraction word problems), whereas Participants 2 and 3 strongly agreed on both the pre- and post-surveys. Participants 1 and 2 strongly agreed on both the pre- and post-surveys with statement three (i.e., Math is one of my favorite subjects), while Participant 3 strongly disagreed on the pre-survey and strongly agreed on the post-survey. Both Participants 1 and 3 strongly agreed on the pre-survey with statement four (i.e., I think math word problems are fun). However, Participant 1 strongly agreed on the post-survey while Participant 3 disagreed somewhat, and Participant 2 agreed somewhat on the pre-survey and strongly disagreed on the post-survey. Participant 1 strongly disagreed on the pre-survey and strongly agreed on the
post survey with statement five (i.e., I think math word problems are easy), while
Participants 2 and 3 strongly agreed on both the pre- and post-surveys. Table 11 provides
a complete list of each Participant’s pretest and posttest responses, along with the
directional change in opinion towards mathematics and word problems.

Table 11

*Attitude Survey Ratings for Participants with Mathematics Disabilities*

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th></th>
<th>Participant 2</th>
<th></th>
<th>Participant 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-</td>
<td>Post-</td>
<td>Change</td>
<td>Pre-</td>
<td>Post-</td>
<td>Change</td>
</tr>
<tr>
<td>Q1</td>
<td>4</td>
<td>4</td>
<td></td>
<td>3</td>
<td>1</td>
<td>down</td>
</tr>
<tr>
<td>Q2</td>
<td>1</td>
<td>4</td>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>4</td>
<td>4</td>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>4</td>
<td>4</td>
<td></td>
<td>3</td>
<td>1</td>
<td>down</td>
</tr>
<tr>
<td>Q5</td>
<td>1</td>
<td>4</td>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

*Note:* Q1 = Question 1, Q2 = Question 2, Q3 = Question 3, Q4 = Question 4, Q5 = Question 5, 1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Somewhat Agree, 4 = Strongly Agree, ←→ Attitude stayed the same, ↑ Attitude improved, ↓ Attitude got worse.

Based on mean scores for all five statements when rounded to the nearest whole
number, Participant 1 had a somewhat positive opinion towards math and word problems
on the pre-survey ($M = 2.8^1$) and a strong opinion towards mathematical word problems on the post-survey ($M = 4.0$). Participant 2 had a strong opinion towards math and word problems on the pre-survey ($M = 3.6$) and a somewhat positive opinion on the post-survey ($M = 2.8$). Participant 3 had a somewhat positive opinion towards math and word problems on the pre-survey ($M = 3.4$) and a positive opinion on the post-survey ($M = 3.6$).

Part two: Group design. The Attitude Survey (i.e., pre- and post-survey) evaluating each participant’s opinion towards mathematics and mathematical word problems was administered immediately after the pretest and posttest measures (see Appendix W). The directions of the Attitude Survey required participants to indicate the extent to which they agreed or disagreed to five statements. The Attitude Survey was designed using a four-point Likert scale: (a) circling the number 1 indicated that the participant strongly disagreed with the statement, (b) circling the number 2 indicated that the participant somewhat disagreed with the statement, (c) circling the number 3 indicated that the participant somewhat agreed with the statement, and (d) circling the number 4 indicated that the participant strongly agreed with the statement. After each participant completed the Attitude Survey, Mean scores were calculated for each statement (see Table 12). A comparison of mean scores indicates that participant attitudes towards mathematics and word problem-solving increased after the READER Strategy intervention lessons were provided.

---

1 Mean scores were obtained from a 4-point Likert scale ratings: (a) 1 strongly disagree, (b) 2 disagree somewhat, (c) 3 agree somewhat, and (d) 4 strongly agree.
Table 12

*Attitude Survey Ratings for Treatment Group Participants Receiving Tier 2 Intervention*

*(N = 11)*

<table>
<thead>
<tr>
<th>Statements</th>
<th>Pre- Attitude Survey M</th>
<th>Post - Attitude Survey M</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am good at addition word problems.</td>
<td>2.73</td>
<td>3.09</td>
</tr>
<tr>
<td>I am good at subtraction word problems.</td>
<td>2.36</td>
<td>2.64</td>
</tr>
<tr>
<td>Math is one of my favorite subjects.</td>
<td>2.73</td>
<td>2.91</td>
</tr>
<tr>
<td>I think math word problems are fun.</td>
<td>2.89</td>
<td>3.27</td>
</tr>
<tr>
<td>I think math word problems are easy.</td>
<td>2.27</td>
<td>2.64</td>
</tr>
</tbody>
</table>

**Interscorer Reliability**

**Single-Subject Design: Students with Mathematics Disabilities**

The researcher and implementer (i.e., special education teacher) scored 100% of the student baseline probes, pretests, intervention probes, posttests, and maintenance probes. The researcher served as the primary scorer and the implementer served as the secondary scorer. An agreement was considered when both scorers (i.e., researcher and implementer) obtained the same score for the participant’s response to a problem. The formula agreements ÷ (agreements + disagreements) X 100 was used to determine reliability levels (Tawney & Gast, 1984). The percentage of agreement for baseline probes, maintenance probes, pretests and posttests was 100%. The percentage of agreement for intervention probes was 99.8%, having identified one disagreement out of
the 510 intervention probes. Table 13 provides the data from the single-subject design interscorer reliability checks.

Table 13

*Single-Subject Design: Interscorer Reliability*

<table>
<thead>
<tr>
<th>Measures</th>
<th>Total Agreements</th>
<th>Total Agreements + Disagreements</th>
<th>Percentage of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Probes</td>
<td>120</td>
<td>120</td>
<td>100%</td>
</tr>
<tr>
<td>Intervention Probes</td>
<td>509</td>
<td>510</td>
<td>99.80%</td>
</tr>
<tr>
<td>Maintenance Probes</td>
<td>30</td>
<td>30</td>
<td>100%</td>
</tr>
<tr>
<td>Pretest</td>
<td>36</td>
<td>36</td>
<td>100%</td>
</tr>
<tr>
<td>Posttest</td>
<td>36</td>
<td>36</td>
<td>100%</td>
</tr>
<tr>
<td>Total</td>
<td>731</td>
<td>732</td>
<td>99.86%</td>
</tr>
</tbody>
</table>

*Group Design: Students Receiving RTI*

The researcher and implementer (i.e., mathematics strategist) scored 100% of the student pretests, posttests, generalization tests, and maintenance test. The researcher served as the primary scorer and the implementerserved as the secondary scorer. An agreement was considered when both scorers (i.e., researcher and implementer) obtained the same score or response for an answer. The formula agreements ÷ (agreements + disagreements) X 100 was used to determine reliability levels (Tawney & Gast, 1984). The percentage of agreement for all assessments was 100%. Table 14 provides the data from the group design interscorer reliability checks.
Table 14

*Group Design: Interscorer Reliability*

<table>
<thead>
<tr>
<th>Measures</th>
<th>Total Agreements</th>
<th>Total Agreements + Disagreements</th>
<th>Percentage of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>252</td>
<td>252</td>
<td>100%</td>
</tr>
<tr>
<td>Posttest</td>
<td>252</td>
<td>252</td>
<td>100%</td>
</tr>
<tr>
<td>Maintenance Test</td>
<td>252</td>
<td>252</td>
<td>100%</td>
</tr>
<tr>
<td>Generalization Test</td>
<td>252</td>
<td>252</td>
<td>100%</td>
</tr>
<tr>
<td>Total</td>
<td>1,008</td>
<td>1,008</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Fidelity of Treatment**

**Single-Subject Design: Students with Mathematics Disabilities**

The special education teacher used a FLIP digital video camera to record each lesson. To determine interobserver agreement related to fidelity of treatment, the researcher and the research assistant each completed fidelity of treatment checklists while viewing the lessons recorded by the digital video camera (see Appendix AA). Items on the fidelity of treatment checklist were marked appropriately to indicate compliance with the READER Strategy scripted lessons. The formula agreements ÷ (agreements + disagreements) x 100 was used to establish the fidelity of treatment level (Tawney & Gast, 1984). The researcher and research assistant completed the fidelity of treatment checklist for 29.4% of lessons recorded by the digital video camera. The percent of agreement related to the fidelity of treatment within the single-subject design was 100% (see Table 15).
Table 15

*Single-Subject Design: Fidelity of Treatment*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Total Agreements</th>
<th>Total Agreements + Disagreements</th>
<th>Percentage of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fidelity of Treatment</td>
<td>25</td>
<td>25</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Group Design: Students Receiving RTI**

The mathematics strategist used a FLIP digital video camera to record each lesson. To determine interobserver agreement related to fidelity of treatment, the researcher and the research assistant completed fidelity of treatment checklists while viewing the lessons recorded by the digital video cameras (see Appendix AA). Items on the fidelity of treatment checklist were marked appropriately to indicate compliance with the READER Strategy scripted lessons. The formula agreements ÷ (agreements + disagreements) x 100 was used to establish the fidelity of treatment level (Tawney & Gast, 1984). The researcher and research assistant completed the fidelity of treatment checklist for 29.4% of the lessons recorded by the digital video camera. The percent of agreement for fidelity of treatment within the group design was 100% (see Table 16).
Table 16

*Group Design: Fidelity of Treatment*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Total Agreements</th>
<th>Total Agreements + Disagreements</th>
<th>Percentage of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fidelity of Treatment</td>
<td>25</td>
<td>25</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Summary of Findings**

Within the single-subject design, all three participants (i.e., Participant 1, Participant 2, and Participant 3) increased their ability to solve mathematical word problems after receiving explicit instruction using the combined problem-solving strategy. The improvement was also evident in the pre- and posttest measures; where all three participants improved their ability to solve mathematical word problems. Within the group design, both groups (i.e., treatment and comparison) significantly improved their ability to solve mathematical word problems from pretest to posttest. Although there was no statistically significant difference between treatment and comparison group scores, there was a larger percentage point gain from pre- to posttest for the treatment group.

Within the single subject design, one participant (Participant 1) maintained the ability to solve mathematical word problems after a one-week period, whereas, Participants 2 and 3 were unable to maintain their skills at the same level as their mean intervention performance after a one-week period. Within the group design, there was no significant change between posttest scores and maintenance scores for either group (i.e.,
treatment and comparison); which indicates that both groups maintained their ability to solve mathematical word problems after a period of two weeks. There was a significant difference between treatment group and comparison group maintenance scores, favoring the treatment group.

Within the group design, there was no significant change between posttest scores and generalization scores for either group (i.e., comparison and treatment). This indicates that both groups were able to generalize their abilities to solve mathematical word problems in a different setting with a different teacher.

The data from the Social Validity Questionnaire for participants in both parts of the research (i.e., single subject design and group design) indicate that a majority of participant responses for all ten questions were either Somewhat Agree or Strongly Agree. The data from the Attitude Survey for participants in part one of the research (i.e., single subject design) indicate that a majority of the participant responses were positive both before and after the intervention. The data from the Attitude Survey for participants in part two of the research (i.e., group design) indicate a minimal improvement in attitude from pre- to posttest based on mean scores for each question.
Many students with learning difficulties in the area of mathematics demonstrate specific weaknesses with mathematics reasoning (Griffin & Jitendra, 2009); such weaknesses negatively affect students’ ability to solve word problems. Researchers have identified a variety of factors that contribute to word problem challenges including (a) limited conceptual understanding related to mathematical word problems, (b) lack of computation readiness, (c) difficulty reading the problem, (d) inability to comprehend the sentences, (e) inability to identify the question asked in the problem, (f) confusion related to extraneous information in the problem, (g) difficulty developing and following a plan for solving the problem, (h) difficulty completing multiple steps to solve the problem, and/or (i) forgetting to label the problem appropriately (Bryant, Smith, & Bryant, 2008; and Forsten, 2004).

The ability to solve mathematical word problems has received increased emphasis within mathematics curricula in recent years (NCTM, 2010). The need to understand and solve mathematical word problems is evident in many aspects of the school culture including: (a) mid-term and final exams, (b) high stakes testing, (c) graduation exams, and (d) college entrance exams. Based on the poor performance of many students in this aspect of the school curricula, it appears that the cognitive demands placed on students as they attempt to solve mathematical word problems are significant and consequently robust instructional interventions are needed to help students meet these demands.

Earlier researchers have investigated the effects of various instructional methods to assist students in solving mathematical word problems. Harris, Miller, and Mercer
(1995) examined the use of the Concrete-Representational-Abstract (CRA) teaching sequence combined with a cognitive strategy to help elementary students with mathematics disabilities solve multiplication word problems. Maccini and Ruhl (2000) also conducted research investigating the effects of a CRA teaching sequence combined with a cognitive strategy to help middle school-aged students solve algebraic word problems.

Another instructional method used in earlier research to assist students while solving mathematical word problems was the use of schema-based diagrams. These visual representations or drawings have been effective in terms of helping elementary- and middle-school students with solving mathematical word problems (Griffin & Jitendra, 2009; Jitendra & Hoff, 1996; Jitendra et al., 1998; Jitendra, Hoff, & Beck, 1999). In each study, students with learning disabilities received explicit instruction in using schema-based diagrams, and then were able to use the diagrams effectively.

Finally, Montague, Applegate, and Marquard (1993) investigated the use of cognitive strategies without the CRA sequence or schema-based diagrams. The participants in their research demonstrated positive effects related to solving mathematical word problems after learning to use the cognitive strategy RPVHECC (i.e., Read, Paraphrase, Visualize, Hypothesize, Estimate, Compute, and Check). The researchers found positive results related to word problem performance among students with learning disabilities.

The current study involved the combination of these research-based instructional approaches (i.e., CRA teaching sequence, schema-based diagrams, and a cognitive strategy) delivered via explicit instruction to teach students with mathematics disabilities.
(i.e., single subject design) and students receiving Tier 2 instruction within a Response-to-Intervention program (i.e., group design) how to solve mathematical word problems. The results for both types of students were positive.

The remaining sections of Chapter 5 will include (a) a sequential discussion related to the results associated with the five research questions, (b) a list of conclusions based on the results obtained, (c) a discussion of practical implications obtained from the current research, and (d) a list of recommendations for future research.

Discussion of Results

The purpose of this research was to examine the effects of a combined problem-solving strategy (i.e., READER strategy) on word problem performance of students with mathematics disabilities and students who are at-risk to fail in mathematics. A sequential discussion of results related to each question is provided.

Research Question 1

Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention (RTI) program improve their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

Part one: Single-subject design (students with mathematics disabilities). There were two data sets (i.e., ongoing probes and pre-/post-test) used to answer this question. Both data sets revealed that all three participants improved their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy. Additionally, all participants reached mastery level on each intervention lesson.
It was interesting to note that even Participant 2, who started out with much lower baseline probes and a lower pretest score was able to meet mastery criteria after receiving the intervention. It was also interesting to note, Participant 2s intervention probes were either equal to or higher than the other participants’ intervention probes.

Only one participant (i.e., Participant 2) had to repeat one intervention lesson (i.e., Lesson 5) due to not meeting the criteria for moving forward (i.e., 80% or higher). It appeared that the errors on that lesson were not following the operational signs (i.e., adding rather than subtracting or subtracting rather than adding). The participant had not been taught the READER Strategy yet (i.e., lesson 8), which includes a step for students to examine the sign prior to solving the problem. Once Participant 2 was taught the READER Strategy, he no longer displayed the error pattern of ignoring the operational sign. Thus, when teaching students with mathematics disabilities to solve word problems, it appears to be very important to explicitly teach them to think about the appropriate operation to perform and then to attend to the operational sign after the computational problem has been extracted from the word problem. Integrating this important aspect of solving a word problem into a cognitive strategy step is likely to help students avoid making operational errors.

The findings of Part One (i.e., single-subject design) concur with previous research (i.e., Harris, Miller, & Mercer, 1995; Maccini & Hughes, 2000; Maccini & Ruhl, 2000; Scheuermann, Deshler, & Shumaker, 2009) related to the use of the CRA instructional sequence with computation and/or word problems when working with students with learning disabilities. The findings also concur with previous research (Jitendra, DiPipi, & Perron-Jones, 2002; Jitendra et al., 1998; Jitendra & Hoff, 1996;
Jitendra, Hoff, & Beck, 1999; Van Garderen, 2007) related to the use of schema-based diagrams while working with students with learning disabilities. Additionally, the findings concur with previous research on cognitive strategies (Case, Harris, & Graham, 1992; Montague, 1992; Montague, Applegate, & Marquard, 1993). However, this study extends previous research by combining CRA, Schema-based, and cognitive strategies; whereas previous research only examined one instructional method or a combination of two.

**Part two: Group design (students receiving RTI).** There was one data set (i.e., pretests and posttests) used to answer this question related to students receiving RTI services. A review of the findings indicates that both the comparison and treatment group improved from pretest to posttest after receiving an intervention, (i.e., READER Strategy or *Investigation*). The analysis revealed that there was not a significant difference between groups prior to beginning the intervention (i.e., pretest) nor was there a significant difference between groups after the intervention (i.e., posttest). Both interventions (i.e., READER Strategy and *Investigations*) had the effect of increasing student performance, but it should be noted that the comparison group did not meet the posttest mastery criteria of 80%. Whereas the treatment group posttest scores exceeded the mastery criteria of 80%. Given the current emphasis on accountability and meeting high educational standards and mastery criteria, this difference in performance is worthy of further consideration.

No previous research was located related to the effects of cognitive strategy, schema-based instruction, or CRA on students receiving RTI services. Therefore, this study extends the research to this population. The findings from Part Two (i.e., group
design) differ from Xin, Jitendra, and Deatline-Buchman (2005), where students in the schema-based group out performed students in the textbook group. It is likely that the textbook program used in the Xin et al. (2005) study was different than the textbook program used in the current study. Perhaps the program used in the current study was a higher quality program, and therefore resulted in higher outcomes for the comparison group participants. Additional research would have to be conducted to determine whether this is an accurate explanation. Another plausible explanation for the difference in findings between Xin et al. (2005) and the current study may be the difference in the schema-based diagrams used in Xin et al. (2005). It is possible that more detailed diagrams are more beneficial for students. Again, further study would help determine whether this is true.

Research Question 2

Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program maintain their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

Part one: Single-subject design (students with mathematics disabilities). Two data sets (i.e., intervention probes and maintenance probes) were used to answer this question. Participant 1 increased in maintenance compared to the intervention probe scores. Whereas Participant 2 and Participant 3 decreased in maintenance compared to their intervention probes. Participants 1 and 2 met mastery criteria of 80 or higher for maintenance. Participant 1 and 2 also exceeded their baseline mean probe scores; whereas Participant 3 did not exceed her baseline mean probe scores. Participant 3 has a
history of severe inconsistent academic performance from day to day and from one lesson to the next within a given day. This behavior has been noted by the participant's parents, teachers, school psychologist, and school nurse. The teacher also noted that this participant took longer to complete each independent practice section of the lessons than the other two participants. Participant 3 would periodically stop mid-problem and appear to be day-dreaming. After the teacher tapped the table or verbally cued the participant, she would get back to work. This finding was not particularly surprising because Participant 3 has been demonstrating this behavior for a few years. It is also interesting to note that this participant qualified for special education services only in the area of mathematics, whereas the other participants qualified for both reading and mathematics services. Qualifying for services in multiple areas is the norm within this school. Historically, more students are referred for special education testing because teachers observe reading difficulties. The fact that participant 3 was referred for special education testing in spite of her ability to read on grade level, was a bit unusual, and may indicate that her mathematics difficulties appeared to be quite severe. The severity of her mathematics disability may be one explanation for her lower ability to maintain the newly learned problem-solving strategies.

**Part two: Group design (students receiving RTI).** Two data sets (i.e., posttests and maintenance tests) were used in the group design. The analysis revealed that there was no significant change between posttest scores and maintenance test scores for either group. There was, however, a significant difference between group maintenance scores, indicating that the treatment group maintained at a higher level than the comparison group. Thus, although both interventions were effective related to skill maintenance, the
combined problem-solving strategy was more effective than *Investigations*. It is also interesting to note that if the mean scores on these tests were translated into grades, the comparison group would have received a C on the posttest and a D on maintenance test, whereas the treatment group would have received a B on both. Thus, these findings appear to be socially significant (Scheuermann, Deshler, & Shumaker, 2009). The emphasis on grades in American schools is readily apparent to teachers, parents, and students. Higher grades are valued and frequently result in added benefits for students (e.g., honor roll recognition, school awards, access to special activities, and eligibility for sports). Higher grades can increase student motivation, and subsequently improve willingness to engage in the learning process. Thus, interventions that improve student grades are important.

The findings of the current study related to skill maintenance concur with Jitendra et al. (1998) in which students who received schema-based instruction maintained their abilities to solve mathematical word problems. Similar to the current study, Jitendra et al. (1998) revealed a significant difference between groups, favoring the treatment group over the comparison group with regard to maintenance. These findings inform researchers and educators that schema-based diagrams used alone or in conjunction with other evidence-based practices assist students in learning and maintaining mathematical problem-solving skills. The current study extended the literature on combining CRA, schema-based, and cognitive strategies to maintain word problem-solving skills in students receiving Tier 2 instruction within a Response-to-Intervention program.
**Research Question 3**

Do students receiving Tier 2 intervention within a Response-to-Intervention program generalize their abilities to solve word problems after receiving explicit instruction in a combined problem-solving strategy?

Two data sets (i.e., posttests and generalization tests) were used to answer this research question related to participants in a Response-to-Intervention program. The analysis revealed that there was no significant change between posttest scores and generalization test scores for either the treatment or comparison group. This finding supports the use of either the combined problem-solving strategy or the *Investigations* series in terms of skill generalization related to word problem-solving abilities. It is interesting to note that although there was no significant difference between group generalization scores (i.e., treatment group and comparison group), if the generalization mean scores were translated into grades, the comparison group would have received a C on the posttest and a D on the generalization test, whereas the treatment group would have received a B on the posttest and C on the generalization test. Again, these findings appear to be socially significant (Scheuermann, Deshler, & Shumaker, 2009).

The findings in the current study related to generalization concur with those of Maccini and Hughes (2000) in which students who received teacher directed and explicit instruction combined with the use of a Concrete-Representational-Abstract teaching sequence experienced generalization success related to their ability to solve mathematical word problems. Jitendra et al. (1998) and Jitendra, Hoff and Beck (1999) also noted positive results in student abilities related to the ability to generalize mathematical word problems, but with the use of schema-based diagrams. The current study extended the
literature related to combining CRA, schema-based, and cognitive strategies to assist with generalization of word problem solving in students receiving Tier 2 instruction within a Response-to-Intervention program.

**Research Question 4**

Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program report high satisfaction levels related to the components of a combined problem-solving strategy and associated instruction?

**Part one: Single-subject design (students with mathematics disabilities).** A ten statement Social Validity Questionnaire was used to answer this research question. The analysis revealed that when participants with mathematics disabilities were asked to rate their satisfaction towards the combined problem-solving strategy, all three participants somewhat agreed or strongly agreed on eight of the statements (i.e., statements two, three, four, five, seven, eight, nine, and ten), indicating a high level of satisfaction related to the READER Strategy. On two statements, Participant 2 strongly disagreed. Both of the statements dealt with his ability rather than his enjoyment related to the strategy. Given the histories of failure that many students with mathematics disabilities have experienced, it is not surprising to find they have doubts about their abilities. The high level of satisfaction ratings obtained from these three participants supports social validity related to the combined problem-solving strategy.

The findings from the current study concur with Maccini and Ruhl (2000) study related to measuring participant satisfaction while using a combined Concrete-Representation-Abstract instruction sequence and a cognitive strategy. Participants in
both studies (i.e., the current study and Maccini and Ruhl) reported high satisfaction levels related to a combined problem-solving strategy and associated instruction. These findings also concur with Jitendra and Hoff (1996) in that the students enjoyed solving mathematical word problems while using schema-based diagrams.

**Part two: Group design (students receiving RTI).** A ten statement Social Validity Questionnaire was used to answer this research question. The analysis revealed that when participants receiving Tier 2 intervention within a Response-to-Intervention program were asked to rate their satisfaction towards the combined problem-solving strategy, a majority of the participants somewhat agreed or strongly agreed in favor of the combined problem-solving strategy on nine of the statements. On one statement (i.e., I will be able to use the READER Strategy in math class while solving word problems), five participants strongly agreed or somewhat agreed, whereas five participants strongly disagreed or somewhat disagreed to the statement. This may indicate a need for opportunities to use the READER Strategy in the general education classroom before discontinuing instruction on how to use the strategy. This type of generalization practice could be integrated into the lessons when the instruction is taking place outside of the general education classroom. The current study concurs with Owen and Fuchs (2002) in that the participants in both studies (i.e., the current study and Owen & Fuchs) enjoyed solving mathematical word problems while using schema-based diagrams.

**Research Question 5**

Do students with mathematics disabilities and students receiving Tier 2 intervention within a Response-to-Intervention program report a positive attitude towards solving mathematics word problems?
**Part one: Single-subject design (students with mathematics disabilities).** Two data sets (i.e., pretest and posttest) in the form of a five statement attitude survey were used to answer this research question. The analysis revealed that when participants with mathematics disabilities were asked to rate their attitude towards mathematics and problem-solving prior to receiving the combined problem-solving strategy, all three participants reported positive attitudes on two statements (i.e., I am good at addition word problems and I think math word problems are fun).

After receiving the combined problem-solving strategy, Participant 2 no longer thought he was good at adding problems. Similarly, Participant 2 no longer thought math word problems were fun. It is possible that Participant 2 was having a bad day when he took the Attitude Survey Posttest or perhaps he was more aware of his skill limitations as a result of the lessons. Participant 3 also thought word problems were less fun at the posttest stage. It is possible that both Participant 2 and Participant 3 were losing motivation after receiving 17 word problem lessons. This may indicate a need to build in motivational activities during the latter series of word problem lessons.

There were only a few indications that attitudes improved after receiving the combined math strategy instruction. Participant 1 believed he was better at subtraction word problems and that word problems were more fun after receiving the instruction. Participant 3 indicated that math was one of her favorite subjects after receiving the word problem instruction. For the most part, participant attitudes were unchanged as a result of the word problem instruction. It is possible that 17 lessons was not enough time to change attitudes toward mathematics and/or problem solving. Attitudinal changes may take more time, especially when this aspect of the school curriculum has been a challenge.
for multiple years. The current study extends the literature by measuring student attitudes towards solving mathematical word problems while using a combined problem-solving strategy, but future research is needed to determine additional variables that influence attitudinal change.

**Part two: Group design (students receiving RTI).** Two data sets (i.e., pretest and posttest) in the form of a five-statement attitude survey were used to answer this research question. The analysis revealed that participant attitudes towards mathematics and problem-solving positively increased, on all five statements, after receiving the combined problem-solving strategy. These findings support that attitude towards mathematics and problem-solving among students in Response-to-Intervention programs positively increase after receiving instruction using the combined problem-solving strategy. It is interesting to note that the findings for the students participating in a Response-to-Intervention program reflected a greater degree of positive attitude change than what was seen among students with mathematics disabilities. A possible explanation for this finding may be that different teachers provided the instruction (e.g., mathematics strategist and special education teacher). Another possible explanation could be that students receiving Response-to-Intervention may have more accurate intuition about their mathematics performance skill abilities, especially prior to receiving the instruction. These findings also contribute to and extend the literature, but again additional research in the area of mathematics attitudinal changes could result in more information related to this important topic.
Conclusions

Based on the results obtained in this research, the conclusions of the study include:

1. A combined word problem strategy that incorporates a Concrete-Representational-Abstract instructional sequence, schema-based diagrams, and a cognitive strategy (i.e., READER) maybe used to improve students' ability to solve word problems (i.e., both students with mathematics disabilities and students receiving Tier 2 instruction within a Response-to-Intervention program).

2. Students receiving Tier 2 instruction who receive 17 lessons related to the combined problem-solving strategy are able to maintain their ability to solve word problems better than students receiving Tier 2 instruction who receive 17 *Investigations* lessons.

3. Students with mathematics disabilities may need additional review and practice beyond the current 17 lessons to improve their ability to maintain word problem-solving skills.

4. Students receiving Tier 2 instruction within a Response-to-Intervention program who receive a combined problem-solving strategy or instruction in *Investigations* are able to generalize their ability while solving word problems in a different setting with a different teacher.

5. Both *Investigations* and the combined problem-solving strategy are effective for teaching students, receiving Tier 2 instruction within a Response-to-Intervention program, to solve word problems. However, higher gain scores may be expected from students who receive the combined problem-solving strategy.
6. Students who are taught the combined problem-solving strategy enjoy using the strategy while solving mathematical word problems (i.e., students with mathematics disabilities and students receiving Tier 2 instruction within a Response-to-Intervention program).

7. Students receiving Tier 2 instruction within a Response-to-Intervention program report an increase in attitude about math after receiving the combined problem-solving strategy.

8. Students with disabilities generally have positive attitudes about their abilities both before and after receiving the combined problem-solving strategy.

**Practical Implications**

Several practical implications emerged from this study. First, teachers using the combined problem-solving strategy should allow more time for lessons that involve the use of manipulative devices (i.e., Lessons 1-5). Both of the teachers involved in this research reported feeling a bit rushed during these initial lessons. Clearly, there is additional management involved in lessons that require the use of manipulative devices (e.g., distributing and organizing the materials, establishing rules for use of the manipulative devices). In spite of the extra effort involved in using the manipulative devices, both teachers said the process for solving word problems became easier and more efficient over time due to the participants mastering the important concepts in earlier lessons.

A second practical implication that emerged from this research is when working with students who struggle with math, it may be important to supplement core curricula with specialized strategies such as schema-based diagrams, cognitive strategies, and a
Concrete-Representational-Abstract instruction sequence, to promote skill maintenance. It appears these strategies influence how much students remember overtime. It also appears that some students, especially those with mathematics disabilities would benefit from reviews and additional practice to maintain newly learned skills.

A third implication that emerged from this research involved the use of systematic instructional approaches when teaching students that struggle in the area of mathematics word problems. The use of explicit teaching that includes advance organizers, teacher demonstrations, guided practice, and independent practice served the participants well in this study. The students seemed to enjoy the structure and predictability of using this process during the word problem lessons. Additionally, this lesson sequence seemed to set the students up for success due to extensive teacher support at the beginning of each lesson that was gradually withdrawn as the lesson progressed. Even though word problems are especially difficult for many students, there were no serious behavioral issues during the implementation of the lessons (e.g., refusal to engage in the lessons, refusal to complete the Learning Sheets, acting out to avoid answering the word problems). The teachers reported that students seemed to enjoy the lessons and their success with the lesson content.

**Recommendations for Further Study**

Recommendations for further study emerged from the results obtained in this study. Included among these recommendations are the following:

1. Research should be conducted to investigate the effects of the combined problem-solving strategy when teaching word problems that require the use of
multiplication and division. The outcomes may be different when teaching these higher-level skills.

2. Research should be conducted to investigate the effects of the current study on different populations (i.e., students with Intellectual Disabilities, Emotional Disturbance, students from advantaged families, or students with gifts and talents). The required number of lessons may need to be changed based on ability or disability. Additionally, the outcomes may be different when teaching the combined problem-solving strategy to a more diverse population.

3. Research should be conducted to investigate the effects of the combined problem-solving strategy with different grade levels (i.e., second graders or students in middle school or high school). The outcomes may be different when teaching the combined problem-solving strategy at different grade levels. The number of lessons at each level (i.e., Abstract, Representational, or Concrete) may require some adjustments based on the maturity and skill level of students in different grades.

4. Research should be conducted to investigate the effects of the combined problem-solving strategy on different instructional levels of addition and subtraction (i.e., multi-digit with and without regrouping). Changes to the current teaching sequence may be needed. Outcomes may also differ based on a higher skill level.

5. Research should be conducted to investigate the long term effects of the combined problem-solving strategy. Administering additional maintenance measures (i.e., one week, three weeks, and five weeks after posttest) may assist the researcher in determining possible changes in the strategy to increase maintenance skill level.
6. Research should be conducted to investigate participant abilities to generalize the combined problem-solving strategy into core curriculum (i.e., during mathematics instruction in the general education classroom with the general education curriculum). The outcomes may be different when comparing multiple settings and teachers.

7. Research should be conducted to investigate participant abilities to generalize the READER Strategy to the next or higher mathematical skill (i.e., addition and subtraction problems with regrouping). The outcomes may be different when teaching these higher-level skills.

8. Research should be conducted to investigate participant abilities to generalize the READER Strategy to the next grade level (i.e., from third grade to fourth grade). The outcomes may be different when teaching these higher-level skills in a different setting with a different teacher.

9. Research should be conducted with fewer than 17 lessons to examine a possible positive change in student attitudes towards mathematics or word problem-solving without compromising academic gains. The outcomes may support whether students with mathematics disabilities are more attuned to their attuned related to academic abilities after receiving the combined problem-solving lessons.

10. Research should be conducted with an additional extension activity or word problem-solving game to increase student motivation before, during, and after the combined problem-solving strategy. The outcomes may support whether students with mathematics disabilities or students receiving Tier 2 intervention within a
Response-to-Intervention program would report higher levels of satisfaction related to mathematics and word problem-solving.
APPENDIX A

ADDITION SCHEMATIC DIAGRAM
Lesson 1

Objective:

- The teacher will describe the Addition Schematic Diagram.
- The teacher will model how to use the Addition Schematic Diagram with manipulative devices to solve addition computation problems.
- The students will be able to use the Addition Schematic Diagram and manipulative devices to solve addition problems.

Materials:

- Learning Sheet 1 (one per student)
- Addition Schematic Diagram (one per student)
- Manipulative Devices (15 cubes per student)
- Pencils
- Overhead projector or ELMO

Advanced Organizer:

“We see word problems or story problems everywhere. If we have to solve them during math class, during the CRT tests, and when we go shopping. Where have you seen word problems? Have you had to solve a word problem outside of school? Being able to solve word problems – correctly – is important. Over the next few weeks, I will be teaching you a strategy, or an easy way, to correctly solve math word problems.”
Describe and Model:

The teacher will describe the Addition Schematic Diagram.

"Today I am going to model or show you how to solve addition problems using a diagram and cubes. This is our diagram. Teacher holds up the Addition Schematic Diagram. Notice that this diagram has one square, then an addition sign, followed by a second square, then the equal sign, and ending with a large addition sign. Teacher points to each part of the Addition Schematic Diagram. I am going to model how to use this diagram and our cubes to solve three problems. Watch me, as I solve problem number one."

The teacher will describe and model problems one through three.

"Problem number one says, 4 + 5 = ____. First, I am going to look at the first number, 4. I am going to count out that many blocks... Teacher counts out the coordinating number of blocks... and place them in the first square. Second, I am going to look at the second number, 5. I am going to count out that many blocks... Teacher counts out the coordinating number of blocks... and places them in the second square. Third, I am going to slide all of the blocks, from square one and square two, into the addition sign. Fourth, I am going to count how many blocks are in the addition sign. Teacher counts each block in the addition sign, aloud. I counted 9 blocks. So, I am going to place the number 9 in the answer space for problem number one." Teacher models this same process for problems two and three.

Guided Practice:

The teacher guides the students in solving problems four through six.

"Now, let’s work together to solve problems four through six. Remember, I want to see
you use the addition diagram and the cubes to solve each problem. Teacher guides students through problems four through six, gradually reducing support. Who can tell me what I should do first? Right! I must represent the first number, which is X, by placing X cubes in the first square. Now what should I do? Yes! I am going to represent the second number by placing X number of cubes in the second square of our diagram. What is the next step? Thank you – you really have the hang of this! Let’s all slide our cubes, from both squares, into the addition sign. Who can tell me what comes next? Right on! I am going to count my cubes and place the number in the answer for problem number four.” Teacher continues to guide the students through problems five. “Who can tell me how we use our diagram and cubes to solve problem 5? That’s correct. Do that now and let me know if you need assistance.” Teacher monitors student answers and provides immediate corrective feedback if needed. Teacher continues to guide the students through problem six. “Now I’d like you to complete problem six using your diagram and cubes. I’ll help you if you need assistance.” Teacher monitors student answers and provided immediate corrective feedback if needed.

**Independent Practice:**

The students will independently solve problems seven through fifteen. “I really enjoyed solving problems four, five, and six with you, now I want to see if you can solve some addition problems without my support. Just like the previous problems, you will use your addition diagram and cubes to solve each problem. While you’re solving each problem, I will be walking around the room and checking your answer. If you have any questions, please raise your hand.” Teacher walks around the room,
monitoring student answers. If students have an error, the teacher circles the problem number and says, “Let’s try this problem again. I will watch you solve this problem.” The teacher observes the student, providing any necessary corrective feedback. The teacher MUST circle the number of each incorrect problem, as these problems will be scored incorrect during grading. It looks like everyone has completed their problems. Thank you for working so hard today. Tomorrow, we will solve some more addition problems using our diagram.”

**Fluency Practice:**

Teacher will administer the Computation Review Minute sheet. “After each lesson, we are going to take a Computation Review Minute. This is just like your multiplication minute timed tests. You will solve as many addition and subtraction problems as you can in one minute.” Teacher provides a Computation Review Minute to each student. “When I say begin, you may start on the addition and subtraction problems. After one minute, you will hear me ask you to please stop. At that time, I would like you to place your pencils on the desk and I’ll collect your Computation Review Minute. Ready? Begin.” Students are given one minute to work on the Computation Review Minute. After one minute, the teacher says, “please stop.”

**Scoring:**

The teacher will plot the percentage score for problems six through fifteen and the fluency score (number of correct and incorrect digits) on the student progress chart.
## APPENDIX D

### GRADUATED WORD PROBLEM SEQUENCE

<table>
<thead>
<tr>
<th>Lesson Number</th>
<th>Operation</th>
<th>Instructional Approach</th>
<th>Problem Example</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Addition</td>
<td>Concrete Schema</td>
<td>4 + 3 = ____</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ 4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Addition</td>
<td>Concrete Schema</td>
<td>7 dogs + 2 dogs = ____ dogs</td>
<td>8 cats</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ 3 cats</td>
<td>cats</td>
</tr>
<tr>
<td>3</td>
<td>Subtraction</td>
<td>Concrete Schema</td>
<td>4 -1 = ____</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Subtraction</td>
<td>Concrete Schema</td>
<td>9 girls - 3 girls = ____ girls</td>
<td>5 boys</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 2 boys</td>
<td>boys</td>
</tr>
<tr>
<td>5</td>
<td>Addition &amp; Subtraction</td>
<td>Concrete Schema</td>
<td>7 kites + 1 kites = ____ kites</td>
<td>10 CDs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 2 CDs</td>
<td>CDs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8 cars - 2 cars = ____ cars</td>
<td>5 bags</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+ 5 bags</td>
<td>bags</td>
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<tr>
<td>6-7</td>
<td>Addition &amp; Subtraction</td>
<td>Representation Schema</td>
<td>16 dogs were at the park</td>
<td>+ 14 more dogs joined them</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>dogs were at the park in all</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Addition &amp; Subtraction</td>
<td>Abstract</td>
<td>Introduce the READER Strategy</td>
<td></td>
</tr>
<tr>
<td>9-11</td>
<td>Addition &amp; Subtraction</td>
<td>Abstract</td>
<td>There were 20 dogs at the dog park. 10 dogs joined them. How many total dogs were at the dog park?</td>
<td></td>
</tr>
<tr>
<td>12-14</td>
<td>Addition &amp; Subtraction</td>
<td>Abstract</td>
<td>Thirty dogs were at the dog park. Twenty-four more dogs joined them. How many total dogs were at the dog park this morning?</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------</td>
<td>----------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>15-17</td>
<td>Addition &amp; Subtraction</td>
<td>Abstract</td>
<td>At 7:00 this morning, thirteen dogs were at the dog park. Thirty minutes later, four dogs joined them. How many total dogs were at the dog park this morning?</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E

READER STRATEGY

READER Strategy

Step 1: **R** – read the problem.
Step 2: **E** – examine the question.
Step 3: **A** – abandon irrelevant (unneeded) information.
Step 4: **D** – determine the operation using diagrams, if needed.
Step 5: **E** – enter numbers.
Step 6: **R** – record answer.
APPENDIX F

SAMPLE LEARNING SHEET #1

Learning Sheet 1

Name ________________________________

Describe and Model

1) 4 + 5

2) 8 + 3 = ____

3) 3 + 7

Guided Practice

4) 6 + 2

5) 4 + 4 = ____

6) 1 + 5

Independent Practice

7) 9 + 1

8) 5 + 0 = ____

9) 7 + 3

10) 5 + 5 = ____

11) 2 + 4 = ____

12) 6 + 3

13) 8 + 1

14) 4 + 3 = ____

15) 5 + 4
APPENDIX G

PROGRESS CHART

PROBLEM-SOLVING PROGRESS CHART

Name ____________________________________

Percentage Graph

Rate Graph

Graph Key

<table>
<thead>
<tr>
<th>Percentage Graph</th>
<th>Rate Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>• # Percentage Score Earned</td>
<td>• # correct digits per minute</td>
</tr>
<tr>
<td>○ # incorrect digits per minute</td>
<td></td>
</tr>
</tbody>
</table>

Note. Adapted from *Multiplication Facts 0 to 81* (p. 105), by C.D. Mercer and S.P. Miller, 1992, Lawrence, Kansas: Edge Enterprises.
APPENDIX H

PERMISSION GRANTED FOR THE USE REQUESTION: DR. CECIL MERCER

Dustin B. Mancl
3020 Spokane Drive
Las Vegas, NV 89121

February 9, 2011

Dr. Cecil Mercer
6007 NW 50th Lane
Gainesville, FL 32653

Dear Dr. Mercer:

I am completing a doctoral dissertation at the University of Nevada-Las Vegas entitled "Investigating the Effects of a Combined Problem-Solving Strategy for Students with Learning Difficulties in Mathematics." My doctoral committee chair is Dr. Susan P. Miller. I would like your permission to reprint in my dissertation excerpts from the *Strategic Math Series: Multiplication 0-81* (Mercer & Miller, 1992). The excerpts to be reproduced include: (a) *Student Progress Chart* and (b) *Student Learning Contract*.

The requested permission extends to any future revisions and editions of my dissertation, including non-exclusive world rights in all languages, and to the prospective publication of my dissertation by ProQuest through its UMI® Dissertation Publishing business. ProQuest may produce and sell copies of my dissertation on demand and may make my dissertation available for free internet download at my request. These rights will in no way restrict republication of the material in any other form by you or by others authorized by you. Your signing of this letter will also confirm that you own the copyright to the above-described material.

If these arrangements meet with your approval, please sign this letter where indicated below and return it to me in the enclosed return envelope. Thank you very much.

Sincerely,
Dustin B. Mancl
Doctoral Candidate
University of Nevada, Las Vegas

PERMISSION GRANTED FOR THE USE REQUESTED ABOVE:

Signature: Dr. Cecil Mercer

Date: 2-16-2011

160
APPENDIX I

PERMISSION GRANTED FOR THE USE REQUESTED: DR. SUSAN P. MILLER

Dustin B. Manel
3020 Spokane Drive
Las Vegas, NV 89121

February 9, 2011

Dr. Susan P. Miller
Department of Special Education and Early Childhood
College of Education: University of Nevada Las Vegas
4505 Maryland Parkway, Box 453014
Las Vegas, NV 89154-3014

Dear Dr. Susan P. Miller:

I am completing a doctoral dissertation at the University of Nevada-Las Vegas entitled "Investigating the Effects of a Combined Problem-Solving Strategy for Students with Learning Difficulties in Mathematics." I would like your permission to reprint in my dissertation excerpts from the Strategic Math Series: Multiplication 0-81 (Mercer & Miller, 1992). The excerpts to be reproduced include: (a) Student Progress Chart and (b) Student Learning Contract.

The requested permission extends to any future revisions and editions of my dissertation, including non-exclusive world rights in all languages, and to the prospective publication of my dissertation by ProQuest through its UMI® Dissertation Publishing business. ProQuest may produce and sell copies of my dissertation on demand and may make my dissertation available for free internet download at my request. These rights will in no way restrict republication of the material in any other form by you or by others authorized by you. Your signing of this letter will also confirm that you own the copyright to the above-described material.

If these arrangements meet with your approval, please sign this letter where indicated below and return it to me in the enclosed return envelope. Thank you very much.

Sincerely,
Dustin B. Manel
Doctoral Candidate
University of Nevada, Las Vegas

PERMISSION GRANTED FOR THE USE REQUESTED ABOVE:

[Signature: Dr. Susan P. Miller] Date: 2/19/11

161
Learning Contract

I, _________________________________________, agree to learn the READER Strategy to solve addition and subtraction word problems. If I work hard, I will learn to solve word problems quickly and accurately. This will help me understand math and get better grades.

________________________________ _____________________
Student Signature    Date

I, _________________________________________, agree to do whatever I can to help you learn how to solve addition and subtraction word problems. I will follow the instructions outlined in the READER Strategy Lesson Plans, and I will put my creative energies into showing you how to solve word problems quickly and accurately.

________________________________ _____________________
Teacher Signature    Date

Note: Adapted from Multiplication Facts 0 to 81 (p. 104), by C.D. Mercer and S.P. Miller, 1992, Lawrence, Kansas: Edge Enterprises.
### APPENDIX K

#### COMPUTATION REVIEW MINUTE

<table>
<thead>
<tr>
<th>Computation Review Minute</th>
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</thead>
<tbody>
<tr>
<td>23</td>
</tr>
<tr>
<td>+ 46</td>
</tr>
</tbody>
</table>

| 79 | 84 | 43 | 45 | 52 | 84 |
| - 25 | + 14 | - 40 | + 32 | - 41 | + 15 |

| 52 | 66 | 33 | 73 | 21 | 29 |
| + 45 | - 23 | + 65 | - 50 | + 78 | - 19 |

| 81 | 76 | 48 | 39 | 99 | 53 |
| - 71 | + 13 | - 27 | + 50 | - 54 | + 26 |

| 49 | 57 | 72 | 27 | 61 | 38 |
| + 50 | - 36 | + 22 | - 25 | + 10 | - 14 |

| 79 | 25 | 19 | 56 | 65 | 80 |
| - 68 | + 34 | - 11 | + 12 | - 53 | + 19 |

| 22 | 64 | 64 | 39 | 73 | 53 |
| + 33 | - 32 | + 31 | - 17 | + 26 | - 10 |
# APPENDIX L

## READER SCREENER

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<th>79</th>
<th>84</th>
<th>43</th>
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<td>+14</td>
<td>-40</td>
<td>+32</td>
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</tr>
<tr>
<td></td>
<td>52</td>
<td>66</td>
<td>33</td>
<td>73</td>
<td>21</td>
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<td></td>
<td>+45</td>
<td>-23</td>
<td>+65</td>
<td>-50</td>
<td>+78</td>
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<td>+50</td>
<td>-36</td>
<td>+22</td>
<td>-25</td>
<td>+10</td>
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<tr>
<td>Problem Number</td>
<td>Word Problem</td>
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<td>---------------</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1)</td>
<td>At 7:30 this morning, twenty-six students got on the bus. At 8:00 this morning, twenty-three students got on the bus. How many total students got on the bus?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2)</td>
<td>Belinda is collecting box-tops for a school fundraiser. Belinda’s goal is to collect 75 box-tops in one month. In the past three weeks, Belinda has collected 64 box-tops. How many more box-tops must Belinda collect in order to reach her goal?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3)</td>
<td>Jessica’s dad is flying to Madison, Wisconsin to visit his brother. While he is gone, Jessica will help her mother prepare for a surprise birthday party for her dad. Jessica invites thirteen friends. Jessica’s mother invites thirty-four friends. How many friends did Jessica and her mother invite altogether?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4)</td>
<td>Sammy is volunteering to shovel snow this winter. Last year he shoveled 45 driveways. If he wants to shovel 85 driveways this year, how many more driveways must Sammy shovel?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5)</td>
<td>At 4:00, Tyler baked thirty cookies. At 4:30, Lilly baked forty cookies. At 5:00, Jason baked three cakes. How many total cookies did Tyler and Lilly bake?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6)</td>
<td>Patrick had 17 color crayons in his box. On the bus this morning, Patrick lost some. Now, Patrick only has 10 color crayons in his box. How many color crayons did Patrick lose?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7) Juan had 35 pieces of candy in his bag. He gave some candy to his friends. After arriving home, Juan counted 15 pieces of candy in his bag. How many pieces of candy did Juan give to his friends?

8) Robert is going to help his grandmother this weekend. He will spend 24 hours helping with chores, cooking dinner, and feeding the animals. If Robert spends 14 hours helping with chores and feeding the animals, how many hours are left for cooking?

9) Jeanie is collecting pop cans to recycle for student council. She found thirty-six cans yesterday and thirty-one cans today. Jeanie also found four soda bottles. How many pop cans did Jeanie collect altogether?

10) Becky really enjoys collecting rocks. While at the park, Becky found 24 rocks for her collection. If Becky gives 13 of her new rocks to her younger brother, how many rocks will she have left?

11) Bryan has 14 gold fish in his fish tank. Joey has 13 gold fish in his fish tank. How many gold fish do the boys have all together?

12) Twenty-four ducks were at the pond. Thirty minutes later, some of the ducks flew away. Twelve ducks are still at the pond. How many ducks altogether flew away?
# APPENDIX N

## WORD PROBLEM POSTTEST

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1)</td>
<td>At 7:30 this morning, twenty-six students got on the bus. At 8:00 this morning, twenty-three students got on the bus. How many total students got on the bus?</td>
</tr>
<tr>
<td>2)</td>
<td>Belinda is collecting box-tops for a school fundraiser. Belinda’s goal is to collect 75 box-tops in one month. In the past three weeks, Belinda has collected 64 box-tops. How many more box-tops must Belinda collect in order to reach her goal?</td>
</tr>
<tr>
<td>3)</td>
<td>Jessica’s dad is flying to Madison, Wisconsin to visit his brother. While he is gone, Jessica will help her mother prepare for a surprise birthday party for her dad. Jessica invites thirteen friends. Jessica’s mother invites thirty-four friends. How many friends did Jessica and her mother invite altogether?</td>
</tr>
<tr>
<td>4)</td>
<td>Sammy is volunteering to shovel snow this winter. Last year he shoveled 45 driveways. If he wants to shovel 85 driveways this year, how many more driveways must Sammy shovel?</td>
</tr>
<tr>
<td>5)</td>
<td>At 4:00, Tyler baked thirty cookies. At 4:30, Lilly baked forty cookies. At 5:00, Jason baked three cakes. How many total cookies did Tyler and Lilly bake?</td>
</tr>
<tr>
<td>6)</td>
<td>Patrick had 17 color crayons in his box. On the bus this morning, Patrick lost some. Now, Patrick only has 10 color crayons in his box. How many color crayons did Patrick lose?</td>
</tr>
</tbody>
</table>
7) Juan had 35 pieces of candy in his bag. He gave some candy to his friends. After arriving home, Juan counted 15 pieces of candy in his bag. How many pieces of candy did Juan give to his friends?

8) Robert is going to help his grandmother this weekend. He will spend 24 hours helping with chores, cooking dinner, and feeding the animals. If Robert spends 14 hours helping with chores and feeding the animals, how many hours are left for cooking?

9) Jeanie is collecting pop cans to recycle for student council. She found thirty-six cans yesterday and thirty-one cans today. Jeanie also found four soda bottles. How many pop cans did Jeanie collect altogether?

10) Becky really enjoys collecting rocks. While at the park, Becky found 24 rocks for her collection. If Becky gives 13 of her new rocks to her younger brother, how many rocks will she have left?

11) Bryan has 14 gold fish in his fish tank. Joey has 13 gold fish in his fish tank. How many gold fish do the boys have all together?

12) Twenty-four ducks were at the pond. Thirty minutes later, some of the ducks flew away. Twelve ducks are still at the pond. How many ducks altogether flew away?
APPENDIX O

WORD PROBLEM MAINTENANCE PROBE

1) At 7:30 this morning, twenty-six students were picked up by the red bus. About thirty minutes later, twenty-three students were picked up at a bus stop three blocks away. The bus arrived at school around 8:10 this morning. How many total students were picked up by the red bus?

2) Belinda is collecting box-tops for a school fundraiser. Her class must collect 150 box-tops by the end of the year. Belinda’s goal is to collect 75 box-tops in one month. In the past three weeks, Belinda has collected 64 box-tops. How many more box-tops must Bonnie collect in order to reach her goal?

3) Jessica’s dad is flying to Madison, Wisconsin to visit his brother. While he is gone, Jessica will help her mother prepare for a surprise birthday party for her dad. Jessica invites thirteen friends. Jessica’s mother invites thirty-four friends. Jessica’s brother will turn ten in four days. How many total friends did Jessica and her mother invite altogether?

4) Sammy is volunteering to shovel snow this winter. Last year he shoveled 45 driveways. If he wants to shovel 85 driveways this year, how many more driveways must Sammy shovel?

5) At 4:00, Tyler baked thirty cookies. At 4:30, Lilly baked forty cookies. At 5:00, Jason baked three cakes. How many total cookies did Tyler and Lilly bake?

6) Patrick enjoys making cards for his friends and family. Three weeks before Valentine’s Day, Patrick started to make cards. After three weeks he has made fifty-four cards. Patrick has sixty-five friends he would like to give cards to. How many more cards must Patrick make so each friend will get one card?
7) Bernard is going to his uncle’s house in the country. On the way there, he counts 25 cows and 24 horses eating grass in a pasture. He also saw 10 red barns. How many total farm animals did Bernard count on his way to the country?

8) Robert is going to help his grandmother this weekend. He will spend 24 hours helping with chores, cooking dinner, and feeding the animals. Although Robert enjoys cooking the dinner most, he spends 14 hours helping with chores and feeding the animals. How many total hours can Robert spend helping his grandmother cook dinner?

9) Jeanie is collecting pop cans to recycle for student council. She found thirty-six cans yesterday and thirty-one cans today. Jeanie also found four pop bottles. How many pop cans did Jeanie collect altogether?

10) Becky really enjoys collecting rocks. While at the park, Becky found 24 rocks for her collection. Carlee, Becky’s best friend, also collects rocks. Carlee found 22 rocks for her collection. If Becky gave 13 of her new rocks to her younger brother, how many total rocks did Becky bring home for her collection?
1) At 7:30 this morning, twenty-six students were picked up by the red bus. About thirty minutes later, twenty-three students were picked up at a bus stop three blocks away. The bus arrived at school around 8:10 this morning. How many total students were picked up by the red bus?

2) Belinda is collecting box-tops for a school fundraiser. Her class must collect 150 box-tops by the end of the year. Belinda’s goal is to collect 75 box-tops in one month. In the past three weeks, Belinda has collected 64 box-tops. How many more box-tops must Bonnie collect in order to reach her goal?

3) Jessica’s dad is flying to Madison, Wisconsin to visit his brother. While he is gone, Jessica will help her mother prepare for a surprise birthday party for her dad. Jessica invites thirteen friends. Jessica’s mother invites thirty-four friends. Jessica’s brother will turn ten in four days. How many total friends did Jessica and her mother invite altogether?

4) Sammy is volunteering to shovel snow this winter. Last year he shoveled 45 driveways. If he wants to shovel 85 driveways this year, how many more driveways must Sammy shovel?

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9) Jeanie is collecting pop cans to recycle for student council. She found thirty-six cans yesterday and thirty-one cans today. Jeanie also found four pop bottles. How many pop cans did Jeanie collect altogether?

10) Becky really enjoys collecting rocks. While at the park, Becky found 24 rocks for her collection. Carlee, Becky’s best friend, also collects rocks. Carlee found 22 rocks for her collection. If Becky gave 13 of her new rocks to her younger brother, how many total rocks did Becky bring home for her collection?

11) Bryan has 14 gold fish in his fish tank. Joey has 13 gold fish in his fish tank. How many gold fish do the boys have all together?

12) Twenty-four ducks were at the pond. Thirty minutes later, some of the ducks flew away. Twelve ducks are still at the pond. How many ducks altogether flew away?
1) Michelle had 16 stickers. She gave 5 stickers to her friend. How many stickers does Michelle have left?

2) Kirsten has 16 pairs of shoes. Her older sister gave her 4 more pairs of shoes. How many pairs of shoes does Kirsten have in all?

3) Curt saw 31 movies last year. He saw 24 movies this year. How many total movies has Curt seen?

4) Jenny threw the ball 53 times. Kelly threw the ball 41 times. How many times in all did the girls throw the ball?

5) Ian collects buttons. He found 27 buttons yesterday at three garage sales. Today he found 11 more buttons. How many total buttons did Ian find yesterday and today?

6) Kenny had 46 chocolate chip cookies. He gave 35 chocolate chip cookies to his friends. How many chocolate chip cookies does Kenny have left?

7) Bernard is going to his brother’s house in the country. On the way there, he counts 21 cows and 17 horses eating grass in a pasture. He also saw 12 red barns. How many total farm animals did Bernard count on his way to the country?

8) Anthony can play 17 songs on his guitar. He can also play 11 songs on his violin. How many songs in all can Anthony play?
9) Andrea and her father grilled 24 hamburgers for her party. Andrea’s friends ate 20 hamburgers. How many hamburgers are left over?

10) Becky really enjoys collecting rocks. While at the park, Becky found 24 rocks for her collection. Carlee, Becky’s best friend, also collects rocks. Carlee found 22 rocks for her collection. If Becky gave 13 of her new rocks to her younger brother, how many total rocks did Becky bring home for her collection?
APPENDIX R

PROBE B

1) Jimmy rode his bike 38 miles during the first week of school. He rode his bike 31 miles during the second week of school. How many miles did Jimmy ride his bike?

2) Jeff played 18 games on Friday and 16 games on Saturday. How many games did Jeff play in all?

3) Ron found 27 seashells at the beach. He only brought 14 seashells home. How many seashells did Ron leave at the beach?

4) Alicia has 17 cousins that live in Arizona and 12 cousins that live in Oregon. How many cousins does Alicia have that live in both Arizona and Oregon?

5) Christie ran around the track 26 times. She walked around the track 14 times. How many more times did Christie run around the track than walk around the track?

6) Doug saw 23 ships on the Lake Superior and 13 ships on the Lake Michigan. How many ships in all did Doug see on both the Lake Superior and Lake Michigan?

7) Lisa sang five songs at the talent show. Linda sang three songs at the talent show and Carrie played three songs on her guitar. How many total songs were sung at the talent show?

8) Susan counted 52 trees on the way to school. Sandy counted 32 trees on the way to school. How many trees in all did Susan and Sandy count?
9) Mary saved 53 dollars from her birthday party. She earned 16 dollars for doing her shores. How much money does Mary have now?

10) Sixty-three students were at the talent show. Fifteen students performed in front of their peers. Twenty-three parents also were at the talent show. How many more students were watching the show compared to parents?
<table>
<thead>
<tr>
<th></th>
<th>1) Amanda bought 64 color crayons. She bought 14 more color crayons. How many color crayons does Amanda have?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2)</td>
<td>Jennifer has 43 CDs. She gave 11 CDs to her little brother. How many CDs does Jennifer have left?</td>
</tr>
<tr>
<td>3)</td>
<td>Raul read 58 pages yesterday and 21 pages today. How many pages has Raul read in all?</td>
</tr>
<tr>
<td>4)</td>
<td>Paula can type 86 words per minute on the computer. Patrick can type 55 words per minute on the computer. How many more words per minute can Paula type on the computer than Patrick?</td>
</tr>
<tr>
<td>5)</td>
<td>Karen made 37 phone calls to her friends. 26 phone calls were long distance. How many phone calls were not long distance?</td>
</tr>
<tr>
<td>6)</td>
<td>Gail played 17 games of golf on Friday and 15 games of golf on Sunday. How many games of golf did Gail play in all?</td>
</tr>
<tr>
<td>7)</td>
<td>David and Donna were collecting leaves. They found 74 green leaves and 53 red leaves. How many more green leaves than red did David and Donna find?</td>
</tr>
<tr>
<td>8)</td>
<td>Susan counted 15 clouds on the way to school. Sandy counted 12 clouds on the way to school. How many clouds in all did Susan and Sandy count?</td>
</tr>
</tbody>
</table>
9) At three o’clock this afternoon a storm moved into Las Vegas lasting forty-five minutes. At six o’clock this evening another storm moved into Las Vegas lasting fifteen minutes. How many more minutes did the afternoon storm last compared to the evening storm?

10) Kelly is walking dogs for a summer job. Her goal is to walk 77 dogs by the end of the summer. Last month Kelly walked 43 dogs. How many more dogs must Kelly walk to reach her goal for this summer?
Describe and Model

1) At 7:00 this morning, three dogs were at the dog park. Thirty minutes later, four more dogs joined them. How many total dogs were at the dog park this morning?

2) Mr. Mancl had 65 pieces of candy on Halloween. He handed out 45 pieces to children in his neighborhood. How many total pieces of candy does Mr. Mancl have left?

3) Mary must catch two buses to school each day. The first bus takes 23 minutes. The second bus takes 35 minutes. How many total minutes does Mary ride the bus to school each day?

Guided Practice

4) Joan has to set the table for dinner. She places 12 forks and 12 knives at each place setting. How many total forks and knives did Joan set on the table?

5) Matt enjoys watching Saturday morning cartoons. Last Saturday he watched four cartoons. This Saturday he watched seven cartoons. How many cartoons did Matt watch all together?

6) Tom is going fishing with three of his friends. While fishing, Tom uses 20 worms as bait. Originally, Tom bought 30 worms. How many worms does Tom have left to use as bait?

Independent Practice

7) Jean is collecting box-tops for a school fundraiser. Her goal is to collect 95 box-tops. Joan has collected 75 box-tops thus far. How many more box-tops must Jean collect to reach her goal?
8) Jimmy enjoys reading chapter books. The book he is reading has 26 chapters. If he reads 5 chapters today, how many more chapters must Jimmy read in order to finish the book?

9) Kyle is planning a birthday party. He is inviting 26 friends from school and 13 friends from church. How many total friends is Kyle inviting to his birthday party?

10) Dolores is buying birthday candles for Kyle’s birthday cake. She bought a box of 20 birthday candles. If Kyle is turning 10 years old, how many birthday candles will Dolores have left after the party?

11) Jessica read 24 pages yesterday and 10 pages today. How many pages has Jessica read in all?

12) Juan is volunteering at the animal shelter. He will spend 24 hours at the animal shelter over the next two weeks. If Juan spent 14 hours at the animal shelter last week, how many more hours must Juan spend at the animal shelter this week?

13) Brian collects stuffed animals. He bought 13 dogs and 14 cats. How many stuffed animals does Brian have in all?

14) Heidi is collecting pop cans to recycle. She found 25 cans yesterday and 31 cans today. How many pop cans did Heidi collect altogether?

15) Mrs. Larson has 54 books. She gave 42 books to her students. How many books does Mrs. Larson have now?
APPENDIX U

GENERALIZATION TEST

1) At 8:00 this morning, twenty-four students got on the bus. At 8:30 this morning, twenty-one students got on the bus. How many total students got on the bus?

2) Belinda is collecting soup labels for a school fundraiser. Belinda’s goal is to collect 65 soup labels in one month. In the past three weeks, Belinda has collected 54 soup labels. How many more soup labels must Belinda collect in order to reach her goal?

3) Jessica’s dad is flying to St. Paul, Minnesota to visit his brother. While he is gone, Jessica will help her mother prepare for a surprise birthday party for her dad. Jessica invites fourteen friends. Jessica’s mother invites twenty-four friends. How many friends did Jessica and her mother invite altogether?

4) Jenny is volunteering to shovel snow this winter. Last year she shoveled 35 driveways. If she wants to shovel 65 driveways this year, how many more driveways must Jenny shovel?

5) At 5:00, Kyle baked twenty cookies. At 5:30, Lilly baked forty cookies. At 5:45, Jason baked three cakes. How many total cookies did Kyle and Lilly bake?

6) Pat had 17 color crayons in his box. On the bus this morning, Pat lost some. Now, Pat only has 11 color crayons in his box. How many color crayons did Pat lose?

7) Jason had 25 pieces of candy in his bag. He gave some candy to his friends. After arriving home, Jason counted 15 pieces of candy in his bag. How many pieces of candy did Jason give to his friends?
8) Bob is going to help his grandmother this weekend. He will spend 26 hours helping with chores, cooking dinner, and feeding the animals. If Bob spends 16 hours helping with chores and feeding the animals, how many hours are left for cooking?

9) Jean is collecting pop cans to recycle for student council. She found thirty-four cans yesterday and thirty-two cans today. Jean also found five soda bottles. How many pop cans did Jean collect altogether?

10) Sara really enjoys collecting rocks. While at the park, Sara found 22 rocks for her collection. If Sara gives 12 of her new rocks to her younger brother, how many rocks will she have left?

11) Mark has 13 gold fish in his fish tank. Tim has 12 gold fish in his fish tank. How many gold fish do the boys have altogether?

12) Twenty-three geese were at the pond. Thirty minutes later, some of the geese flew away. Thirteen geese are still at the pond. How many geese altogether flew away?
# APPENDIX V

## SOCIAL VALIDITY QUESTIONNAIRE

<table>
<thead>
<tr>
<th>Social Validity Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please indicate the extent to which you agree or disagree with the following statements regarding the READER Strategy by circling a number that most closely reflects your opinion.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

1) The READER Strategy helped me solve math word problems.

   1   2   3   4

2) I will be able to use the READER Strategy in math class while solving math word problems.

   1   2   3   4

3) The READER Strategy was easy to use.

   1   2   3   4

4) I enjoyed learning how to use the READER Strategy.

   1   2   3   4

5) I enjoyed solving the word problems on the learning sheets.

   1   2   3   4

6) The READER Strategy lessons where easy to understand.

   1   2   3   4

7) I enjoyed using the READER Strategy diagrams.

   1   2   3   4

8) I will be able to use the READER Strategy diagrams in math class.

   1   2   3   4

9) The READER Strategy diagrams helped me solve math word problems.

   1   2   3   4

10) I would recommend the READER Strategy to my friends who struggle with solving math word problems.

    1   2   3   4
APPENDIX W

ATTITUDE SURVEY

Social Validity Attitude Survey
Please indicate the extent to which you agree or disagree with the following statements by circling a number that most closely reflects your opinion.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Agree</th>
<th>Somewhat Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) I am good at addition word problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2) I am good at subtraction word problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3) Math is one of my favorite subjects.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>4) I think math word problems are fun.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5) I think math word problems are easy.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX X

ENGLISH PARENT CONSENT FORM

PARENT PERMISSION FORM
Department of Special Education

TITLE OF STUDY: Investigating the Effects of a Combined Problem-Solving Strategy for Students with Learning Difficulties in Mathematics

INVESTIGATOR(S): Mr. Dustin B. Mancland Dr. Susan Miller (Doctoral Committee Chair)

CONTACT PHONE NUMBER: 702-799-8950 (Mr. Mancl) or 702 895-1108 (Dr. Miller)

Purpose of the Study
Your child is invited to participate in a research project. The purpose of this study is to explore the effectiveness of mathematics lessons designed to help students solve addition and subtraction word problems.

Participants
Your child is being asked to participate in the study because he/she needs help with math word problems, which include addition or subtraction.

Procedures
If you allow your child to volunteer to participate in this study, the scores your child earns on a pretest, posttest, and daily worksheets that accompany his word problem lessons will be shared with the investigator. Your child will receive the word problem instruction regardless of whether you give permission for his or her pretest, posttest, and daily worksheet scores to be used in the study. If you choose not to participate, your child’s pretest, posttest, and daily worksheet scores will not be included in the study analysis.

Benefits of Participation
There may be direct benefits to your child as a participant in this study. Allowing the investigator to analyze your child’s mathematics performance using the tests and worksheets he/she completes during his mathematics instruction will help inform his/her teacher about the effectiveness of the instruction he/she is providing to your child. This information will help plan future mathematics instruction to better address your child’s educational needs.

Risks of Participation
There are risks involved in all research studies. The risks associated with this study are minimal. It is possible that your child may experience minimal stress or discomfort related to the sharing of test and worksheet scores if he/she makes errors on some of the problems.

**Cost /Compensation**
There will not be financial cost to your child to participate in this study. There will be no compensation.

**Contact Information**
If you or your child have any questions or concerns about the study, you may contact Mr. Dustin B. Mancl at 702-799-8950 or Dr. Susan Miller at 702-895-1108. For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted you may contact the UNLV Office for the Protection of Research Subjects at 702-895-2794.

**Voluntary Participation**
Your child’s participation in this study is voluntary. Your child may refuse to participate in this study or in any part of this study. Your child may withdraw at any time without prejudice to your relations with the university or Paradise Professional Development School. You or your child are encouraged to ask questions about this study at the beginning or any time during the research study.

**Confidentiality**
All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials that could link your CHILD to this study. All records will be stored in a locked facility at UNLV for three years after completion of the study. After the storage time, the information gathered will be destroyed and computer files erased.

**PARENT PERMISSION:**
I have read the above information and agree to ALLOW MY CHILD TO participate in this study. I am at least 18 years of age. A copy of this form has been given to me.

________________________________________  __________________________
Signature of Parent                                             Date

Parent Name (Please Print)

________________________________________

CHILD’S NAME

*Participant Note: Please do not sign this document if the Approval Stamp is missing or is expired.*
APPENDIX Y

SPANISH PARENT CONSENT FORM

CONSENTIMIENTO GENERAL PARA LOS PADRES

Departamento de Educación Especial

TITULO: Investigación de los efectos de una estrategia combinada para resolver problemas para los estudiantes con dificultades de aprendizaje en matemáticas

INVESTIGADOR(ES): Sr. Dustin B. Mancl Dra. Susan Miller (Doctoral Committee Chair)

NÚMERO DE TELÉFONO: 702-799-8950 (Sr. Mancl) or 702 895-1108 (Dra. Miller)

Propósito del Estudio
Se invita a su niño/a que participe en un proyecto de investigación. El propósito de este estudio es explorar la eficacia de las lecciones de matemáticas diseñadas para ayudar a los estudiantes a solucionar problemas de matemáticas de las sumas y de las restas.

Participantes
Están pidiendo que su niño/a participe en el estudio porque él/la necesita ayuda con los problemas de palabra de matemáticas, que incluyen en las sumas o las restas.

Procedimientos
Si usted permite que su niño/a se ofrezca voluntariamente para participar en este estudio, las calificaciones que su niño/a saque en una prueba preliminar, posterior, y las hojas de trabajo diarias que acompañan sus lecciones del problema de palabras serán compartidas con el investigador. Su niño/a recibirá la instrucción del problema de palabras sin importar si usted da el permiso para que suprueba preliminar, posterior, y hojas de trabajo diarias sean utilizadas en el estudio. Si usted elige no participar, la prueba preliminary, posterior y las hojas de trabajo diarias de su niño/a no serán incluidos en el análisis del estudio.

Beneficios para los participantes
Puede haber ventajas a su niño/a como participante en este estudio. Permitir que el investigador analice el funcionamiento de las matemáticas de su niño/a usando las pruebas y las hojas de trabajo que él/la terminadurantes la instrucción de las matemáticas ayudará a informar a su maestro/a sobre la eficacia de la instrucción ésta proporcionando a su niño/a. Esta información ayudará a planear la instrucción futura de matemáticas para mejorar las necesidades educativas de su niño/a.
### Riesgos de la participación
Hay riesgos implicados en todo estudio de investigación. Los riesgos asociados en este estudio son mínimos. Es posible que su niño pueda sentir la tensión o el se disguste minimamente relacionado al recibir las calificaciones de sus pruebas y sus hojas de trabajo si él/la comete errores en algunos de los problemas.

### Costos/Pagos al participante
No habrá ninguno costos para compensaciones por participar en este estudio.

### Información para hacer contacto
Si usted o su niño/a tiene alguna pregunta o duda con respecto a este estudio, usted puede comunicarse con el **Sr. Dustin B. Mancl** al 702-799-8950 o la **Dra. Susan Miller** al 702 895-1108. Para preguntas con respecto a los derechos de los participantes de la investigación, cualquier queja o comentario con respecto a la manera de la cual el estudio se está conduciendo, contacte las **Oficinas para la protección de sujetos de investigación de UNLV** al 702-895-2794.

### Participación Voluntaria
La participación de su niño/a en este estudio es voluntaria. Su niño/a puede rechazar participar en este estudio o en cualquier parte de este estudio. Su niño/a puede retirarse en cualquier momento sin prejuicio a algunas relaciones con la universidad o de la Escuela Primaria de Paradise Development School. Les recomendamos a usted o a su niño/a hacer preguntas acerca de este estudio al principio o en cualquier momento durante el desarrollo del estudio de la investigación.

### Confidencialidad
Toda información recopilada en este estudio será manejada en forma confidencial. No se hará ninguna referencia en los materiales escritos u orales que podrían ligar a su NIÑO/A a este estudio. Todos los expedientes serán archivados en una facilidad cerrada en UNLV porters años después de la terminación del estudio. Después del tiempo estipulado, la información recopilada será destruida y los ficheros informáticos serán borrados.

### PERMISO DEL PADRE:
He leído la información antedicha y acuerdo PERMITIR que MI NIÑO/A participe en este estudio de investigación. Doy fe que soy mayor de edad y que he recibido copia de este documento.

<table>
<thead>
<tr>
<th>Firma de Padre</th>
<th>Fecha</th>
</tr>
</thead>
</table>

Nombre del Padre (Favor de escribir en letra de molde)

**NOMBRE DEL NIÑO/A**

*Nota al Participante:* Favor de no firma este documento si el Sello de Aprobación falta o estecaducado.
STUDENT FORM
ASSENT TO PARTICIPATE IN RESEARCH

Investigating the Effects of a Combined Problem-Solving Strategy for Students with Learning Difficulties in Mathematics

1. My name is Mr. Dustin B. Mancl.

2. We are asking you to be in a project that will help us teach math better.

3. If you agree to be in the project, your teacher will tell me some of your math grades. He/she will tell me the grades you get on word problem tests and worksheets.

4. You might not feel good about having your grades shared if you miss some of the problems, but I think you are going to get good grades on this work.

5. If you agree to let your teacher tell me your math grades, we’ll be able to tell if the instruction helped you learn.

6. Please talk to your parents before you decide to participate in this project. We will also ask your parents to give their permission for you to take part in this project. But even if your parents say “yes” you can say “no.”

7. If you don’t want to share your grades, you don’t have to. No one will be mad if you don’t want to share your grades. If you say “yes” now and change your mind later, that’s OK. You can stop sharing your grades any time you want.

8. You can ask any questions that you have about this project. You can call me at 702-799-8950 or my university advisor, Dr. Susan P. Miller at 702 895-1108. If I don’t answer your questions or you do not want to talk to me about your question, you or your parent can call the UNLV Office for the Protection of Research Subjects at 702-895-2794.

9. Signing your name on the line below means that you agree to be in this project. You and your parents will be given a copy of this form after you have signed it.

______________________________  ______________________________
Print your name                                      Date

______________________________
Sign your name
APPENDIX AA
FIDELITY OF TREATMENT

Directions: The Observer will place a check (√) next to “Yes” if the action is observed during the READER Lesson. If the action is NOT observed, the Observer place a dash (-) next to “No.”

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Advance Organizer</td>
</tr>
<tr>
<td>2.</td>
<td>Describe and Model</td>
</tr>
<tr>
<td>3.</td>
<td>Guided Practice</td>
</tr>
<tr>
<td>4.</td>
<td>Independent Practice</td>
</tr>
<tr>
<td>5.</td>
<td>Fluency</td>
</tr>
</tbody>
</table>

190
REFERENCES


Retrieved from http://vnweb.hwwilsonweb.com/hww/results/get


Individuals with Disabilities Education Improvement Act of 2004 (IDEA), 20 U.S.C. §614 et seq.


Degrees:
   Bachelor of Science, Education, 2001
   University of Nevada, Las Vegas

   Masters of Education, Special Education, 2005
   University of Nevada, Las Vegas

Publications:


Dissertation Title:
*Investigating the Effects of a Combined Problem-Solving Strategy for Students with Learning Difficulties in Mathematics*

Dissertation Examination Committee:
   Chairperson, Susan P. Miller, Ph. D.
   Committee Member, Pamela Campbell, Ph. D.
   Committee Member, Kyle Higgins, Ph. D.
   Committee Member, Dick Tandy, Ph. D.