USE OF A MATHEMATICS WORD PROBLEM STRATEGY TO IMPROVE
ACHIEVEMENT FOR STUDENTS WITH MILD DISABILITIES

by

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This dissertation was prepared under the direction of the candidate’s dissertation advisor, Dr. Mary Lou Duffy, Department of Exceptional Student Education, and has been approved by the members of her supervisory committee. It was submitted to the faculty of the College of Education and was accepted in partial fulfillment of the requirements for the degree of Doctor of Education.

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Mathematics can be a difficult topic both to teach and to learn. Word problems specifically can be difficult for students with disabilities because they have to conceptualize what the problem is asking for, and they must perform the correct operation accurately. Current trends in mathematics instruction stem from the National Council of Teachers of Mathematics (NCTM) Principles and Standards for School Mathematics that call for an inquiry learning model (NCTM, 2000). Unfortunately, this model may not be sufficient to meet the needs of students with disabilities. Researchers are currently looking at what elements will assist students with disabilities to learn mathematics both conceptually and procedurally. Explicit direct instruction, modeling, guided and independent practice, and providing advanced organizers have been found to help students with disabilities to be successful. This study focused on students with mild disabilities being served in the general education classroom for most of the school day.

Three fifth-grade students with mild disabilities were selected to be taught a
strategy incorporating the concrete-representational-abstract (CRA) sequence of learning, schematic strategy based instruction, and self-regulation strategies. A multiple baseline across participants design was used with a follow-up phase. The intervention was implemented extending the work of Jitendra, DiPipi, and Perron-Jones (2002) and consisted of instruction in determining word problem types using the CRA sequence of learning. In addition, self-monitoring was incorporated using a mnemonic strategy.

Results indicated that students with mild disabilities were able to use the strategy independently to accurately solve the training word problems using division or multiplication. Also, students were able to generalize both the strategy use as well as the word problem accuracy to the measurement of area problems. Additionally, two of the three students continued to use the strategy appropriately to accurately solve word problems in the 6-week follow-up phase. Suggestions for future studies are provided as well as educational implications.
DEDICATION

This manuscript is dedicated to my family, particularly to my understanding and patient husband, Jack, who has provided solace, comfort, and support during the many years of research and study. I also dedicate this manuscript to my late parents, Frank and Patricia, who always encouraged me to reach for the stars.
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Chapter 1: Introduction

Mathematics can be a daunting topic to students with disabilities as well as to those who struggle to acquire mathematics skills. While the areas of science, history, and social studies require skill in reading, mathematics is an area that not only requires reading skill, but has its own set of unique characteristics. According to the National Research Council’s (NRC) Publication *Adding It Up*, success in mathematics requires conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (NRC, 2001). Similar to the NRC’s requirements for success in mathematics, the National Mathematics Advisory Panel (NMAP, 2008) advocated conceptual understanding, computational fluency, and problem solving. These components or strands are interwoven and all must be addressed to make for an effective and balanced mathematics curriculum.

Conceptual understanding, according to the NRC (2001), refers to an integrated comprehension of mathematical concepts and requires that students be able to represent numbers and concepts in different ways. Therefore, methods, procedures, and basic facts are not learned in isolation; rather new concepts are connected with previously learned material so that students are better able to not only retain the new skills, but to decide whether the new methods make sense.

Procedural fluency has three critical elements. The first is the ability to remember the steps involved in solving a long division problem or a 3-digit by 3-digit
multiplication problem, for example. The second part is the ability to apply the procedure with fluency, and the third part is knowing when and how to use the steps appropriately. All of these elements are interrelated and require many practice experiences for students to become proficient (NMAP, 2008; NRC, 2001).

Strategic competence involves students formulating or representing problems in order to solve them. Formulating problems involves getting a “picture” of the word problem to be solved and is an essential first step in problem solution. Strategic competence not only involves deriving a picture of the problem but also involves the plan or strategy to solve it.

The NRC defines adaptive reasoning as justifying answers as reasonable and reflecting on different ways to solve word problems. Powers of estimation are important as well in that students need to be able to estimate the number of people who could fit into a movie theater for example (NMAP, 2008). The last component for success in mathematics is productive disposition. This is defined as seeing mathematics as sensible, useful, and worthwhile. According to the NMAP, emphasis needs to be placed on the importance of student effort when learning mathematics concepts, rather than on ability. This emphasis can lead to increased mathematics performance and an increased sense of mathematics efficacy, another important component of productive disposition (NMAP, 2008; NRC, 2001).

For students to learn mathematics deeply and conceptually, a whole new set of teaching techniques is required. No longer is it acceptable to have students memorize the steps to solving equations for example. Students must understand why the steps are necessary and how they fit together. Students must also understand that there are
various methods to solve mathematical problems and that one method is not necessarily
to another. The model that was proposed by the NCTM Principles and
Standards for School Mathematics encourages students to explain, discuss, and seek
varying solutions to problems thus tending to promote conceptual thinkers (Carnine,

Moreover, it is vital that all students obtain a working knowledge of mathematics
so that they are able to apply their knowledge to real world situations. Therefore, one of
the most important goals of K-12 education is the development of mathematical
reasoning (NRC, 2001). In addition, the NRC’s Adding It Up (2001) warns that students
will be vastly unprepared for careers in our technological age if schools don’t work to
change their focus from rote learning to conceptual understanding. In our computerized
and fast paced society, there is a need for good mathematicians as well as good readers.
Technological advances have increased the need for mathematics knowledge for future
employees in all domains (Middleton & Spanias, 1999).

**Trends in Mathematics Instruction**

Current trends in mathematics instruction stem from the NCTM Principles and
Standards for School Mathematics (NCTM, 2000). Real mathematics reform began to
take place with the establishment of the NCTM Curriculum and Evaluation Standards of
1989 (NCTM, 1989; Woodward & Montague, 2002). These standards encouraged
teachers to look at instructional pedagogy in different ways focusing on conceptual
learning rather than rote memory and drill and practice. It became important for students
to understand the concepts underlying the algorithms that they were learning.
Cooperative learning strategies were encouraged allowing students to converse with each
other as to the correct ways to solve word problems (Carr, 2010; NCTM, 2000).

Moreover, research indicates that students are better able to conceptualize math word problems by talking about or explaining the underlying concepts to others to discover various ways of solving them (L. Ma, 1999). Therefore, the NCTM took a constructivist stance allowing students to learn through project based instruction and inquiry learning. In addition, the NCTM principles call for high expectations for all students and a cohesive and connected curriculum across grade levels. The 2000 revision of the 1989 NCTM Standards included a new standard on representation involving the acquisition of concepts in various ways: that is, mentally, symbolically, graphically, and through the use of manipulative objects (NCTM, 2000). The NRC’s *Adding It Up* (2001) stressed that students need to interact with materials representing numbers and problems in various ways to construct their understanding of mathematics as well. The evolution of the NCTM standards is important because the standards provide the template used by the majority of states in designing their own curriculum and standards (Maccini & Gagnon, 2002).

Strengthening the trends that are guided by the NCTM’s Principles and Standards is legislation emphasizing the need for education reform. No Child Left Behind [NCLB], 2002) and the Individuals with Disabilities Education Improvement Act (IDEA, 2004) have stressed the need for high expectations for all students as well. In addition, IDEA stresses that students with disabilities be educated in the least restrictive environment which would be the general education classroom where appropriate. Therefore, more and more students with disabilities are being educated in general education settings. In addition, it has been estimated that between 5% and 8% of students in general education
classrooms have mathematics learning disabilities (Cawley, Parmar, Foley, Salmon, & Roy, 2001; Fuchs & Fuchs, 2003; Geary, 2004).

Holding the same high expectations for students with mild disabilities as for typically developing students is essential. However, current trends in mathematics education emphasizing constructivism and conceptual learning may not be enough for students with mild disabilities, especially those who participate in general education classrooms. Providing explicit instruction and plenty of practice experiences may be necessary for students with mild disabilities to be successful.

**Students With Disabilities and Mathematics Reform**

Students with mild disabilities (e.g., learning disabilities or other health impairments) are different from typically developing students in several fundamental ways (Reid & Leinemann, 2006). According to Gersten and Clarke (2007), impulsivity frequently prevents students with mild disabilities from thinking and reflecting on a problem before giving an answer. Students with mild disabilities often display inattention, lack of motivation and difficulties with self-regulation as well. They tend to be passive learners making them reluctant to try new tasks or to persevere when something seems difficult (Maccini & Gagnon, 2000; Montague, 2007). Some have experienced so much failure in mathematics that they tend to give up in order to avoid the emotional stress of failing again.

Therefore, students with mild disabilities often have difficulties acquiring mathematics concepts. When problem solving, many students with mild disabilities exhibit an inability to detect and correct mistakes, have an uncertain approach to solving problems, and have difficulty with problem representation (Montague, 2007). Their use
of self-regulatory strategies is frequently immature and their knowledge of mathematical concepts is weak (Swanson, 2006). In general, students with mild disabilities have difficulty activating and regulating strategic behavior, possess incomplete or poorly integrated knowledge, and show low levels of engagement (Graham & Harris, 2003). The call by NCTM to teach using inquiry learning that is student directed may not meet the needs of those students who struggle with mathematical concepts. A meta-analysis conducted by Swanson, Hoskyn, and Lee (1999) identified direct instruction as the most effective way of teaching students with mild disabilities. Student centered instruction, discovery learning, and the accompanying high expectations may not be enough for students with mild disabilities without careful planning and scaffolding built in by teachers (Woodward & Montague, 2002). In fact, over the last 40 years special education classrooms have used primarily teacher directed instruction and have focused on computation and basic skills, at times neglecting the areas of word problem solving and higher order application skills. Special education in general has a strong history in the drill and practice paradigm (Cawley, 2002; Cirino et al., 2008). This drill and practice approach required that students memorize math facts through repeated exposure and immediate feedback. Students with disabilities however, have tremendous difficulty with memorization in general. Therefore, so much cognitive effort goes into remembering basic math facts that there is little cognition left for application to word problems (Baker, Gersten, & Lee, 2002). Moreover, remembering basic math facts does not automatically lead to proficiency at solving word problems.

Typically, these students need teacher direction in the form of scaffolding when initially learning new concepts (Kroesbergen, Van Luit, & Maas, 2004). In 2004,
Kroesbergen, et al. conducted a study where they compared the effectiveness of an explicit model of instruction with a constructivist approach in teaching multiplication skills in small groups. The study involved 265 students who had difficulty learning mathematics. The participants were divided into three groups: One group used constructivist methods, one group received explicit systematic instruction, and one group received traditional instruction. Results indicated that students receiving either the constructivist or explicit, systematic models of instruction improved their multiplication skills more than those in the traditional model. However, it was also observed that explicit math instruction was more effective than constructivist instruction especially for students with difficulty learning multiplication facts (Kroesbergen et al., 2004).

**Statement of the Problem**

Unfortunately, students with weaknesses in mathematics are likely to fall further behind because much of mathematics learning is cumulative, with each new concept building upon mastery of the previous one (Montague, 2007). For example, learning division is contingent upon mastery of subtraction concepts. To solve a word problem involving division, students must not only exhibit skill at division and subtraction, they must also conceptualize what the problem is asking for. Just as good readers who employ metacognitive strategies to “fix up” failing comprehension, good mathematicians use self discovered strategies to solve word problems, in the same manner. However, students with disabilities typically either don’t know the correct strategies to use or when to use them (Montague, 1997; Swanson, 2006). These factors make mathematics a difficult discipline to teach and to learn. Therefore, research in the area of mathematics should
focus on the most effective interventions and practices, particularly in the area of strategy instruction, for students with mild disabilities.

The mediocre progress made internationally in math achievement over the last 12 years lends additional support for mathematics intervention research. For example, the most recent Trends in International Mathematics and Science Study (TIMSS) represents the fourth in a series of mathematics assessments begun in 1995 (Mullis, Martin, & Foy, 2008). Although U.S. fourth graders show a general trend of improvement from 1995 to 2007, they were still outperformed by their counterparts in eight other countries (Mullis et al., 2008). Additionally, comparing results from 1990 to 2001 of the National Assessment of Educational Progress (NAEP) in Mathematics (Institutes of Education Sciences, 2009), disseminated by the National Center for Education Statistics (NCES), fourth graders’ results were higher in 2009 than in 1990. However, from 2009 to 2011, average scores increased in only five states while in one state, scores actually went down. There were no significant changes in the remaining states (NCES, 2011). In addition, although students with disabilities made gains between 1996 and 2011 the actual score increases were small (NCES, 2011). Therefore, there remains the need to develop new models for teaching mathematics so that all students can become proficient, especially those students with disabilities and those who struggle with math concepts.

Current laws require that students with disabilities achieve the same high standards as typically developing students. For example, the NCLB has stipulated that all students achieve proficiency in reading and mathematics by the year 2014 (Ketterlin-Geller, Chard, & Fein, 2008; NCLB, 2002). In addition, IDEA (2004) emphasizes that all students have access to the general education core curriculum in order to have the best
opportunities for career and life style choices. Because many students with mild
disabilities tend to struggle with conceptual understanding in mathematics, they may not
be able to access readily the general education curriculum. Compliance with NCLB and
IDEA require that new models of mathematics instruction are necessary to assist all
students to be successful (IDEA, 2004; NCLB, 2002). Clearly, these laws indicate a need
for research on effective mathematics intervention (Ketterlin-Geller et al., 2008).

Teachers of mathematics continue to search for models that will meet the needs of
all students in their classrooms, both those with weaknesses in math as well as those with
enrichment needs. While clearly there have been many more studies done in the area of
reading than in mathematics, it is now evident that researchers are taking a closer look at
those strategies and tactics that will assist students in math achievement. However, little
research on the acquisition of conceptual knowledge has been done in terms of helping
students to know how to pull out concepts, principles, and procedural knowledge from
the instruction that they receive (Butler, Beckingham, & Novak Lauscher, 2005). In
addition, it would be difficult to argue that students with disabilities don’t need teacher
direction and guidance when acquiring new concepts. For example, researchers are now
discovering that explicit instruction in strategy use can help students with disabilities to
transfer knowledge of basic math facts to real life word problems. In addition, cognitive
theory offers tools for breaking down problem solving into component processes
including representing, planning/monitoring, executing, and self regulating (Mayer &
Wittrock, 2006).
Summary

To prepare students with mild disabilities for yearly high stakes testing as well as for careers that may require conceptual knowledge of mathematics, it is vital that researchers continue to look for ways to teach them in meaningful contexts. This study combined a graduated sequence of instruction, schema-based strategy instruction, and self-regulation in teaching students with mild disabilities how to solve one- and two-step word problems involving pre-algebra and geometry. Thus, the study included elements of the concrete-representational-abstract (CRA) sequence of instruction, self-regulated strategy instruction, and schema-based instructional strategies as an instructional package to help students with mild disabilities learn to solve word problems. All three of these areas have been well researched and documented as effective instructional strategies for students with mild disabilities. The CRA sequence of instruction has been successful in assisting students with learning basic facts using all four operations, as well as with learning fraction equivalencies, area and perimeter concepts, algebraic problem solving, and place value (Butler, Miller, Crehan, Babbitt, & Pierce, 2003; Cass, Cates, Smith, & Jackson, 2003; Harris, Miller, & Mercer, 1995; Maccini & Hughes, 2000; Maccini & Ruhl, 2000; Peterson, Mercer, & O’Shea, 1988). In this study, the CRA methodology was paired with schema-based strategy instruction to solve word problems. The students visualized the word problems using the CRA methodology and then applied the strategy to solve either vary or restate problem types. Students learned to identify the problem type (vary or restate), categorize problems based on their semantic structures, and then represent them on appropriate schematic diagrams with concrete objects (e.g., the concrete component of the CRA methodology). The use of the CRA methodology helped
students to solve basic math facts and conceptualize the relationships inherent in the word problems themselves. Self-instruction, self-monitoring, and self-evaluation were employed as well (Montague, 2007). This process meets the rigor of procedural fluency by stressing procedural accuracy as well as fluency (NRC, 2001).
Chapter 2: Literature Review

This study built on and extended the work that has been done with the CRA paradigm. In addition, it incorporated schema-based strategy instruction (SBI) along with an original mnemonic strategy to teach students how to solve two different types of word problems involving multiplication and division. Self-regulation strategies, especially those of self-monitoring and self-evaluation, were incorporated into the mnemonic strategy instruction to assist students to become independent problem solvers.

Although the combination of SBI and self-regulation strategies has been researched extensively (Case, Harris, & Graham, 1992; Fuchs et al., 2003b; Griffin and Jitendra, 2009; Xin, Jitendra, & Deatline-Buchman, 2005) the systematic use of an instructional package incorporating all three components (e.g., SBI, self-regulation, and CRA) has not been studied. The rationale for the systematic use of all three components was to target both math fact fluency and mathematics concept acquisition. Many students with mild disabilities have difficulty with both areas. The CRA levels of learning gave them the tools to solve basic facts in multiplication and division through the use of manipulatives, graphic representations, or equations, depending on their basic fact knowledge. In this way, students were not hindered in their progress at word problem solution even though their basic fact knowledge might be weak. The following sections review the literature in each of the three areas incorporated into this study. In addition,
because SBI deals exclusively with word problem solving rather than mathematics calculations, a brief section defining mathematics word problem solving was included before the section on SBI.

Because real mathematics reform began in 1989 with the NCTM Standards, research from 1986-2010 is included for this literature review. The next section is divided into three parts: first, CRA literature and research, second, self-regulation studies, and third, SBI studies. A definition of terms and a description of each study as it relates to the others in the domain are provided.

The CRA Domain

Definition. The CRA sequence or levels of learning is grounded in Bruner’s (1983) theory of intellectual development (Witzel, Riccomini, & Schneider, 2008). For example, one of the precursors for the CRA levels of learning approach was proposed by Bruner, who conceived of three different systems of representation as pertaining to information acquisition (Bruner, 1966). One system pertains to action, the second, to imagery or pictures, and the third pertains to representation through symbols or abstract thought. Therefore, the action phase refers to manipulating objects. The imagery phase refers to interpreting pictures, while the representation phase refers to abstract thought (Bruner, 1966).

The CRA sequence evolved from Bruner’s early work, and includes three levels of learning, the first being concrete (C), or hands on instruction using actual manipulative objects (Witzel et al., 2008). The second level of learning, the representational (R), builds upon the concrete in that the student is exposed to pictorial representations of the
manipulative objects used in level one. The abstract (A) level includes learning abstract notation such as numerals and operational symbols (Flores, 2009; Strickland & Maccini, 2012; Witzel et al., 2008).

Most importantly, the CRA sequence of instruction has been scientifically validated with both elementary and secondary school students with various mathematics topics. Studies conducted in the CRA area point to the need for connections between the levels of learning so that students learn the procedural as well as the conceptual aspects of mathematics (Strickland & Maccini, 2010; Witzel, 2005). In addition, the CRA sequence provides multiple opportunities for students to acquire math skills through multimodal forms of learning. It has been shown that learning through visual, tactile, auditory, and kinesthetic modes aids in memory and retrieval for all students including those with mild disabilities. The use of the CRA sequence can assist students with remembering the sequence of steps in a strategy and conceptualizing math problems (Engelkamp & Zimmer, 1990; Maccini & Ruhl, 2000). Moreover, the CRA sequence can result in retention of math concepts over time (Cass et al., 2003; Witzel, 2005).

Finally, vital to this method is the selection of appropriate manipulative objects to teach particular concepts (NRC, 2001). For example, when teaching subtraction with regrouping, teachers could use bundles of 10 Popsicle sticks to represent 2-digit numerals. They could show students how these bundles could be used to represent a numeral such as 46 with 4 tens and 6 ones, 3 tens and 16 ones, or 2 tens and 26 ones; a process known as decomposition of numbers (L. Ma, 1999). The decomposition process becomes important when subtracting 39 from 46. Students would need to decompose the
number 46 as 3 tens and 16 ones to make the correct calculations. In this way, students make connections between the objects themselves, the notion of subtraction, the concept of renaming numbers, and place value (Mayer & Wittrock, 2006, Witzel et al., 2008).

**Studies in CRA.** In the 1980s, researchers began to look at the CRA sequence of instruction as an approach that might assist students with conceptual understanding. For example, Peterson et al. (1988) tested the entire sequence of instruction (e.g., concrete-semi concrete-[representational]-abstract) by assigning 24 students with learning disabilities ranging in age from 8 to 13 to an experimental CRA group that moved through the CRA sequence to a control group that received traditional or the abstract component of the sequence. Teacher training, scripted lesson plans, and explicit instruction were employed and students were taught the same place value concepts in each group: specifically, to identify how many tens and ones there were in 2-digit numbers. A total of nine, 15-minute lessons were conducted. For the experimental group, the first three lessons were taught using manipulatives (concrete), while the next three lessons were taught using pictures or graphs (representational). The last three lessons were taught on the abstract level similar to the traditional instruction that the control group received. Results indicated that students in the experimental group performed significantly better than students in the control group in terms of acquisition, retention, and generalization. This means that students with learning disabilities who followed the CRA sequence were more successful at place value concepts than students receiving traditional instruction.
The Strategic Math Series (Mercer & Miller, 1992) utilized the CRA sequence coupled with a mnemonic strategy designed to teach students mathematics concepts involving calculations and simple mathematics word problems. Similar to the lesson sequence used by Peterson et al. (1988) this framework consisted of a series of lessons where the first three lessons were taught using concrete objects while the next three lessons were taught with pictorial representations: that is, with pictures of objects rather than the concrete objects themselves. In Lesson 7, a mnemonic strategy was introduced to assist students in solving word problems while Lesson 8 introduced the abstract level of CRA where students began examining problems the way they are traditionally written (for example, $3 \times 2 = 6$). Additional lessons provided practice with the concepts as well as application of the strategy to word problems. Therefore, this math curriculum applied CRA with support from strategy instruction. Results indicated that elementary-aged students with learning problems were able to acquire computational skills across tasks, solve word problems, apply a mnemonic strategy for difficult problems, and to generalize math skills across examiners, settings, and tasks (Mercer & Miller, 1992).

Several subsequent researchers successfully utilized this framework. For example, Harris et al. (1995) combined the CRA sequence of instruction with the use of mnemonic strategies in a single subject multiple baseline design. Participants included 13 students with disabilities in second grade. Also included were 99 of their typically developing peers. All of the students participated in general education classrooms and were taught by their general education teachers. Multiplication skills were taught by first using the concrete objects (e.g., paper plates and plastic counters), then the pictorial
drawings, and finally the DRAW strategy along with abstract instruction. The DRAW strategy consisted of D meaning Discover the sign, R meaning Read the problem, A meaning Answer or draw and check, and W meaning Write your answer. Students were encouraged to draw and check if they weren’t sure of the answer in the abstract part of the strategy. The FAST DRAW strategy was introduced with Lesson 10 where students were expected to increase automaticity with basic multiplication facts. In this case, F meant Find what you are solving for, and A meant Ask yourself “What are the parts of the problem?” S meant Set up the numbers while T referred to Tying down the sign.

Results indicated that students with learning disabilities performed similarly to their typically developing peers in solving basic multiplication facts when they applied the FAST DRAW strategy. However, when it came to applying multiplication skills to word problems, the students with learning disabilities performed poorly when compared with their typically developing peers. Results from this study indicate that the CRA sequence of instruction had potential in terms of providing meaningful mathematics interventions within a general education setting for second graders. However, it appeared that further research should be done to determine whether use of the CRA sequence could impact directly instruction in word problem solving.

Seeking to extend the CRA sequence’s effectiveness, Morin and Miller (1998) worked with a group of three seventh-grade students with moderate disabilities. These researchers employed the DRAW and FAST DRAW strategies in a single subject multiple baseline design across individuals. The mnemonic strategies were presented using the instructional framework presented by the Strategic Math Series. In addition,
this study combined direct instruction with teacher modeling, self-regulated strategy instruction, and the CRA sequence of instruction to teach multiplication skills. Results indicated that students with moderate disabilities learned both basic multiplication facts and how to solve word problems involving multiplication using the CRA sequence. Therefore, this study again extends the work done in the cognitive strategy area with the CRA sequence with students with learning disabilities (Harris et al., 1995) by utilizing similar procedures with students with moderate disabilities as participants.

Researchers have examined the use of CRA in teaching basic algebraic equations (Maccini & Ruhl, 2000) and multivariable algebraic equations (Witzel, Mercer, & Miller, 2003) as well. For example, using the Strategic Math Series framework for instruction, Maccini and Ruhl (2000) and Maccini and Hughes (2000) conducted studies including algebra word problem solving with integers. Both studies made use of the STAR strategy with S standing for Search the problem, T standing for Translate the problem into an equation, A standing for Answer the problem, and R standing for Review the solution (Maccini & Ruhl, 2000). In addition, both used a multiple baseline design across subjects to examine the use of the CRA sequence, strategy instruction, self-monitoring, and a think-aloud protocol. The representation and solution of word problems involving the subtraction of integers were taught using the STAR strategy as a mnemonic to assist students at remembering the steps. Each session consisted of an advanced organizer, modeling, guided practice, and independent practice similar to the Strategic Math Series (Mercer & Miller, 1992). In the Maccini and Ruhl study, results indicated that students’ percent of strategy usage and problem solving skills involving integers improved when
they applied the STAR strategy. The Maccini and Hughes study indicated that while all six students increased their ability at solving addition problems with integers, five learned to solve problems with subtraction, multiplication, and division again using the STAR strategy.

Continuing this line of research with secondary students and algebra, Witzel et al. (2003) conducted a study comparing the CRA method (without a mnemonic strategy) and a repeated abstract instruction method with middle school students in the solution of algebra transformation equations. Thirty-four students participated in the study and were divided into two groups, one control and one experimental. Both groups were taught by the same teacher in general education settings but in different classes, some utilizing the CRA method while others used a more traditional repeated abstract instruction method. A pre-post-follow up design with random assignment of clusters was used. Both groups showed significant improvement in answering single-variable algebraic equations from the pretest to the posttest and from the pretest to the follow up. However, the group who followed the CRA sequence outperformed their traditional abstract counterparts on both the posttest and the follow up test.

Continuing to focus on secondary students with disabilities and algebra, Witzel (2005) conducted a study with 231 middle school students and six teachers to compare student achievement in solving linear algebraic functions across two procedural approaches: a multisensory algebra model using the CRA sequence of instruction and a repeated explicit instruction model. Each teacher taught one class
using the CRA method and one class using traditional algebra instruction. A pre-
post-follow up design was employed with random assignment of clusters. Students 
were clustered by class and divided into two groups across each teacher (e.g., a 
treatment class and a comparison class, allowing for two teaching sequences were 
compared). Results indicated that both students with low and high achievement in 
math profited from the use of the CRA sequence of instruction. This may have 
been because some of the higher achieving students explained the reasoning behind 
their use of manipulative objects to their peers therefore deepening their knowledge 
(Witzel, 2005).

Secondary students with disabilities were again targeted by Butler et al. (2003) 
when they conducted a group design study focusing on equivalent fractions. The authors 
compared the effects of teaching middle school students with math disabilities equivalent 
fraction concepts and procedures using a CRA or a RA approach. This study was 
deemed important because many upper elementary and secondary teachers are resistant to 
using manipulative objects in their math classes (Hatfield, 1994). Fifty students with 
mild to moderate disabilities formed two treatment groups. An additional 65 eighth-
grade students participated as the control group. The two intervention groups 
participated in a pretest and posttest while the control group did the posttest only. One 
intervention group was instructed using the CRA approach while the other was instructed 
using the RA approach. Both of the intervention groups outperformed the control group. 
An interesting outcome of this experiment was that the CRA group showed greater gains 
than the RA group in equivalent fractions concepts. This study adds to the literature on
the efficacy of using the concrete-representational-abstract approach to teaching math concepts (Harris et al., 1995; Maccini & Hughes, 2000; Mercer & Miller, 1992; Morin & Miller, 1998; Peterson et al., 1988). In addition, this study may offer potential options for those secondary students who may feel self-conscious using concrete objects to solve math problems. Pictorial representations served the purpose of assisting students at problem solution almost as well as the entire sequence of CRA.

In an effort to add to the literature in terms of geometry and measurement concepts, Cass et al. (2003) examined the use of the CRA method of instruction in teaching area and perimeter concepts utilizing a multiple baseline design across subjects and two behaviors, those of finding the perimeter and the area of rectangular objects. Participants included three secondary students with LD. The intervention consisted of teaching the students the concepts of perimeter and area utilizing modeling, with concrete objects (e.g., a geoboard and rubber bands), with pictorial representations, and then with abstract problems. Rapid acquisition and maintenance of both perimeter and area concepts resulted. These results replicated previous findings that indicated manipulative devices were effective in promoting the acquisition and maintenance of various math skills (Maccini & Hughes, 2000; Maccini & Ruhl, 2000; Marsh & Cooke, 1996; Mercer & Miller, 1992; Peterson et al., 1988). In addition, this study made an important contribution to the field because it was one of very few studies in the geometry and measurement domain. This research focused on the solution of 1- and 2-step word problems while ameliorating any basic fact problem deficits through the use of CRA. In addition, the study involved specific transfer procedures so that students would recognize
the semantic structures embedded in geometry and measurement word problems. As Cass et al. (2003) noted, geometry is a very important area of mathematics but it remains an under researched domain.

**Summary**

In reviewing the studies from the CRA area, several features stand out. First, while seven studies were conducted with secondary students and two were conducted with elementary-aged students, all students showed increased performance with mathematics skills using the CRA sequence of learning. Second, seven studies took place either on a one-on-one basis or in a special education setting while two of the studies took place in the general education setting. Many of these studies included word problem solution, but not as the initial focus of the research. The initial focus for the most part was on the solution of basic math operations, fractions, and algebra (Butler et al., 2003; Cass et al., 2003; Mercer & Miller, 1992; Peterson et al., 1988). The current study focused on word problem solution, with scaffolding provided by the CRA levels of learning approach to assist students with basic fact fluency.

All of the studies used some form of explicit instruction, employing advanced organizers, rationales for each lesson, guided and independent practice, frequent feedback, and progress monitoring. In addition, these studies used scripted lesson plans making use of the framework initiated by the Strategic Math Series (Mercer & Miller, 1992). Strategy use was incorporated with the CRA sequence after students became proficient with the concrete and representational components of the sequence. All of the studies reviewed found that the CRA sequence was more effective than the traditional
method in providing students with both conceptual and procedural knowledge. The current study used the CRA sequence with the strategy use presentation model that had been successful previously. In addition, explicit instruction was also used incorporating all of the elements referred to above.

**Self-Regulated Strategy Instruction**

**Definition.** Self-regulation involves a number of methods used by students to manage, monitor, record, and assess their behavior or academic achievement. This type of instruction has been called metacognitive strategy training or learning strategy instruction. In terms of mathematical problem solving, the goal is for individuals to identify the problem, select and apply a strategy, and check for a successful solution. Explicit instruction (i.e., teacher led instruction) is needed to assist students at goal setting, self-monitoring, self instruction, and self-evaluation to regulate their use of specific strategies to solve problems (Graham & Harris, 2003). Ultimately, teacher modeling of the self-regulation process is designed to gradually release responsibility to the students allowing them to become independent in their learning (Case et al., 1992).

Self-regulation and the self-regulatory strategy model (SRSD) originated from several theoretical and empirical sources in the early 1980s (Wong, Harris, Graham, & Butler, 2003; Reid & Lienemann, 2006). The SRSD Model closely resembles the Strategic Instruction Model (SIM) (Deshler, Ellis, & Lenz, 1996) in that they both address student independence, goal setting, planning, and self assessment. However, use of the SRSD Model necessitates individualizing strategy instruction directly to student need. Therefore, a student with attention deficits and math calculation problems may use
a totally different set of strategies than a student who is able to focus attention but has difficulties with reading. On the other hand, the SIM strategic instruction stresses following a specific series of steps with all students. This model can be useful when developing units of study or when teaching how to write an essay.

Students with disabilities typically lack self-regulatory skills in several different ways. Frequently these students lack the ability to select the correct strategy to apply to specific situations (Montague, 2007; Swanson, 2006). In addition, students with disabilities may have difficulty applying a strategy to solve a problem, such as figuring out what a vocabulary word means or what operation to apply in a math problem. Students with mild disabilities frequently have difficulty replacing ineffective strategies and adapting or generalizing strategies to novel situations as well (Montague, 2007). Typically, students with mild disabilities lack the metacognitive skills needed to self-monitor their progress and to make corrections when needed (Montague, 2007; Swanson, 2006).

Students with disabilities however, can learn to regulate both behavior and attention to task as well as academic accuracy and production. Educators need to explicitly instruct students to acquire the self-regulatory strategies of self-instruction, self-questioning, and self-checking (Carr, 2010). For example, in terms of word problem solving, self-instruction involves students reading the problem and telling themselves what to do. Self-questioning has to do with asking themselves questions as they go about solving the problem. Self-checking has to do with checking over their work to make sure that it is complete, accurate, and that their answers make sense (Montague, 2007). This
section will review literature on self-regulated strategy instruction and the need for explicit instruction in the strategies necessary for the success of students with mild disabilities.

**Self-monitoring in math.** While many studies were conducted on self-regulation in the areas of reading and writing, there were significant contributions in the area of mathematics as well. For example, self-monitoring and self-evaluation were studied as they related to students with learning disabilities (LD) and mathematics learning (Brown & Frank, 1990; Dunlap & Dunlap, 1989; Maag, Reid, & DiGangi, 1993). Dunlap and Dunlap (1989) conducted a multiple baseline study across participants with three students ages 10, 12, and 13 with LD in a resource room setting. The purpose was to extend the literature on self-monitoring with students with LD in terms of learning subtraction with regrouping. Individual error analyses were conducted with baseline data, and individual self-monitoring packages were prepared consisting of self-monitoring check lists, reinforcement, and feedback. The checklists were used by the students when performing subtraction problems with regrouping. Results indicated that the use of a self-monitoring package based on individual error analysis was both efficient and effective for increasing problem solving accuracy.

Extending this work, Brown and Frank (1990) were interested in whether a generic check list would be as effective as those used by Dunlap and Dunlap (1989). Dunlap and Dunlap used individualized check lists based on errors made on pretests by individual students. Brown and Frank devised a generic check list with a mnemonic strategy and utilized a multiple baseline across subjects design for two experiments. The
first experiment consisted of teaching three 10- and 11-year-old students with LD to calculate subtraction problems utilizing a self-monitoring checklist. The second experiment employed three different 8- and 9-year-old students with learning disabilities and taught students to solve addition problems, again using a generic self-monitoring checklist. Results indicated that performance of all six students increased to reach criterion of 90% accuracy. In addition, these results were maintained up to 7 weeks. Results of these two studies have two important implications for teachers. The first is that the use of the generic checklist was effective for all students, indicating that a separate individualized checklist need not be devised as in the Dunlap and Dunlap (1989) study. The second implication is that the treatment phase was relatively quick ranging from 2 weeks to 6 weeks. For teachers, this study indicates that students with disabilities can learn to perform addition and subtraction problems utilizing a generic checklist relatively quickly, leaving time for the application of these skills to word problem solving.

Maag et al. (1993) conducted a study to determine whether the use of self-monitoring of attention (e.g., on task behavior), academic productivity, and academic accuracy would improve the mathematics performance of fourth- and sixth-grade students with learning disabilities in a general education setting. A multiple baseline design across subjects was used. Specifically students were working at addition and subtraction basic facts (0-20), addition of 1- and 2-digit numbers without regrouping, and basic multiplication facts. The hypothesis was that self-monitoring of academic productivity and academic accuracy would result in a greater number of problems
completed accurately than self-monitoring of attention. Materials included structured worksheets and cue cards appropriate to each condition of the study (e.g., self-monitoring attention, productivity, or accuracy). Results corroborated the hypothesis: that is, that self-monitoring academic productivity and accuracy was more effective than self-monitoring attention in terms of students completing more problems accurately than during baseline. In addition, when questioned, students preferred to monitor academic outcomes rather than attention to task. This study was the first to report effects of self-monitoring on academic productivity and accuracy for students with learning disabilities in a general education classroom. The generalization results were good as well, because instruction began in special education classrooms and was implemented in the general education setting. This study sought to determine which type of self-monitoring would improve the achievement of students with disabilities in basic math facts. This factor is important when working with students with disabilities who may need different types of self-monitoring according to their individual needs as is delineated in the SRSD.

The previous three studies focused on mathematics achievement in terms of basic math facts. Word problem solving interventions were explored during that same time period using cognitive strategy instruction, metacognition, and self-regulation. For example, six adolescent students with LD ages 15 through 19 participated in a study conducted by Montague and Bos (1986). The purpose of the study was to investigate the effectiveness of an 8-step learning strategy designed to teach secondary students with learning disabilities to self-regulate as they solved word problems. This cognitive strategy training consisted of modeling, corrective feedback, verbal rehearsal, self-
questioning, and cueing in a multiple baseline design across individuals. Their findings indicated that the use of their 8-step cognitive strategy model helped students with LD to solve word problems.

Seeking to extend this work, Case et al. (1992) examined the use of self-regulatory strategy instruction combined with a learning strategy to solve 1-step addition and subtraction problems. Specifically, these researchers were interested in helping students identify the correct operation to use (e.g., addition or subtraction) in solving word problems, a common error made by students with LD. In fact, on the pretest component for this study 95% of the errors made were due to choosing the wrong operation to solve the word problems. Therefore the strategy focused on writing equations and circling key words in the word problems promoting students’ choice of correct operation. A multiple baseline across subjects, across two behaviors design was used and four fifth- and sixth-grade students with LD participated. The students set goals for themselves and made commitments to learn the strategy. Of importance was the fact that the instructor modeled and used a think-aloud protocol as she worked the problem. Students were then encouraged to think-aloud as they worked each problem. Results indicated that performance with addition problems remained high, while accuracy of subtraction problems increased as well. This study showed that using a strategy that is designed to be sensitive to student need (e.g., the selection of the wrong operation) can be effective in improving student achievement.

Continuing this line of research, Hutchinson (1993) conducted a study with secondary students with LD and algebra problem solving. Hutchinson recognized that
many previous studies had been done with elementary school students with either basic facts or simple 1-step word problems. Therefore, she studied the effectiveness of cognitive strategy instruction with 20 adolescents with LD in Grades 8, 9, and 10 in algebra. Similar to the Case et al. (1992) study, Hutchinson utilized the self-regulatory components of self-instruction, self-questioning, self-monitoring, and self-evaluation. In addition, Hutchinson used structured worksheets to assist students in their problem solving similar to the cue cards that Case et al. (1992) used to depict the strategy. Modeling and think-aloud protocols were also employed and successfully used on a one-on-one basis. Use of think-aloud strategies in teaching word problem solving was seen as critical in that students with LD typically make far fewer verbalizations while solving word problems than the higher achieving students (Montague & Applegate, 1993). Results indicated that secondary students with LD learned to solve algebra word problems utilizing self-regulatory strategies and structured worksheets to remind them of the strategy (Hutchinson, 1993).

In an effort to extend the work of Case et al. (1992), Barrera et al. (2006) conducted a study utilizing general think-aloud procedures and self-regulation strategies. A multiple baseline across four English Language Learning students with LD for two different behaviors was used. Specifically the instructional package used a math think-aloud strategy in teaching various mathematics concepts. The Barrera et al. study included six research participants: two teachers and four students ages 12 to 15 identified with LD and limited literacy proficiency in English. One teacher and student pair was located in Minnesota and the student was of the Hmong background. The other teacher
and three students were located in Texas. These students were of Mexican-American background. Pre-intervention data were collected at the beginning of the study including content area test results, students’ state testing results, and IEP records. Post-intervention data were collected as well. Teachers were trained initially to implement the think-aloud strategy. The student that was located in Minnesota learned to simplify improper fractions with the use of this strategy. The other three students located in Texas were taught strategies to solve for an unknown variable. Results indicated that use of a think-aloud strategy was effective in improving student achievement levels in meeting these mathematics objectives.

Continuing this line of research to examine self-regulation in mathematics problem solving, Montague, Enders, and Dietz (2011) sought to determine whether a research validated intervention strategy (e.g., Solve It) would be effective when implemented in inclusive middle school classrooms. Previous studies had been conducted using this intervention strategy with either individuals or small groups and found to be effective (Montague, 1992; Montague & Bos, 1986). These researchers worked with a total of 24 middle schools in a large urban school district, 8 of which served as intervention schools while 16 served as comparison schools. General education mathematics teachers at the intervention schools were recruited to take a 3-day professional development course on how to implement the Solve It program. Sessions were held 3 days per week with weekly practice problem solving days and spanned an entire school year. Results indicated that students who were low achieving, average achieving, and those with learning disabilities increased problem solving performance
significantly better than students at the comparison schools. This study had important implications for educational practice in that use of a scientifically validated strategy could be useful for students of diverse abilities in general education settings.

**Summary**

The importance of the 8-step strategic process to teach self-regulatory skills employed by Montague and Bos (1986) cannot be overemphasized. Specifically geared for self-regulation in mathematics, this strategy encompassed all of the components of the Strategic Instruction Model (Deshler et al., 1996). The intervention consisted of three distinct components: strategy acquisition, strategy application, and testing. During the strategy acquisition phase, students needed to learn and memorize the 8-step strategy to a 100% criterion just as Deshler et al. (1996) required students to do. The rationale for memorizing the strategy before beginning to apply it is so that students will be able to apply the strategy with fidelity and generalize to other situations.

The studies that were reviewed for the self-regulatory section stressed the importance of teacher training or the use of scripted lessons. For example, Hutchinson (1993) prepared scripted lessons for teaching adolescents algebra problem solving skills. In the Case et al. (1992) and the Barrera et al. (2006) studies, extensive teacher training was provided prior to implementing the intervention. This training of teachers was important to be certain that the delivery of instruction was implemented with fidelity. In addition, all of the studies reviewed had components for frequent progress monitoring.

Five studies employed modeling, think-aloud protocols, check lists, as well as cue cards (Barrera et al., 2006; Case et al., 1992; Hutchinson, 1993; Montague & Bos, 1986;
Montague et al., 2011). These components were all effective in improving student performance and as a result, were used in the current study. In addition, the cue card or checklist used for this study included the following components: an original mnemonic strategy depicting the steps to problem solving, self-questions, self-monitoring, and self-evaluation items.

**Schema-Based Strategy Instruction**

**Definition.** Schema can be defined as a memory structure for organizing both objects and procedures into a general framework which can be filled in with details of a specific situation: for example, particularities of a word problem (Reed, 1999). The underlying premise behind schema theory is that all new information interacts with internal knowledge already possessed by an individual. For example, the ability to classify cats or dogs as animals is based upon an individual’s schema for those categories of living things.

**Mathematics word problem solving.** Problem solving in mathematics can be defined as a method of getting from a given state (e.g., the math problem itself) to a goal state or the solution of the problem. Therefore, math problem solving is a cognitive process that is used to figure out a solution to the problem when the solution is not readily apparent (Mayer & Hegarty, 1996). Part of the cognitive process is the understanding of the problem and planning its solution. Polya (1985) incorporated the understanding and planning components into his four step strategy for word problem solving by requiring that students think through the process by understanding the problem, devising a plan, carrying out the plan, and looking back. Therefore, word
problem solving consists of two major processes: those of representation and solution. Within this framework, there are two major strategies that students use to solve problems. One is the direct translation strategy and the other is the problem model strategy (Hegarty, Mayer, & Monk, 1995).

The direct translation or key word strategy is often used as a computational shortcut for solving word problems. Utilizing this strategy, students typically read the problem, select what appear to be key numbers and words from the problem, and try to fit them together into an algorithm. Therefore when reading a word problem, students frequently only look for key words to solve the problem. This is only moderately successful in that typically, key words can only be used with one step, simple problems (Marshall, 1995). The system breaks down as problems become more complex requiring several operations to solve them. Moreover, the key word strategy can be misleading because the underlying semantic structure of the problem may be contrary to the key word used (Reed, 1999). Therefore, the direct translation or key word strategy can be quick but only sometimes correct, primarily because the relationships between numbers and concepts is typically overlooked. Unfortunately, this is the method of choice for less able problem solvers because it is quick and at least some of the time, use of the strategy leads to correct problem solution (Mayer & Hegarty, 1996). In the long run, however, word problem solving requires more than just reading a problem and calculating its solution (Zawaiza & Gerber, 1993).

The problem model strategy offers a more comprehensive method of solving problems in that it emphasizes problem representation before problem solution. The
representation of word problems takes place through translating, integrating, and planning. Translating involves constructing a mental representation of each statement in the problem where integrating involves formulating a mental picture of the relationships between those statements. Planning requires the problem solver to devise a plan by which to solve the problem (Mayer & Hegarty, 1996). Polya’s (1985) seminal work on mathematics problem solving emphasizes the understanding and planning phases of word problem solving as essential to solving the problem correctly.

However, a major difficulty with problem translation is to understand the situations embedded in the problem (Marshall, 1995). According to Marshall, situations can vary in terms of surface features, syntactic features, and the relations that they express. Surface features such as story context can confuse students, in that the same solution plan can be called for in several different problems that use vastly different stories. Syntactic features can also confuse students by varying the complexity of the language used, or the length of the problems themselves. However, it is the knowledge of relationships that is most salient in terms of comprehending mathematics story problems particularly for unsuccessful problem solvers (Marshall, 1995). The number of objects in a word problem and their relationship to each other needs to be understood to arrive at correct solutions. Therefore the language of word problems guides students toward understanding, representing, and manipulating relationships within the problem (Zawaiza & Gerber, 1993).

It is critical that students learn to recognize specific situations and their relationships as presented in word problems. Marshall (1995) proposed five different
situations that could describe the relationships within common word problems. These are *change, group, compare, restate,* and *vary* (Marshall, 1995; Riley, Greeno, & Heller, 1983). Change, group, and compare problems typically involve addition or subtraction, while vary and restate problems involve multiplication or division. See Appendix A for examples of each type of problem.

Schema-based strategy instruction (SBI) represents an explicit, systematic method of assisting students to focus on the important elements of problem representation so that they can arrive at successful solutions. This means that there are two distinct phases to solving word problems. Mayer and Hegarty (1996) referred to these phases as problem representation and problem solution, while Riley et al. (1983) labeled these components as problem schemata and action schemata. These definitions are used interchangeably in SBI research and in this review.

**History.** The notion of the schema can be traced as far back as the ancient Greeks (Marshall, 1995). Piaget introduced the schema as an important construct in his work on the stages of intellectual development (Piaget, 1970). For Piaget, there were four great stages in the development of intelligence in children, the earliest being sensori-motor intelligence. During this stage of development, the young child acts upon his environment discovering that certain objects fit into previous schemata while other objects may not. These schemata can be generalized and are applicable to new situations. For example, a young child explores a new toy by shaking or rolling it to see if it behaves in a similar manner to his/her other toys (Piaget, 1970). Therefore, for Piaget, cognition is an active, constructive, and reciprocal process whereby individuals assimilate their
experiences onto existing schemas and adapt schemas as experiences require—a process known as accommodation (Marshall, 1995).

The process of accommodation is central to schema in math word problem solving. To understand the situations depicted in story problems, one needs to possess prior knowledge which is attached to new situations. When students possess prior strategic knowledge of how to solve word problems that involve multiplying different quantities of items, they are able to employ that strategic knowledge to solve novel word problems. For example, if Susie has three times as many cupcakes as Ann, and Ann has three, how many does Susie have? If students understand the relationships in this situation, they know that the number that Susie has is nine. When presented with a problem that states that Billy has two times as many fishing lures as Bobby has and Bobby has four, how many does Billy have? Students recognize the same relationship as in the cupcake problem and are able to solve this problem as well. Therefore, solving math problems requires using schema to recognize key relationships and how they are presented in stories (Marshall, 1995).

The literature on schema-based strategy instruction includes two distinct but similar sequences of research studies. One sequence of studies incorporated schema broadening instruction with a transfer element and explored the issue of transferring knowledge of problem types to novel problems. The other major line of research using SBI explored its application to teaching students with disabilities how to solve mathematics word problems. In addition, these studies compared the use of SBI and
general strategy instruction (GSI) in terms of which approach was more effective in teaching word problem solving to students with disabilities

**Schema broadening instruction.** Fuchs and colleagues initiated a line of study incorporating schema broadening instruction and the component of transfer from specifically taught word problem schemas to novel problems. For example, the purpose of a study conducted by Fuchs et al. (2003a) was to assess the effects of explicitly teaching for transfer so that students would not only learn to identify problem types and solutions, but they would also learn to transfer these skills to novel problems requiring similar solutions. The novel problems were defined by adding superficial problem structures that changed the problem without changing the structure or solution (Ross, 1989). For example, these researchers modified existing word problems by changing the format, changing the key-word vocabulary, asking an additional question, or placing the problem into a larger problem.

The intervention took place in third-grade general education classrooms with 24 teachers and 375 students. The teachers and the students had been randomly assigned to four different conditions. Students assigned to the control condition received teacher designed instruction following the district’s curriculum. The other three conditions were experimental and they incorporated the district’s mathematics curriculum along with SBI. Students in all four conditions received comparable amounts of daily instruction.

One of the experimental conditions focused on problem solution strategies. Students assigned to this condition were taught to identify rules for problem solution based on narrow schemas for sorting problems (Cooper & Sweller, 1987). The problem structures
were shopping list problems, buying bag problems, half problems, and pictograph problems. See samples of each of these problem types in Appendix A. These problem types were selected because they typically are the ones taught in a third-grade curriculum (Fuchs et al., 2003a).

The remaining two experimental conditions combined identifying problem structure, recognizing the schema of the problem type, problem solution, and a transfer component. In the transfer component, teachers explicitly taught students to search problems for schema types and solution strategies with the added superficial problem structures referred to above (e.g., changing the format, changing the key-word vocabulary, asking an additional question, or placing the problem into a larger problem). The difference between these two conditions was that one offered the full component of solution sessions before transfer instruction was begun. This condition was termed full solution plus transfer. The other condition offered half of the sessions for problem solution before transfer instruction began. This condition was termed partial solution plus transfer.

Results indicated that students in the full solution plus transfer condition outperformed their peers in the control condition and the partial solution plus transfer condition. These results seem to indicate that both problem solution and transfer instruction are necessary to improve students’ problem solving abilities. The partial solution condition did not offer as much instruction on solution strategies and for students with disabilities in the partial solution plus transfer condition, results indicated that from 60% to 80% of students failed to progress more than the control group. These
disappointing results also indicate the need for a solid foundation in the problem solution component along with transfer instruction.

Ultimately, this research was important because it indicated that explicitly teaching for transfer is effective and necessary for students with disabilities. By focusing students’ attention on the structure of novel word problems, the transfer instruction broadens the schemas by which problems can be classified. These classifications can then be seen as requiring similar solutions (Fuchs et al., 2003a).

Extending the work of Fuchs et al. (2003a) was a study conducted by Fuchs et al. (2003b). The purpose of this study was to examine the contribution of self-regulated learning (SRL) to mathematics problem solving. Participants included 395 third graders who were designated as high achieving, average achieving, and low achieving. These students were randomly assigned to one of three conditions: basal control treatment, transfer, and transfer plus SRL. Also included were 24 teachers who were also randomly assigned to one of three conditions. Two 30- to 40-minute sessions were delivered each week for a total of 32 sessions.

The transfer group involved teaching the rules for problem solution, teaching for transfer, and cumulative review. Basic procedures were similar to the Fuchs et al. (2003a) study. However, an important difference was the incorporation of an introductory 3-week unit on basic mathematics problem solving information: for example, making sure answers made sense, lining up numbers from the text to perform calculations, labeling of answers, and checking computation (Fuchs et al., 2003b). After the first 3 weeks, students were taught how to solve the shopping list type of word
problem. Next, after each session students completed one problem independently and checked their own work to see if they used the correct problem diagram using an answer key. Finally, students were assigned a problem for homework which they turned in the next day for peer review.

In the transfer-plus-SRL treatment, SRL components were incorporated into each instructional phase. Components such as scoring of students’ own work, charting their daily work and scores, and graphing events such as number of homework assignments turned in, were all considered self-regulatory activities. In addition, goal setting was built in to this instructional condition by having students review their work charts on a daily basis and set new goals. Again, these researchers used the same procedures for teaching and measuring in the transfer condition as in previous studies.

Results supported the Fuchs et al. (2003a) findings that math problem solving is strengthened with explicit transfer instruction. In addition, students in the transfer-plus-SRL treatment outperformed their peers who participated in the transfer only condition. Students with disabilities improved in problem solving performance as well, indicating that SRL holds promise for this population even when educated in a general education setting.

In assessing the effects of SBI among third graders, Fuchs et al. (2004) were interested in whether practice in sorting word problem types into various problem type schemas requiring the same solution strategies would help strengthen knowledge of schema types and their respective solutions. Participants included 24 third-grade teachers who were randomly assigned to one of three conditions (e.g., contrast, SBI, and SBI plus
sorting practice). Student participants included 366 third graders who were designated as low performing, average performing, and high performing. Participants in all of the treatment conditions worked with the adopted math curriculum materials and textbooks, and began with 3 weeks of training on math word problem solving strategies just as in previous work (e.g., making sure your answers made sense, lining up the numbers from the textbook to perform math calculations, checking computation, and labeling work with monetary signs, and correct math symbols). The four problem types were shopping list, half, buying bags, and pictograph as in previous work by Fuchs et al. (2003a). Samples of these problem types are provided in Appendix A.

The first unit focused on general problem solving strategies such as making sure answers made sense, lining up numbers from the text to perform calculations, labeling of answers, and checking computation (Fuchs et al., 2003b). These components were taught to ensure that all students understood the prerequisites to word problem solving. Therefore, this unit was taught to students in all conditions. Students in the SBI and the SBI plus sorting conditions received 3-week long units on each of the four problem types. Students learned the steps for solving each problem during the first session of each unit. During the latter part of each unit, students learned to recognize previously taught problem types even when superficial elements were added such as using unfamiliar words, posing a different question, or placing the problem into a larger problem solving context. These superficial elements are similar to those referred to by Marshall (1995). Finally, in the SBI plus sorting condition students learned to sort problems according to problem type with or without superficial features added.
Results indicated that this form of SBI training incorporating the problem types with added superficial features, improved mathematical problem solving among third graders regardless of achievement status. Interestingly, the addition of the sorting practice to the SBI training had no significant effect over the SBI training alone. Both conditions were equally effective in developing dramatically stronger schemas when compared with the contrast group. However, these researchers did see some potential for use of the SBI with sorting techniques for students with disabilities in terms of inducing superficial schema development (e.g., a different cover story, unfamiliar words, or posing a different question). This finding was particularly important in that previous work had documented that younger primary grade children and children with low achievement often had difficulty with math problem solving (Chen, 1999; Cooper & Sweller, 1987).

Fletcher et al. (2008) extended this research by assessing the efficacy of a Tier 2 tutoring protocol addressing math word problem solving outside of the general classroom. Thirty-five third-grade students with documented reading and math difficulties were participants in this randomized control trial study. The study design was a randomized controlled trial in which individual students were randomly assigned to either the control condition or to the tutoring condition. Problem types were selected based upon what typical third graders are expected to solve.

These researchers were testing the power of teaching for transfer by introducing a schema broadening strategy. Specifically, the schema broadening strategy consisted of four instructional components: understanding the underlying structure of word problems, identifying the basic schema for the problem type, solving the problem type, and
transferring schemas to novel problems. Students assigned to the control condition continued in their general education classes in the regular math program, while students assigned to the tutoring condition received supplemental instruction to the classroom curriculum. Tutoring was conducted one on one in a separate setting and took place three times per week for 12 weeks. Students were taught basic mathematics word problem methods first, followed by three units of 3-week sessions focusing on problem types (e.g., total, change, and difference). Samples of these problem types are provided in Appendix A. Procedures similar to those used by Jitendra et al. (2007) were followed. However, Fletcher et al. (2008) added the component of teaching students to transfer their schemas to novel problems. Their belief was that transfer instruction designed to broaden schemas would allow students to solve problems that included irrelevant information or information presented in a novel way such as in a table or chart.

**Schema-based strategy instruction.** Exploring schema-based strategy instruction, Jitendra and Hoff (1996) conducted a study involving three third and fourth graders with learning disabilities. Their intervention consisted of using direct explicit instruction to teach students three different problem types (i.e., change, group, and compare) as categorized by Marshall (1995) and Riley et al. (1983). These particular problems involved addition and subtraction of one digit numerals. Scripted lesson plans and cue cards depicting the rules for word problem solution for each type of problem were used. The intervention was initiated by presenting the students with story problems with no missing numerical elements. For example, if Tim had three bananas and two oranges, he had five pieces of fruit altogether. The students were expected to focus
attention on the problem schemata or problem type rather than on solving the problem. Students were also provided with schematic diagrams for each problem type (e.g., change, group, and compare).

The researcher first modeled how to map, or set up, the problem on the appropriate schematic diagram for the problem type. Guided and independent practices were provided for students until proficiency was achieved. After this step had been mastered by the students, they were introduced to typical problems with a missing element: specifically a missing answer. Teacher modeling, and guided and independent practice were again provided. Students were taught a solution strategy to solve the problems. Students were encouraged to interact with the researcher to guide understanding of the concepts. Worksheets were completed at the end of each session and used to measure results. Outcomes indicated that students with learning disabilities increased achievement on one step word problems using schema-based instructional strategies that included schematic diagrams and teacher modeling.

The next study conducted by Jitendra et al. (1998) sought to replicate and extend previous findings. The purpose of the study was to investigate the differential effects of a schema-based strategy and traditional strategy use on the acquisition of simple one step addition and subtraction word problems by students with mild disabilities. An additional purpose was to assess the maintenance over time and the transfer to a new context. Participants included 34 students from Grades 2 through 5, 25 of whom had learning disabilities and 9 who struggled with math. In addition, 24 other third graders were part of the study as a comparison group. Instructional sessions took place with small groups
of three to six children and consisted of two phases. The first phase was called problem schema during which students learned to identify problem types. The second phase was called problem solution where students learned the solution strategies for each problem type or schema. Results indicated that SBI improves students’ word problem solving ability to a greater degree than traditional instruction.

In an effort to replicate previous studies on SBI and to investigate generalization of the strategic effects from one to two step problems and across settings, Jitendra, Hoff, and Beck (1999) conducted a study with middle school students with LD as participants. Materials for this study were similar to those used in previous work (e.g., scripted lessons, strategy diagram sheets, collections of word problems, and cue cards with strategy rules). Intervention phases were similar as well and followed the procedures delineated by Jitendra and Hoff (1996). Students were trained in problem schemata to mastery and then moved onto action schema or the solution phase. The 2-step problem intervention used the same materials and procedures. Students were taught to identify the problem type (problem schemata) for each step of the problem first. Then students solved each step of the problem (action schemata) following the rules listed on their cue cards. Results of this study support the work of Jitendra and Hoff (1996), Jitendra et al. (1998), and Zawaiza and Gerber (1993) in that the researchers found that the performance of middle school students with disabilities improved with the use of schema-based instruction.

Extending their work into the solution of multiplication and division problems, Jitendra et al. (2002) conducted an exploratory study with four eighth graders with
learning disabilities. Using a multiple probe across participants design, students were taught to identify the characteristics of vary and restate problems and to map results onto the appropriate diagram: the problem schemata phase. Examples of each problem type are provided in Appendix A. A vary problem concerns the relationship between two objects such that when one object increases or decreases in number, so does the other object, such as in a ratio or proportion word problem. For example, “Joe had three boxes of pencils. Each box has eight pencils. How many pencils does Joe have?” On the other hand, a restate problem is one in which a comparison is made at a specific moment in time. A restate problem includes phrases like twice as many or one half of. For example, “Mary has twice as many cookies as Kathy has. Kathy has three cookies. How many does Mary have?” It is important to note here that the problems initially were presented with no missing information as in previous work.

Once mastery had been reached at identifying problem types, the action schemata phase began. During this phase students were presented with problems with missing answers. The teacher explicitly modeled how to solve each problem and students were provided with guided and independent practice. Results indicated that students with learning disabilities in middle school learned to solve one step multiplication and division problem utilizing SBI instruction. In addition, students were able to generalize their skill to untaught problem types and to 2-step problems.

In an effort to extend the findings of Jitendra et al. (1998), Xin et al. (2005) investigated two different problem solving instructional approaches: schema-based instruction (SBI) versus general strategy instruction (GSI). Recognizing that previous
research had been limited to algebra word problem solving (Hutchinson, 1993) or addition and subtraction problems (Jitendra et al., 1998), Xin et al. (2005) were interested in whether SBI would have an effect on the solution of multiplication and division word problems. The SBI condition included focusing on the problem type before attempting problem solution. The GSI condition consisted of learning a 4-step general heuristic problem solving procedure similar to Polya’s seminal work on word problem solving strategies (Polya, 1985). Polya’s strategy calls for the following steps:

1. Understanding the problem
2. Making a plan
3. Carrying out the plan
4. Looking back.

The rationale for choosing this similar general strategy was that the Polya strategy was commonly used in commercial textbooks: that is (a) read to understand, (b) develop a plan, (c) solve, and (d) look back (Xin et al., 2005). The read to understand step required students to think about what is being asked for in a problem and what information is given in the problem. The develop a plan step consisted of choosing a strategy: that is, draw a picture, make a table, write a math equation, or act it out. The solve step had students show their work and use reasoning to solve the problem. Finally, the look back step involved students justifying their answers, and checking their work.

Utilizing a group design, Xin et al. (2005) selected 22 middle school students as with learning disabilities for their study and randomly assigned them to either the SBI or the GSI conditions. Two graduate students and two special education teachers served as
instructors for this experiment. All instructors received training and were provided with teaching scripts. Students were taught using explicit instruction with teacher modeling, guided and independent practice and frequent feedback. There were 12 sessions conducted for each study condition (i.e., SBI and GSI) and all students were taught to solve two different word problem types—that is, multiplicative compare or restate types and proportion or vary types. Results indicated the group that was taught SBI significantly outperformed the group taught GSI.

Seeking to extend research findings to the general education classroom, Jitendra et al. (2007) conducted a study investigating the differential effects of SBI and GSI in promoting skill at solving one and two step mathematical word problems, computation skills, and mathematical achievement of low achieving third-grade students when taught by classroom teachers. Similar to Jitendra et al. (1998) SBI included explicit instruction in using schematic diagrams to identify the word problem type prior to solving them. The GSI component incorporated the Polya word problem strategy typically found in textbooks with skills including using objects, drawing a diagram, writing a number sentence, and using data from a graph. Participants included 88 third-grade students and six teachers, five of whom were general education teachers while one was a special education teacher. Students were randomly assigned to the SBI or the GSI condition and were instructed in groups of 15 to 16 students. There were three SBI groups and three GSI groups. Teacher training was provided before the study began and scripted lessons were provided. The scripted lessons included instructions for think-alouds, teacher-student interactions, and guided and independent practice. Word problem solving lessons
of 25 minutes per day were held during regular mathematics instructional times over a 9-week period. Results showed that SBI was more effective than GSI in enhancing math problem solving skills of low performing students both at posttest, and 6 weeks later on an author-designed problem solving test utilizing taught problem types. In addition, math computation improved for both groups over time. This research showed that SBI can be effective when taught in a general education classroom and is effective with low achieving students.

Griffin and Jitendra (2009) sought to extend the findings of Jitendra et al. (2007) by determining whether the effects of SBI training maintained over a 12-week period rather than a 2- or 6-week period as previously determined (Jitendra et al., 2007; Jitendra et al., 1998). In addition, these researchers explored the differential effects of SBI and GSI in third-grade general education classrooms with high, medium, and low achieving students. Their interest was in determining whether SBI would be effective for all students no matter what their achievement level. Therefore the purpose of this study was to examine the differential effects of SBI and GSI on students taught in mixed ability general education classrooms (i.e., high, average, and low achieving). These researchers hypothesized that GSI did not provide enough structure or scaffolding to be effective with students with disabilities or those who struggled with mathematics concepts. It was also hypothesized that although both the GSI and the SBI groups would improve their problem solving skills, the SBI group would improve more than the GSI group, because of the use of visual representations (i.e., the schematic diagrams).
Griffin and Jitendra (2009) used a between subjects experimental pretest-to-posttest-to-delayed-posttest group design. Participants were 60 students from three third-grade classrooms. These students were randomly assigned to one of four different conditions. Scripted lessons were used and one and two step word problems were selected from third-grade textbooks. In the SBI condition, schema instruction involved story problems presented with no missing information to allow students to practice categorizing problems by type as in previous work. Posters were provided for teachers in the SBI condition depicting the three diagrams for word problem types. Posters depicting steps for word problem solving were provided for the GSI groups as well.

The SBI group was taught in two stages: that is, problem schema and problem solution. The problem schema stage focused on the underlying problem structure and on mapping math problems onto schematic diagrams. The problem solution stage consisted of solving word problems using a strategy called FOPS:

1. Find the problem type.
2. Organize the information in the problem using the diagram.
3. Plan to solve the problem.
4. Solve the problem.

Similar to the Jitendra et al. (2007), GSI consisted of typical strategies found in textbooks such as using manipulative objects, drawing a diagram, writing a number sentence, or using data from a graph. Students were required to select the appropriate strategy depending on the specific questions in the mathematics word problems. These strategies were based on Polya’s (1985) heuristic.
Results indicated that both groups improved to the same extent thus not replicating the findings of Jitendra’s et al. (2007) study. The reason posited for this unexpected finding was the use of the format of 100 minutes per session. Using this instructional format over time may have masked the SBI’s effectiveness. However, typical school schedules do not allow for 100 minutes a day to be spent on mathematics instruction. It is possible that learning in shorter, more dispersed instructional times might have improved students’ learning in the SBI approach. Generally these results indicated that students of varying ability can improve in word problem solving with strategy instruction in a general education setting taught by regular teachers.

The last in the series of studies reviewed was a study seeking to extend the SBI methodology to a student with autism. Rockwell, Griffin, and Jones (2011) examined the use of SBI to teach addition and subtraction word problems to a fourth-grade student with autism. This study was conducted over an 8-week period during the summer between the student’s third- and fourth-grade years in the first author’s home. Tutoring sessions lasted a total of 2 hours, 45 minutes of which were devoted to SBI. Teaching scripts and lesson checklists were used along with a strategy similar to that used by Jitendra et al. (2007). A single case multiple probe across behaviors design was used. Specifically the behaviors were identification of the three problem types: that is, group, change, and compare. Results indicated that a student with autism can learn to solve 1-step addition and subtraction problems using SBI. Maintenance probes also indicated that SBI can remain effective 6 weeks after instruction.
Summary

Conceptualizing mathematics word problem solving is a component of mathematics that students with disabilities as well as other students who struggle with mathematics find very difficult. Schema broadening or schema-based strategy instruction (SBI) offers a pathway which teachers can follow to assist their students with this very important pursuit. SBI requires that students identify word problem types prior to solving the word problems. Unlike GSI, SBI relies on explicitly teaching students to recognize the underlying structures of word problems thereby uncovering patterns that allow for similar solutions. GSI relies upon the seminal work of Polya (1985) who developed a 4-step strategy for solving word problems. Many modern day textbooks use a version of this 4-step strategy to teach word problem solving. However, as pointed out by Jitendra et al. (2007), the 4-step strategy that is used in many classrooms may be too general to be effective for students with disabilities or those who struggle with mathematics. For example, the 4-step strategy requires that students select a method such as draw a diagram, work backward, or make a table. If students have not been taught how to draw diagrams representing the information in the word problem, they will not be able to solve the problem correctly. While the 4-step strategy can be very useful to some students, especially those who are high achievers, it may be problematic to students who struggle with mathematics. Participants in the current study are students who struggle with mathematics concepts. Therefore, SBI was used to help ensure that students would learn and retain the concepts being taught.
Explicit instruction has been well researched and validated. All of the studies reviewed for this section used explicit instruction that followed a pattern. First, the student was required to identify the word problem type and represent the word problem either on a schematic diagram (Jitendra et al., 2007) or writing an equation (Fuchs et al., 2003a; Fuchs et al., 2003b). Other components of explicit instruction were also included such as using advance organizers, providing rationales, modeling, using think-alouds, providing examples and non-examples, providing frequent feedback, and providing guided and independent practice. These components were included in the current study as well.

Fuchs et al. (2003b) recognized the importance of pre-teaching basic word problem components. Teaching students how to line up the numbers correctly to perform math operations, to label their work with words, and to check computation, are all important prerequisite skills to learn prior to learning how to solve math word problems. Knowledge of basic multiplication facts is a necessary prerequisite to word problem solving as well. Therefore, the current study incorporated the CRA sequence of learning, a form of pre-teaching specifically, for teaching basic multiplication facts.

Several researchers showed that SBI can be effective in general education classrooms (Fuchs et al., 2003a; Jitendra et al., 2007). Working with third-grade students and their teachers, these researchers showed that student achievement can be improved with SBI to a greater extent than with GSI. However, whether the intervention takes place in a general education class or in a separate setting, scheduling needs to closely follow what happens in the general education classroom. If math class typically takes
place during a 45-minute class period, for example, intervention should not take longer than 45 minutes (Griffin & Jitendra, 2009). Griffin and Jitendra (2009) were the only researchers who found that SBI and GSI were equally effective at promoting problem solving abilities. However, one reason that was posited was the length of time for the sessions. The sessions were 100 minutes long which may have been too long to sustain the attention of the students. These results were disappointing in that all of the other studies found the SBI to be more effective than GSI.

The schema broadening strategy was researched by Fuchs and colleagues (2003a, 2003b, 2004) who explicitly taught for transfer: that is, they taught students to recognize similar underlying structures beneath superficial differences. Superficial structures such as presenting a problem in a different format, or embedding a problem in another problem were used to help students to identify similar problem types underlying these structures. However, no evidence was found in this literature review of the structures of geometry or measurement added to problem types. Therefore, in the current study, problems involving measurement of the area of various shapes as superficial structures were added to ascertain whether students could generalize their knowledge of problem types and strategy use to the geometry problems.

Interestingly, Fuchs et al. (2003b) added self-regulated instruction to schema-based strategy instruction. Setting goals, self-monitoring, and self-graphing were incorporated into their study on schema-based strategy instruction. These self-regulation components were shown to develop independence in the students’ progress in word
problem solving. This study also pointed out the importance of providing frequent feedback to students while they learning new concepts.

Several features of this research were incorporated in the current study. The first was that the researcher explicitly taught students to identify different semantic structures before teaching problem solutions. In addition, students were required to learn the strategy to mastery so that they could be successful at identifying the problem types and at solving the problems. Schema-based strategy instruction may be important for students with poor memory abilities because it seeks to help students organize information using semantic relations. Because students with learning disabilities have poor working memories, knowledge of semantic relationships may help them to retain new information (Gersten & Clarke, 2007).

Chapter Summary

Current trends in mathematics instruction are largely directed by the NCTM. One instructional practice advocated by the NCTM is the use of manipulative objects to learn basic math facts and to solve math word problems. The concrete-representational-abstract (CRA) sequence of instruction is one way to make meaningful use of objects to represent word problems. In fact, by using this sequence, students are encouraged to internalize the concepts while learning basic math facts. In other words, students learn to apply their knowledge of basic skills to more complicated concepts concurrently (Mercer & Miller, 1992). The importance of focusing on basic fact fluency and word problem solving in the intermediate grades has also been stressed by the authors of the National Mathematics Advisory Panel (NMAP, 2008). For example, they suggest that students
should be proficient in multiplication and division facts as well as proficient at application of those skills to word problems before going to middle school. This is because in middle school students will be expected to study fractions and decimals in depth, as well as to solve problems involving percent, ratio, and proportionality (NMAP, 2008). The current study incorporated the CRA sequence supported by teacher modeling at each level of learning (Flores, 2009). The purpose of this was to ensure that students learn both basic math facts and how to apply those facts to real world problems.

The characteristics of students with learning disabilities typically include difficulties in the area of self-regulation (Fuchs et al., 2003b; Montague, 2007). However, self-regulated strategy training has been shown to increase students’ independence and self-confidence (Fuchs et al., 2003a; Montague, 2003). Self-monitoring in particular is a component of self-regulation that can be easily implemented in any classroom and when implemented, can increase students’ independence in learning. Self-monitoring is an area that researchers have explored in terms of students’ attention and academic productivity (Maag et al., 1993). Various types of self-monitoring devices and instruments were used including audible signals, student check lists, and self-graphing (Dunlap & Dunlap, 1989; Maag et al., 1993). The current study used a cue card type of check list that students used to monitor their work as they proceeded to solve word problems.

Think-aloud strategies are a form of instructional self-talk in which the teacher begins the dialogue gradually transferring the verbalizations to the student. When teaching students the steps involved in solving word problems, the teacher models the
process while verbalizing each step. During guided practice experiences, the student takes over verbalizing while performing the steps (Montague, 1992). Therefore, the student becomes responsible for the instructional self-talk involved in this lesson. Think-aloud strategies were used in the current study both in terms of teacher modeling and in students’ verbalizations of their thinking.

Explicit, systematic instruction has been recommended by many researchers as being effective in teaching new concepts to students with disabilities as well as to typically developing students. Many of the studies reviewed for the current research included explicit instruction components (Flores, 2009; Fuchs et al., 2003a; Griffin & Jitendra, 2009; Harris et al., 1995; Jitendra et al., 2007; Maccini & Hughes, 2000; Maccini & Ruhl, 2000; Mercer & Miller 1992; Peterson et al., 1988; Xin et al., 2005). Although the definition of explicit instruction has evolved over time, it does include direct instruction, teacher questioning, and frequent feedback (Gersten et al., 2009). Explicit instruction also consists of demonstration or modeling, guided practice with prompts, and independent practice with feedback coupled with advance organizers (Gersten et al., 2009). In general, without explicit instruction, modeling, and guided practice students with mild disabilities have tremendous difficulty accessing the general education curriculum. Students with disabilities frequently exhibit impulsivity as well, making it difficult to think about and work through a word problem before giving an answer (Gersten & Clarke, 2007).

The current study is the next one in line after the study conducted by Rockwell et al. (2011). These researchers used SBI to increase addition and subtraction problem
solving with a fourth grade student with autism. Therefore, instruction took place in problem representation first; that is, the student was required to identify and represent the word problem on the correct schematic diagram. Word problems were presented during this phase with no missing information (e.g., all variables and answers were provided) as in previous work (Jitendra et al., 2002; Jitendra et al., 2007). This meant that the student could focus on identifying problem types without being concerned over problem solution. After the student showed proficiency with problem representation, instruction proceeded to the problem solution phase where the student was expected to solve the problem. Word problems were presented with missing answers during this phase. Teaching scripts and lesson checklists were used along with a mnemonic strategy similar to that used by Jitendra et al. (2007). Outcomes indicated that a student with autism could learn to solve one and two step word problems involving addition and subtraction using SBI.

The NCTM Standards and Principles recommend that students learn algebraic thinking in terms of representing and analyzing patterns and functions, as well as modeling problem situations with objects. In addition, the standards require that students learn to represent the idea of a variable as an unknown quantity using a letter or symbol (NCTM, 2000). Finally, the standards require knowledge of geometry and measurement in terms of measuring the perimeter and area of various shapes. By fifth grade students who are struggling to learn math concepts are significantly behind their typically developing peers and need explicit instruction in strategy acquisition as well as instruction in pre algebra concepts. These concepts are critical for success in algebra in middle and high school (Witzel, 2005).
The current study embedded calculation of basic math facts with meaningful mathematics problem solving. The NCTM Principles and Standards (2000) emphasize that the two areas should be taught simultaneously rather than as separate entities. Historically, math calculations have been taught well before word problems are introduced especially in special education classrooms (Cawley & Parmer, 1992). In some cases, problem solving was not covered at all or only minimally addressed.

Therefore, the purpose of this study was to examine the effects of using an instructional package incorporating the CRA sequence of learning, SBI, and self-monitoring to teach students with mild disabilities to solve multiplication and division problems. The important difference between the current study and previous work was the incorporation of the CRA sequence of learning. The CRA sequence can assist students with basic fact calculation and mathematics word problem concepts (Witzel et al., 2003). This study was conducted with three fifth graders who had mild disabilities. Students were taught to on a one-on-one basis initially, coming together as a group after Day 31.

To answer the research questions this study examined the effects of using the CRA sequence of learning, self-regulated strategy learning, and schema-based strategy instruction on the word problem solving abilities of students with mild disabilities. The word problem solving lessons were taught in two phases: the problem representation phase and the problem solution phase (Hutchinson, 1993; Jitendra, et al., 2007). For example, in the problem representation phase, students learned to differentiate between vary and restate multiplication and division problems by examining the semantic structure and relations between statements within the problem. After categorizing the
problems, they used concrete materials to represent the problems on schematic diagrams designed specifically for each problem type. Students were then explicitly taught to solve the problems using the concrete materials (i.e., the problem solution phase).

After showing mastery of the problem solution phase using concrete objects, they were taught to draw pictures of the representation to connect the picture to their concrete understanding and again were taught to solve the problem. Again, after students showed mastery of the representational (drawing) level of learning, they were taught the abstract symbols involved with each problem. In addition, they were taught self-regulation strategies in the form of a self-monitoring check list and a mnemonic strategy. This mnemonic strategy drew from the work of Montague et al. (2011) as well as the work of Polya (1985) in that it required students to plan and represent math word problems before solving them. After explicit instruction was provided in using the strategy, students used a checklist to check off each step as it was accomplished. Chapter 3 will delineate specific steps and instructional strategies involved.

**Research Questions**

1. Will a training package consisting of schema-based strategy instruction, the concrete-representational-abstract instructional approach, and a self-monitoring checklist increase the independent use of a learning strategy for 1- and 2-step word problems involving multiplication and division?

2. Will an increase in learning strategy use result in increased accuracy in word problem solving involving multiplication and division?
3. Will the implementation of this training package affect generalization to word problems involving measurement of area?

4. How will the use of the instructional package affect maintenance?
Chapter 3: Method

The central research for this experiment was preceded by a pilot study conducted for 8 weeks during the fall 2011 semester. The rationale for conducting the pilot study was to sharpen the data collection tools, assessment measures, and teaching routines. Additionally, a digital recording was made of one of the sessions conducted during the study. This digital recording was used to later train the two observers who were selected to assist with fidelity of treatment for the main study.

The pilot study participant was selected based upon similar criteria used to select the participants for the main study. Carolyn, an 8-year-old student with a learning disability, was recommended by her teacher as needing math remediation, had criterion referenced test scores that indicated that she read on grade level, and had math goals included on her IEP. No FCAT data for mathematics were available due to Carolyn’s grade level. Therefore, a pretest was developed by the researcher to determine Carolyn’s level of proficiency in math word problem solving. This assessment was designed to target students’ ability to solve multiplication and division word problems of the vary or the restate type. See Appendix A for sample problems of each type. These were the types of problems specifically taught in this study. In addition, the pretest consisted of three generalization problems that targeted measurement of the area of various shapes to be solved by multiplication or division. The pretest is provided in Appendix B. In
addition to accessing the third-grade mathematics curriculum in her general education room. Parent permission was obtained to collect data and to video tape selected sessions. The setting for the pilot study was a small classroom similar to the one used in the main study. The sessions were held two or three afternoons a week for 30 minutes during a time when the classroom was not being used for other instructional purposes. Therefore, the classroom was relatively distraction free. The researcher and participant sat at opposite sides of a rectangular table during the intervention sessions.

Behavioral measures included two dependent variables: quiz scores and strategy use. A 6-item quiz was given after each intervention session and each quiz was graded and analyzed for strategy use. These data were converted to percentages and graphed. The independent variable was the instructional package including the schematic based strategy instruction, the CRA methodology, and self-regulated strategy use.

The intervention sessions were conducted using a sequence of lesson plans prepared for the main study. These lesson plans were scripted and served as fidelity data collection sheets as well. Lessons began with instruction in the CRA levels of learning and schema-based strategy instruction. The self-regulatory strategy was introduced in session seven. Carolyn worked hard during each session and appeared to enjoy working one on one with the researcher.

Results indicated that while no noticeable improvement was observed in her quiz scores, she did grasp the notion of problem types and how to set up the problems with manipulative objects. In addition, she memorized the strategy although she did not consistently apply it when solving problems. Unfortunately, due to circumstances
beyond the researcher’s control, there was not enough time to complete the entire sequence of lessons.

As a result of the pilot study, the first two lessons were divided into two sessions each, so that the content became manageable for students to comprehend. In addition, because Carolyn took from 2 to 5 days to complete one lesson, more problems were needed to have a fresh supply for each session.

The digital recording that was made during the pilot study served two purposes. The first purpose was to assist the researcher with revising the fidelity data collection and lesson plan sheets to make them more specific. While viewing the digital recording, the researcher identified specific teacher behaviors and key words that the teacher should say during each lesson. These behaviors and key words were added to the fidelity data collection and lesson plan sheets. The researcher then used the lesson plans to deliver instruction, and checked off each behavior and spoken key word as it was completed. The second purpose for the digital recording was that it became the training video for the observers who were selected to assist with fidelity of treatment.

Participants

Three students with mild disabilities from fifth-grade public school classrooms in southeast Florida participated in this study. Selection criteria for potential participants included having been identified by their teachers as having weaknesses in math calculations and word problem solving. In addition, each participant had an Individual Education Plan that addressed specific mathematics word problem solving goals. Moreover, only participants who scored 40% or below on the researcher designed pretest
that had been developed for the pilot study were eligible to participate. According to Deshler et al. (1996), it is vital to gather as much information as possible regarding present levels of student achievement so that an appropriate intervention can be planned. Scores on the pretest indicated that these students had severe weaknesses in word problem solving. In addition, researcher observations during the administration of the pretest indicated that there was no systematic strategy use as well. Because the pretest had been designed specifically with vary and restate problems, it served as an assessment that collected important information regarding the purpose of the current study. Therefore, the intervention that these students participated in was highly appropriate to their learning needs in terms of math word problem solving. Although no formal test was given to assess basic multiplication fact fluency, researcher observation of students’ daily math class work indicated that all three participants struggled in this area as well.

Reading ability is necessary to solve word problems. Therefore, eligibility criteria included being able to read on at least a third-grade level. This was determined by grade level equivalent scores on the Brigance Diagnostic Comprehensive Inventory of Basic Skills which yields scores in reading comprehension and word attack skills (Brigance, 1999). Students with disabilities in this district take the comprehension and word attack skills components of this test at the beginning of each school year. The participants in the study met these criteria by scoring at least a third-grade level in both reading comprehension and word attack skills (Brigance, 1999). The descriptive demographics and academic achievement levels of the participants are summarized in Table 1.
Table 1

Participant Characteristics

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Gender</th>
<th>Eligibility</th>
<th>Full Scale IQ*</th>
<th>Reading Decoding**</th>
<th>Reading Comprehension**</th>
<th>Math Pretest Score</th>
<th>Math FCAT*** Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles</td>
<td>11-4</td>
<td>M</td>
<td>SLD</td>
<td>81</td>
<td>Gr. 3</td>
<td>Gr.4</td>
<td>17%</td>
<td>Level 1</td>
</tr>
<tr>
<td>John</td>
<td>11-1</td>
<td>M</td>
<td>OHI</td>
<td>92</td>
<td>Gr. 3</td>
<td>Gr.3</td>
<td>0%</td>
<td>Level 2</td>
</tr>
<tr>
<td>Tom</td>
<td>11-6</td>
<td>M</td>
<td>SLD</td>
<td>87</td>
<td>Gr. 3</td>
<td>Gr.3</td>
<td>0%</td>
<td>Level 3</td>
</tr>
</tbody>
</table>

*Full Scale I.Q. as measured by WISC R;  
**Reading Decoding and Reading Comprehension as scored by the Brigance Diagnostic Inventory (CIBS);  
***Statewide Comprehensive Achievement Test
Students were enlisted for the study by contacting the parents and obtaining permission for their child’s participation. In addition, the students were given assent forms on the research process and their rights as research participants were explained to them. The students continuing in the study all provided their assent freely.

Setting

Instruction was delivered at the participants’ school, on a one-to-one basis or in small groups in a quiet room near the resource room. It had a curved table with four chairs and was devoid of typical classroom decorations such as posters or student work. During instructional sessions, the researcher and student sat at the curved table facing each other.

Instruction was provided as part of each student’s math intervention time which is scheduled school-wide for 40-minute periods. During this intervention time, any student who struggles in reading or math receives small group or individual remediation according to their need. Therefore, participants in the study were not pulled out of their general education class during their regularly scheduled mathematics classes. The researcher, a certified special education teacher, conducted the intervention sessions with each student. These sessions lasted approximately 30 to 40 minutes and were conducted 3 to 4 days per week over a 4-month period.

Instructional Materials

There were three major instructional materials employed in this study. The first instructional material was comprised of specially designed math word problems. The researcher adapted these problems from adopted third and fourth grade mathematics
textbooks in the State of Florida (Adams et al., 2011; Carter et al., 2011a; Carter et al., 2011b; Charles et al., 2011; Griffin, Clements, & Sarama, 2007). Vocabulary was simplified where necessary to assure that the task of reading the word problems was at the independent reading level of each participant. Seven of these problems were included on the researcher designed pretest.

Sets of six story problems with no information left out (e.g., with all variables including answers) were provided for each of the first five sessions totaling 120 story problems. Story problems without answers were introduced in Session 6 after students had mastered the earlier sessions’ material. Again, 120 new problems were provided for the final five sessions. These problem types involving multiplication and division were included in the study because they are frequently found in third- through fifth-grade textbooks reflecting the state of Florida’s Next Generation Sunshine State Standards (Florida’s Next Generation Sunshine State Standards, 2007; Fuchs & Fuchs, 2002). In addition, mathematics word problems that dealt with fractions or decimals were excluded. While the word problem types that were being targeted by this study (e.g., vary and restate) could include fractions and decimals, the objectives for this research focused on whole numbers embedded in mathematics word problems. The rationale for the decision to exclude word problems with fractions or decimals was based upon the fifth-grade curriculum which typically does not teach fractions and decimals until later in the school year. Therefore students would not be expected to be proficient in their use especially in math word problems. According to Deshler et al. (1996), prerequisite skills need to be acknowledged prior to beginning instruction in strategy use. Therefore, the
researcher designed pretest included math word problems with both 1-digit and 2-digit whole numbers to assess students’ word problem accuracy. In addition, it is essential that students in third- through fifth-grade become facile with multiplication and division story problems in order to move onto algebra instruction (NMAP, 2008). All problems were printed on 3 x 5 index cards that were laminated for durability.

The second set of materials was the manipulatives provided for participants to use in the CRA instructional sequence. The manipulatives included counters, base ten blocks, and half marbles to be used in the concrete phase of the CRA instructional sequence. The rationale for the inclusion of these particular manipulatives was to provide students with the necessary materials to solve both single digit multiplication facts as well as math word problems using larger 2-digit whole numbers. The first phase of CRA instruction requires that students set up or model word problems using concrete objects. Manipulatives were used in the initial sessions for representing word problems as prescribed by Mercer and Miller (1992) in the Strategic Math Series. After the students became proficient using concrete objects, drawing paper and pencils were provided to draw representations of word problems. Stick figures, tally marks, arrays, and circles were drawn in place of the concrete objects. Some students in the later phases of the study preferred to use colorful Post It notes to facilitate drawing pictures and writing numbers in the correct place on the diagrams. As they were solving the problems, they would either draw a small picture or write numbers on the Post It note and place the note on the diagram. The Post It notes appeared to be motivating for the students and allowed
the students’ schematic diagrams to be reused for subsequent problems. In addition, the Post It notes provided a transition from the representational to abstract levels of learning.

The third set of instructional materials was the strategy-related tool set developed for this study. This set included a poster depicting the specific structures and definitions for the word problems to prompt students during the acquisition phase of instruction. The poster was displayed in the room where instruction took place and students could easily see it from where they were seated. A sample of the poster with word problem features is provided in Appendix C. Another poster depicting the mnemonic strategy was displayed beginning with session seven when the strategy was first introduced, to remind students of the steps involved in the strategy. A sample of the mnemonic strategy poster is provided in Appendix D. Two other strategy-related tools were the schematic diagrams in the form of graphic organizers printed on standard business letter sized paper. Copies of each schematic diagram (i.e., one for each problem type) were given to students to refer to during strategy acquisition. For samples of the vary and restate schematic diagrams, see Appendices E and F respectively. In addition, students were provided with self-monitoring cue cards depicting the mnemonic strategy. Students were to check off each step of the strategy as it was completed. Samples of self-monitoring cue cards along with a completed sample are provided in Appendix G. Each of these items was developed specifically for this study and comprises the instructional package.

**Experimental Procedure**

Phases for this experiment consisted of baseline, intervention, baseline, intervention, and follow up. The first baseline session consisted of administering session
quizzes on a daily basis with no directions to students other than to complete all the problems and to do their best. The first intervention phase began on a staggered basis, after each student had achieved a low or stable baseline on the use of the learning strategy. For example, Charles began the first intervention on Day 7 after six baseline quizzes, John began the first intervention on Day 12 after six baseline quizzes, and Tom began the first intervention on Day 20 after nine baseline quizzes.

The first intervention phase consisted of the following instructional sessions. Sessions 1 through 4 were spent teaching students the difference between vary and restate problems. Specifically, students were asked first to identify whether the multiplication or division word problems were of the vary or restate type (Riley et al., 1983). A vary problem exists when a proportional relationship is found between two items such that when one of the items increases (or decreases) in number, the other item increases or decreases as well. For example, “If one jar (the first item) holds nine buttons (the second item), how many buttons would there be in four jars?” A restate problem consists of a variable compared to itself in a fixed moment in time and generally has a comparative phrase such as two times as much as or one half of. For example, “Johnny’s mom is four times as old as Johnny. Johnny is 6 years old. How old is his mom?” After identifying the problem type, students were asked to set up the word problems using concrete objects (e.g., counters, half marbles). If a problem called for multiplying 4 by 3, participants were shown how to set up four paper plates and put three counters in each one or to make an array of four rows with three counters in each row. Base ten blocks were used when students were asked to multiply 2-digit numbers by a 1 digit number (i.e., 35 x 6).
During these sessions, all word problems had no missing information and included the answers to the word problems. The purpose for using word problems with no missing information was that students were then able to focus on identifying the problem type as well as on setting it up correctly rather than actually solving the problem (Jitendra et al., 2002; Jitendra et al., 1999; Jitendra et al., 1998).

Session 5 connected the use of concrete objects to pictures or diagrams to represent the problems. Therefore, instead of using manipulatives to set up word problems, participants were taught to draw pictures in their place. This step in the CRA learning sequence depicts the representational phase. Session 6 rounded out the CRA learning sequence by connecting the pictures to numbers, the way word problems are usually seen. Additionally, Session 6 was the first session that utilized word problems with missing information--that is, without answers.

During Session 7, an original mnemonic strategy was introduced to assist students with their problem solving. Specifically, the mnemonic strategy was PROBLEM:

- Pick the problem type
- Represent the problem on the correct schematic diagram
- Identify the Operation and equation
- Break the code
- Learn and write the solution
- Examine work
- Make corrections
For example, when students were instructed to Pick and Represent the problem type, they were to select the correct schematic diagram from a set of two and write the correct numbers in the correct places on the corresponding diagrams. For the Identify the Operation and equation steps, students were asked to write the correct operation symbol, (either x or /) and write the equation accurately. For the Break the code and Learn and write the solution, students were asked to calculate accurately and label the answer correctly. The steps for Examine work and Make corrections were added to the strategy so that students would learn to self-regulate their problem solving skills. During Session 9, 2-step problems were introduced requiring students to identify the problem types embedded within each step of the problem. They then were required to use the mnemonic strategy to solve each part of the problem, using manipulative objects, pictures or numerical equations.

Sessions 8 and 9 were spent teaching students how to solve 2-step problems incorporating the restate and vary structures. Decisions about when to move from session to session were made when students were able to complete the independent practice component of the lesson plan and check list accurately with no assistance. Session 10 focused on the strategy PROBLEM and its use in solving 1- and 2-step vary or restate word problems.

A decision was made to implement a second baseline followed by a second intervention. The main reason for this decision was because the data from the first intervention phase did not show a clear pattern of strategy use or an impact on word problem accuracy. In fact, based on student comments during the sessions, it was
observed that there was no real connection being made between strategy use and word problem accuracy. The participants readily memorized the strategy and performed the steps involved but did not use the strategy for assistance at solving the word problems.

The other reason the decision was made to implement the second baseline, was that while participants were eager to work with the researcher one-on-one when the study began, they appeared bored with the routines of the lessons toward the end of the first intervention. This was evidenced by their reticence in working with the researcher as well as by the fact that they tended to rush through their quizzes in order to complete the sessions. As a result of this haste, quiz scores went down for Charles and Tom by the end of the first intervention. To give the participants a break in the lesson routines the researcher instituted a second baseline where the participants were administered either training or generalization quizzes and given the same directions as were given during the original baseline. The second baseline lasted 3 weeks for Charles, 1 week for John, and 2 weeks for Tom. During the second baseline, Charles took five quizzes, John took two quizzes, and Tom took three quizzes.

While during the first intervention phase participants worked one-on-one with the researcher, participants were instructed together during the second intervention with either two or three of the participants working together. The rationale for this change was to prompt students to use self-talk and peer-to-peer discussions on the strategy process and its importance. The second intervention phase focused on the use of the strategy in solving 1- and 2-step word problems. The second intervention phase lasted until an ascending trend was displayed on each student’s graphs.
The number of sessions for each phase of the study varied according to participant. For Charles, the first baseline included six sessions and lasted 3 and one-half weeks. The first baseline for John and Tom spanned the school’s holiday vacation and included six sessions for John and nine sessions for Tom. In addition, the first baseline lasted 9 weeks for John and 10 weeks for Tom.

The first intervention lasted 2 weeks or 11 sessions for Charles, 2 and one-half weeks for John or 14 sessions, and 2 and one-half weeks or nine sessions for Tom. The second baseline lasted for 3 weeks for Charles including five probes while it lasted only 4 days and 5 days respectively for John and Tom. There were two probes for John and three probes for Tom during the second baseline as well. Because Charles and John worked together during the second intervention, this phase lasted 6 weeks and included 20 sessions. Tom joined the sessions after 2 weeks and participated in the small group for 13 sessions. After 5 weeks had elapsed, the follow up phase lasted 1 week.

**Behavioral Measures**

**Dependent variables.** For this study, two dependent variables were selected. The first dependent variable was word problem accuracy. The second dependent variable was strategy use, specifically the PROBLEM strategy.

Permanent products for each student (session quizzes) were examined to determine whether problems were solved accurately. A word problem was considered accurate if the numerical answer was correct and if the answer was labeled correctly. For example, if a word problem involved multiplying 12 muffins by three batches, the correct answer would be 36 muffins, not simply 36. The second dependent variable was strategy
use: specifically the use of the strategy PROBLEM. Students’ use of the strategy was shown on the daily quizzes in terms of writing problem numbers on the correct diagrams, writing the correct equations, calculating correctly, and checking their work.

**Independent variable.** The independent variable was an instructional package including the use of schema-based strategy instruction (SBI), the CRA sequence of instruction, and self-regulated learning strategies. SBI is a research validated system of instruction incorporating the use of schematic diagrams and word problem types (Fuchs et al., 2003a; Fuchs et al., 2004; Griffin & Jitendra, 2009; Jitendra et al., 1998; Jitendra & Hoff, 1996; Jitendra et al., 1999; Jitendra et al., 2007; Xin et al., 2005). Students with mild disabilities are often not able to identify the underlying concepts involved in solving word problems. Requiring students to categorize word problems into problem types can assist them at recognizing the underlying concepts and thus lead to satisfactory solutions (Rockwell et al., 2011).

The CRA sequence of learning was employed because students with mild disabilities often have difficulty memorizing basic facts making solving word problems all the more difficult. In addition, these students tend to have difficulties remembering the procedures necessary for solving word problems correctly. The CRA methodology can assist students with basic fact memorization and with learning the concepts underlying word problems (Harris et al., 1995; Maccini & Hughes, 2000; Mercer & Miller, 1992; Morin & Miller, 1998; Peterson, et al., 1988; Witzel, 2005). The CRA methodology involves three levels of learning through which students progress as they develop proficiency with mathematics concepts and computations. The concrete level
involves interacting with appropriate concrete materials that can help students to remember the procedures necessary to solve problems because of the sensory modalities involved: that is visual, kinesthetic, and haptic (Witzel, 2005). For example, in learning how to multiply 3 by 2, young students begin at the concrete level making three rows of counters with two counters in each row. At this level, students are encouraged to manipulate objects to understand basic concepts. After they demonstrate conceptual understanding with the objects, they begin to draw pictures or interpret information from diagrams depicting multiplication or division (e.g., drawings of arrays or equal groups of items). The final level is the abstract where connections are made between the representational and the abstract algorithms (e.g., $3 \times 2 = 6$).

The last component of the instructional package was self-regulated learning. Self-regulation has been shown to be effective in academic areas such as writing, reading, and math (Case et al., 1992; Graham & Harris, 2003; Maag et al., 1993; Montague, 2007; Swanson, 2006). This study, like the study conducted by Case et al. (1992), incorporated the use of a mnemonic strategy and a self-monitoring cue card that students used to solve multiplication and division word problems.

The components of the instructional package were integrated into scripted lesson plans for lessons 1 through 10. These lesson plans were created for use by the researcher and they were based on a task analysis of all of the steps that were followed during the intervention phase. The lesson plans employed explicit instruction that included advance organizers, modeling of new concepts with verbalizations, guided practice with teacher
and student verbalizations, and immediate feedback (Baker et al., 2002; Butler et al., 2003; Carnine, 1997; Gersten, Jordan, & Flojo, 2005; Swanson et al., 1999).

Each of the lesson plans followed the same presentation format. The plans not only presented the lesson steps, but defined teacher behavior and instructional method. Lesson plans can be found in Appendix H. The lesson steps and defined teacher behaviors include:

**Provides rationale for the day’s lesson.**

A rationale consists of a statement about the value of learning the skills or strategies being presented.

**Provides advance organizer.**

An advance organizer incorporates linking previous knowledge to the new concept to be learned.

**Provides daily review.**

The daily review is a brief review (two to three minutes) of material learned in the last session.

**Provides lesson objective.**

The lesson objective consists of a clear statement of the current session’s content.

**Uses examples and non-examples.**

Examples and non-examples occur in the acquisition phase when the teacher models how to solve multiplication or division problems. The student is shown how to solve problems correctly and one mistake is made: that is, multiplication is
used when division should be used or vice versa. The mistake is then pointed out to students.

*Provides guided practice.*

In providing guided practice, varying levels of support are provided to the student by the teacher through questioning and prompts. Initially, a high level of support is provided where the teacher coaches the student with each step of the strategy. Consistent, specific feedback is given during this stage as well. Gradually this support is faded and the teacher then monitors the student’s progress through questioning and observation (Hudson & Miller, 2006).

*Provides independent practice.*

The independent phase is for students to practice independently their newly learned skills at their instructional level of reading. Students become more fluent and automatic during this phase. The opportunity to practice solving word problems independently can assist students to retain the new material.

*Provides frequent feedback.*

Positive feedback on both the process and the outcomes are provided throughout the lesson.

*Reviews content of the day’s lesson.*

Reviewing the content of the day’s lesson consists of a brief statement by the teacher of what was learned in today’s lesson.
Data Collection

Data collection sheets in the format of event recording sheets were constructed to record the number of problems solved accurately, as well as the number of strategy steps used to solve each problem, both for training and generalization quizzes. Both word problem accuracy and strategy use could be recorded on the same data collection sheet. However, it was necessary to develop separate sheets for the training quizzes and the generalization quizzes because the number of problems for the training quizzes was six, while the number of problems for the generalization quizzes was eight. Sample data collection sheets as well as completed data collection sheets for training and generalization quizzes are provided in Appendices I and J respectively. Each strategy step was marked on the data collection sheet with a plus sign (+) for evidence of the step or a minus sign (−) for no evidence of the step. Plus signs were counted and percentages calculated by dividing the total correct by the total possible correct. These data were put on separate data summary sheets, one for the training and one for the generalization components. From these summary sheets training and generalization graphs were created.

Students could earn a total of six points on a 6-item training quiz for word problem accuracy and a total of 48 points for strategy use. An 8-item generalization quiz consisted of four training problems that represented problems covered during the training phase, and four additional novel generalization problems. Therefore, students could earn a total of four points each on the training and generalization components of the quizzes.
for word problem accuracy. In addition, students could earn a total of 30 points each for strategy use on the training and generalization components.

Data on word problem accuracy were derived from quizzes that were constructed using a pool of word problems adapted from third- and fourth-grade textbooks adopted by the State of Florida (Adams et al., 2011; Carter et al., 2011a; Carter et al., 2011b; Charles et al., 2011; Griffin et al., 2007). The quizzes were designated to be either training quizzes or generalization quizzes.

Each training quiz was constructed so that there were four 1-step and two 2-step problems on each quiz for a total of six problems. For each 1-step problem that was solved correctly, one point was given and for each 2-step problem solved correctly, one point was awarded if both steps were solved correctly. Therefore, the maximum amount of points that a student could earn for word problem accuracy on each quiz was six points. It is important to note that a correct answer must be correct numerically and labeled correctly.

The generalization quizzes included a total of eight problems: six were 1-step problems and two were 2-step problems. The same scoring method was used for generalization quizzes as was used for training quizzes. Thus one point was awarded for each 1-step problem and one point was awarded if both parts of the 2-step problem were correct. Therefore, a total of eight points could be earned for word problem accuracy for the generalization quizzes.
The assessment pattern followed a two-to-one schedule: That is, the students were assessed 2 days in a row using training quizzes and the third day they were assessed using a generalization quiz. The pattern repeated itself throughout the study.

Two follow up probes were administered to all three participants during the fourth and fifth week after the end of the study. All three participants had training follow up quizzes. However, Tom had two generalization follow up quizzes, John had one generalization quiz, and Charles had none. These follow up probes were graded in the same way that the baseline and intervention quizzes were graded. All the quizzes that were used in this study, in both the training and generalization formats, have been provided in Appendices K and L respectively.

In addition to the actual quiz administration, students were given a diagram sheet depicting the diagrams for vary and restate problems. As part of the P and R steps of the strategy, students were asked to select the correct diagram for each problem type and set the problem up on the diagram before completing the quiz. The schematic diagram sheets assisted both the researcher and the observers to determine whether the students had selected the correct diagrams when solving the word problems on the quizzes. Sample schematic diagram sheets in both the training and generalization formats are provided in Appendices M and N respectively. Sample completed schematic diagram sheets can be found in these appendices as well.

The second dependent variable, strategy use, was calculated by counting the number of steps employed in word problem solution which are part of the strategy PROBLEM, for each problem on each quiz. Therefore, students who wrote the correct
numbers in the correct areas on the correct diagrams would receive two points: one point for picking the correct problem type and one point for representing it correctly. Earning two points would indicate that the student had applied the \( P \) and the \( R \) step correctly. In addition, if they wrote the correct operation symbol and equation and correctly performed the calculations to solve the problem, they would receive two additional points. These steps were represented in the strategy by \( O \) and \( B \) respectively. Moreover, a correctly written label for the answer to the problem earned one point. This step is represented by \( L \) in the strategy. Finally, if students had made check marks in at least two places on the quiz or diagram, it indicated that checking and making corrections if necessary, had occurred. These steps are represented by \( E \) and \( M \) respectively and were counted as one point. Therefore, for each 1-step problem there were six opportunities for students to earn points. For each 2-step problem, there were 12 opportunities to earn points.

Individual student strategy use data were collected at the end of every quiz. A total of 48 points for strategy use could be earned from the training quizzes while a total of 30 points for strategy use could be earned on each component of the generalization quizzes, training and generalization.

The timing for the quizzes was determined as a result of normative data collection. Three average achieving fifth-grade students without disabilities were selected to take three different 6-item word problem quizzes. These quizzes were administered to the students in a small group setting on three consecutive days. The average achieving students were allowed 3 minutes to complete the quizzes. The median score of each student’s assessments was taken and student performance was analyzed in
terms of word problem accuracy and word problem completion per minute. From these
data, it was determined that students should be given approximately 8 minutes to
complete each quiz. Because these data were used in the study in terms of determining
rates of accuracy and time, parental permission was obtained to administer these probes.

**Fidelity of treatment.** The independent variable was measured to establish the
fidelity of researcher delivery of instruction. To assess fidelity of treatment, the lesson
plans that were designed for this study also served as checklists to measure the
independent variable. Training of observers took place in two steps. First, the observers
received training that consisted of explanations of each of the terms used in the lesson
plan/checklist. Second, the digital recording that was made during the pilot study was
viewed by the researcher and each of the observers separately. Using the lesson
plan/checklist, the researcher pointed out when each step of the lesson plan did or did not
occur. In addition, they were shown how to use the data collection sheet to mark a + or a
– sign when components of the task analysis were present or absent respectively.

To facilitate the process of checking for fidelity, digital recordings were made of
18 of the sessions, 6 for each participant (approximately 34% of all sessions). The digital
recordings were made only on days when the intervention was implemented. When the
two observers had received both steps of the training, each observer reviewed half of the
digital recordings. That is, each recording was reviewed by one observer using the same
procedure (i.e., for each lesson plan component present, the observer placed a plus sign in
the appropriate box and used a – sign if the teacher behavior was not present). At the end
of each recording, the total number of plus signs was divided by 21, the total number
possible. That result was multiplied by 100 to give a percentage. Across all of the fidelity assessments, the overall fidelity of the intervention averaged 92%. Table 2 presents the six fidelity checks for the individual participants.

Table 2

*Fidelity Checks*

<table>
<thead>
<tr>
<th></th>
<th>Charles</th>
<th>John</th>
<th>Tom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>100%</td>
<td>100%</td>
<td>95%</td>
</tr>
<tr>
<td>3</td>
<td>100%</td>
<td>90%</td>
<td>95%</td>
</tr>
<tr>
<td>4</td>
<td>95%</td>
<td>86%</td>
<td>90%</td>
</tr>
<tr>
<td>5</td>
<td>86%</td>
<td>81%</td>
<td>86%</td>
</tr>
<tr>
<td>6</td>
<td>81%</td>
<td>76%</td>
<td>86%</td>
</tr>
<tr>
<td>Total</td>
<td>94%</td>
<td>89%</td>
<td>92%</td>
</tr>
</tbody>
</table>

**Interobserver agreement.** The researcher graded all of the quizzes of each student. Three observers were then asked to grade 40 quizzes selected at random from the total number of 124 quizzes. Each observer received training on grading the quizzes for word problem accuracy and analyzing strategy use. Two observer training quizzes were provided for this training and the researcher modeled how to grade each quiz. Observers were then provided with two more observer training quizzes and offered guided practice. Finally, two additional observer training quizzes were provided for
independent practice. These observer training quizzes are provided in Appendix O. Training continued until the interobserver agreement between the researcher and observer reached 95% or better. The total points earned divided by the total possible correct for word problem accuracy were calculated. The same procedure was used for strategy use. These results were multiplied by 100 to arrive at a percentage.

Interobserver agreement was established separately for each student’s use of the learning strategy and for word problem accuracy. For example, an interobserver agreement analysis was conducted for Charles’ performance during the study. For Charles, there were 44 total assessments of his performance on the *training problems*, and during 12 of these, a second assessment was conducted to establish observer agreement (i.e., 27% of the sessions). Charles’ total agreement of Strategy Use on the training problems was 93%; his total agreement on Word Problem Accuracy was 98%.

The same interobserver agreement analysis was conducted for John’s performance during the study. For John, there were 44 total assessments of his performance on the *training problems*, and during 16 of these, a second assessment was conducted to establish observer agreement (i.e., 36% of the sessions). John’s total agreement on Strategy Use on the *training problems* was 94%; his total agreement on Word Problem Accuracy on the *training problems* was 90%.

Finally, the same analysis of observer agreement was conducted for Tom’s performance. For Tom there were 36 total assessments of his performance on the *training problems*, and during 12 of these, a second assessment was conducted to establish observer agreement (i.e., 33% of the sessions). Tom’s total agreement on
Strategy Use on the *training problems* was 94%; his total agreement on Word Problem Accuracy on the *training problems* was 95%. A summary of interobserver agreement on the training problems is found in Table 3.

Table 3

*Summary of Interobserver Agreement: Training Problems*

<table>
<thead>
<tr>
<th></th>
<th>Number of Assessments</th>
<th>Number of Agreement Checks</th>
<th>Interobserver Agreement on Strategy Use</th>
<th>Interobserver Agreement on Word Problem Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles</td>
<td>44</td>
<td>12</td>
<td>93%</td>
<td>98%</td>
</tr>
<tr>
<td>John</td>
<td>44</td>
<td>16</td>
<td>94%</td>
<td>90%</td>
</tr>
<tr>
<td>Tom</td>
<td>36</td>
<td>12</td>
<td>94%</td>
<td>95%</td>
</tr>
</tbody>
</table>

On the generalization problems Charles had 14 total assessments of his performance of which 5 had a second assessment to establish observer agreement (i.e., 35% of the sessions). Total agreement on Charles’ Strategy Use on was 94% while his total agreement on Word Problem Accuracy was 95%.

John had 11 total assessments of his performance on the generalization problems of which 7 had a second assessment to establish observer agreement (i.e., 64% of the sessions). On the generalization problems, total agreement on John’s Strategy Use was 94%; total agreement on his Word Problem Accuracy was 87%.
Tom also had 11 total assessments of his performance on the generalization problems of which 7 had a second assessment to establish observer agreement (i.e., 64% of the sessions). On the generalization problems, total agreement on Tom’s Strategy Use on was 97%; total agreement on his Word Problem Accuracy was 93%. A summary of interobserver agreement on the generalization problems for each condition of the study for both Strategy Use and Word Problem Accuracy can be found in Table 4.

Table 4

*Summary of Interobserver Agreement: Generalization Problems*

<table>
<thead>
<tr>
<th></th>
<th>Total Number of Assessments Given</th>
<th>Number of Agreement Checks</th>
<th>Interobserver Agreement: Strategy Use</th>
<th>Interobserver Agreement: Word Problem Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles</td>
<td>14</td>
<td>5</td>
<td>94%</td>
<td>95%</td>
</tr>
<tr>
<td>John</td>
<td>11</td>
<td>7</td>
<td>94%</td>
<td>87%</td>
</tr>
<tr>
<td>Tom</td>
<td>11</td>
<td>7</td>
<td>97%</td>
<td>93%</td>
</tr>
</tbody>
</table>

**Experimental Design**

A multiple baseline design across participants was used (Tawney & Gast, 1984). Each participant was taught to solve word problems involving multiplication and division using the PROBLEM strategy process in one to one instructional sessions after establishing baseline performance. The purpose of the multiple baseline design was to determine if a functional relationship existed with each participant’s performance.
improving only after the intervention was applied. The experimental phases for this study were baseline, intervention, baseline, intervention, and follow up.

Baseline quizzes were administered to all three students over a series of 3 weeks. After Charles entered intervention, John remained in baseline for 1 more week, and Tom remained in baseline another 3 weeks after Charles entered intervention. After Session 18, Charles was brought back to baseline while the other two students remained in intervention. Likewise after Session 28, John was brought back to baseline and after Session 32 Tom was brought back to baseline. Charles and John were taught together in the second intervention phase beginning with Session 31. Tom joined the small group after Session 37 and the study ended with Session 51.
Chapter 4: Results

The research questions guiding this study concerned whether a training package would increase the use of a learning strategy specifically designed for solving mathematics word problems and whether the use of the learning strategy would increase the word problem accuracy of students with mild disabilities. In addition, generalization to mathematics word problems concerning measurement of area was explored and maintenance was assessed 5 and 6 weeks after the intervention ended. The results for the research questions are presented in Figures 1 and 2, with separate presentations for students’ performance on the training problems and for the generalization problems.

Response to Research Question #1

Research Question #1 addressed the following question: Will a training package consisting of schema-based strategy instruction, the concrete-representational-abstract instructional approach, and a self-monitoring checklist increase the independent use of a learning strategy for 1- and 2-step word problems involving multiplication and division?

The top graph of Figure 1 shows the impact of the learning strategy training package on Charles’ use of the strategy on 1- and 2-step word problems involving multiplication and division. During baseline, Charles showed little use of the strategy, with his performance ranging between 2% and 13%. On Day 7, the strategy intervention was implemented and his strategy use increased somewhat, but remained variable ranging from 3-46%.
On 7 of the 11 days of the first intervention phase his strategy use reached 25% or better with a mean of 28%.

During a return to baseline, Charles’ strategy use plummeted, averaging 14% and never exceeding 20%. On Day 31 the strategy training was re-introduced, and Charles began a gradual increase in the use of this strategy. Although his strategy use showed a great deal of day-to-day variability, there was an overall increasing trend until Day 49 when Charles reached 98% strategy use. Five and 6 weeks after the cessation of the intervention, two follow-up probes were conducted to see whether Charles continued to use the learning strategy. Results showed that he continued to use the strategy even in the absence of instruction (71% and 86%).

John’s use of the learning strategy is shown in the middle graph of Figure 1. During baseline, John showed little use of the strategy as well, with his performance ranging from 0% to 4%. When the strategy intervention was implemented on Day 12, his strategy use improved gradually although with great variation (ranging from 0% to 53%). On 8 of the 14 days in Intervention 1, his strategy use was at 25% or better. During a return to baseline, John’s strategy use dropped substantially. On Day 31, the strategy training was reintroduced, and John’s strategy use steadily improved again, with great variation (ranging from 31% to 71%). On Day 49, John’s strategy use reached 71%. Five and 6 weeks after the cessation of the intervention, two follow-up probes were conducted to see whether John continued to use the learning strategy. Results showed that John used the strategy moderately with a performance of 46% and 43% respectively.

The bottom graph of Figure 1 shows the impact of the learning strategy training
package on Tom’s use of the learning strategy. During baseline, Tom’s use of the strategy was minimal with variation ranging from 0% to 38%. On Day 20, the strategy intervention was implemented and his strategy use gradually increased with some variation in his performance ranging from 10% to 30%. In addition, on 5 of the 9 days during Intervention 1, Tom’s performance reached 25% or better. Tom’s strategy use dropped only slightly during a return to baseline. On Day 38 the strategy training was re-introduced, and Tom steadily improved in the use of this strategy reaching 100% on Day 49. Two additional probes were conducted 5 and 6 weeks after the cessation of the intervention to see whether Tom continued to use the learning strategy. Results showed that Tom continued to use the strategy fairly well even in the absence of instruction with performance scores of 60% and 47% respectively.
Figure 1. Participants’ word problem accuracy and strategy use: Training phase.

Data for mean performances of strategy use were calculated and are reported on Table 5. For Charles, mean scores increased from 28% to 63% from Intervention 1 to Intervention 2 while mean scores for John increased from 27% to 50%. Mean scores for Tom increased from 23% to 63% over the two intervention phases. From these data, it is
clear that all three participants increased their use of the learning strategy from the first intervention to the second intervention, in spite of the variability in strategy use scores as shown in Figure 1.

Table 5

Mean Performances and Number of Days in Each Phase: Training Strategy Use

<table>
<thead>
<tr>
<th>Student</th>
<th>B1 Days</th>
<th>B1 Mean</th>
<th>I1 Days</th>
<th>I1 Mean</th>
<th>B2 Days</th>
<th>B2 Mean</th>
<th>I2 Days</th>
<th>I2 Mean</th>
<th>FU Days</th>
<th>FU Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles</td>
<td>6</td>
<td>8%</td>
<td>11</td>
<td>28%</td>
<td>5</td>
<td>14%</td>
<td>20</td>
<td>63%</td>
<td>2</td>
<td>79%</td>
</tr>
<tr>
<td>John</td>
<td>6</td>
<td>2%</td>
<td>14</td>
<td>27%</td>
<td>2</td>
<td>21%</td>
<td>20</td>
<td>50%</td>
<td>2</td>
<td>45%</td>
</tr>
<tr>
<td>Tom</td>
<td>9</td>
<td>13%</td>
<td>9</td>
<td>23%</td>
<td>3</td>
<td>19%</td>
<td>13</td>
<td>63%</td>
<td>2</td>
<td>54%</td>
</tr>
</tbody>
</table>

Note.  B1 = Baseline 1; I1 = Intervention 1; B2 = Baseline 2; I2 = Intervention 2; FU = Follow Up.

Response to Research Question #2

Research Question #2 addressed the following question: *Will an increase in strategy use result in increased accuracy in word problem solving involving multiplication and division?* The accuracy of each student’s Word Problems is also shown on Figure 1.

The top graph shows Charles’ accuracy on the word problems. During baseline before he was introduced to instruction on the use of the strategy, Charles’ accuracy when solving the word problems was low: that is, on 5 of 6 days his word problem accuracy was below 40%. When the strategy intervention was implemented on Day 7,
his accuracy showed improvement although there was great variation in his scores (ranging from 0% to 75%). During a return to baseline, Charles’ performance on word problem accuracy was uneven with scores ranging from 0% to 50%. On Day 31, the strategy training was reintroduced, and Charles’ performance steadily improved even though there was great variation with scores ranging from 0% to 100%. When the follow up probes were administered 5 and 6 weeks after the cessation of the intervention, Charles’ accuracy remained high at 67% for each probe.

John’s word problem accuracy is shown in the middle graph of Figure 1. During baseline, John showed a very low performance rate with scores ranging from 0% to 17%. When the strategy intervention was implemented on Day 12, his word problem accuracy gradually improved reaching 75% on Day 27. During a return to baseline, John’s scores on word problem accuracy dropped to 0%. When the strategy training was reintroduced on Day 31, John’s performance steadily improved although there was much variation between scores. In spite of this variation, John reached a score of 83% on Day 49. Five and 6 weeks after the cessation of the intervention, two follow-up probes were conducted to see whether John continued to show word problem accuracy improvements. Results showed that John’s performance dropped to 17% and 0% respectively.

The bottom graph of Figure 1 shows Tom’s performance on word problem accuracy. During baseline Tom’s performance was low with six out of nine scores being 0% and ranging from 0% to 50%. When the strategy intervention was implemented on Day 20, his performance on word problem accuracy was uneven and variable, ranging from 0% to 67%. During a return to baseline, Tom’s performance dropped with accuracy
scores ranging from 0% to 17%. On Day 38, the strategy training was reintroduced, and Tom’s performance showed a progressive improvement, although there was still variation in scores. Despite this variation, Tom’s performance on Day 49 actually reached 100%. Five and 6 weeks after the cessation of the intervention, two follow-up probes were conducted to see whether Tom maintained his progress at solving word problems. Results showed mixed word problem accuracy with scores of 50% and 25% respectively.

Mean performances for each participant in word problem accuracy were calculated for the baseline, intervention, and follow up phases of the training sessions. These data are reported in Table 6 along with the number of days spent in each phase. Looking at the mean scores for each experimental phase, it is clear that the participants improved performance over baseline. In addition, Charles increased his mean scores from 42% to 59% from the first intervention phase to the second intervention phase while John increased his means scores from 32% to 39%. Tom increased his mean scores from 24% to 39%. The total number of days spent in Intervention 1 and Intervention 2 was 31 for Charles, 34 for John, and 22 for Tom.
Table 6

*Mean Performances and Number of Days in Each Phase: Training Word Problem*  

**Accuracy**

<table>
<thead>
<tr>
<th></th>
<th>B1 days</th>
<th>B1 Mean</th>
<th>I1 days</th>
<th>I1 Mean</th>
<th>B2 days</th>
<th>B2 Mean</th>
<th>I2 days</th>
<th>I2 Mean</th>
<th>FU days</th>
<th>FU Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles</td>
<td>6</td>
<td>28%</td>
<td>11</td>
<td>42%</td>
<td>5</td>
<td>33%</td>
<td>20</td>
<td>59%</td>
<td>2</td>
<td>67%</td>
</tr>
<tr>
<td>John</td>
<td>6</td>
<td>3%</td>
<td>14</td>
<td>32%</td>
<td>2</td>
<td>0%</td>
<td>20</td>
<td>39%</td>
<td>2</td>
<td>9%</td>
</tr>
<tr>
<td>Tom</td>
<td>9</td>
<td>9%</td>
<td>9</td>
<td>24%</td>
<td>3</td>
<td>6%</td>
<td>13</td>
<td>39%</td>
<td>2</td>
<td>38%</td>
</tr>
</tbody>
</table>

*Note. B1 = Baseline 1; I1 = Intervention 1; B2 = Baseline 2; I2 = Intervention 2.; FU = Follow Up.*

**Response to Research Question 3**

Research Question 3 addressed the following question: *Will the implementation of this training package affect generalization to word problems involving measurement of area?* The results of each student’s application of the strategy, as well as the impact on the accuracy of their word problems are shown in Figure 2.

On the generalization problems, initially Charles seldom used the learning strategy, and word problem accuracy was low. For the two generalization probes during baseline, Charles’ scores were 0%. When strategy instruction was implemented with the training problems (first intervention), Charles’ performance showed a modest improvement, with an average score of 25% for word problem accuracy with no variability. There was modest improvement in strategy use on the generalization
problems as well, with scores ranging from 3% to 27%. During a return to baseline where no instruction was provided on the training problems, Charles’ scores on the generalization problems both for word problem accuracy and strategy use dropped to 0%. With the reintroduction of the learning strategy instruction on the training problems in the second intervention, Charles’ performance on the generalization problems improved both in word problem accuracy and strategy use although with much variation. His word problem accuracy scores ranged from 0% to 50% while his scores on strategy use ranged from 0% to 77%.

On the generalization component of three quizzes administered during baseline, John’s performance yielded scores of 0% on both strategy use and word problem accuracy. When the strategy instruction on the training problems was implemented (first intervention), John’s performance showed some improvement toward the end of this phase of the experiment with scores of 50% on word problem accuracy and 73% on strategy use. During the return to baseline where no instruction was provided on the training problems, John’s scores dropped to 0% on word problem accuracy and 23% on strategy use. John’s performance improved with the beginning of the second intervention when training was reintroduced on the training problems; he reached 75% in word problem accuracy and 73% in strategy use. However, there was variability to the scores ranging from 0% to 75% in word problem accuracy and 37% to 73% in strategy use.

During the first baseline phase of the generalization component for Tom, when no instruction was provided on the training problems, three assessments were administered and Tom’s scores on word problem accuracy were all 0%. Tom’s performance on
strategy use was slightly better with a range of scores between 0% and 11%. During the first intervention phase when the strategy instruction on the training problems was implemented, Tom’s performance remained at baseline levels for word problem accuracy and improved only slightly in terms of strategy use (e.g., scores of 10% and 13%). During a return to baseline where no instruction was provided on the training problems, Tom’s word problem accuracy score remained at 0% while his strategy use was slightly better at 7%. With the reintroduction of the learning strategy instruction on the training problems in the second intervention, Tom’s performance improved both in word problem accuracy and strategy use reaching 75% and 77% respectively. Results for the generalization component of this study are displayed in Figure 2.
Figure 2. Participants’ word problem accuracy and strategy use: Generalization phase.

Mean score data are reported for the generalization word problems in terms of word problem accuracy and strategy use in Tables 7 and 8 respectively. For word problem accuracy, Charles increased his mean scores from 25% to 63% from
Intervention 1 to Intervention 2 while John increased his mean scores from 20% to 50%.

Tom increased his scores from 2% to 63% over the two intervention phases. From Intervention 1 to Intervention 2, Charles increased his mean scores on strategy use from 14% to 63%, while John increased his mean scores from 27% to 50%. Tom increased his mean scores from 12% to 63% over the two interventions.

Table 7

*Mean Performances and Number of Days in Each Phase: Generalization*

*Word Problem Accuracy*

<table>
<thead>
<tr>
<th>Student</th>
<th>B1 Days</th>
<th>B1 Mean</th>
<th>I1 Days</th>
<th>I1 Mean</th>
<th>B2 Days</th>
<th>B2 Mean</th>
<th>I2 Days</th>
<th>I2 Mean</th>
<th>FU Days</th>
<th>FU Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles</td>
<td>6</td>
<td>0%</td>
<td>11</td>
<td>25%</td>
<td>5</td>
<td>13%</td>
<td>20</td>
<td>63%</td>
<td>2</td>
<td>79%</td>
</tr>
<tr>
<td>John</td>
<td>6</td>
<td>0%</td>
<td>14</td>
<td>20%</td>
<td>2</td>
<td>0%</td>
<td>20</td>
<td>50%</td>
<td>2</td>
<td>45%</td>
</tr>
<tr>
<td>Tom</td>
<td>9</td>
<td>0%</td>
<td>9</td>
<td>2%</td>
<td>3</td>
<td>0%</td>
<td>13</td>
<td>63%</td>
<td>2</td>
<td>54%</td>
</tr>
</tbody>
</table>

*Note.* B1 = Baseline 1; I1 = Intervention 1; B2 = Baseline 2; I2 = Intervention 2; FU = Follow Up
Response to Research Question 4

Research Question 4 addressed the following question: How will the use of the instructional package affect maintenance? To determine whether any improvements in the strategy use or its impact on word problem accuracy maintained, each student’s data set in the final conditions on both Figures 1 and 2 should be examined. Maintenance of strategy use and word problem accuracy on the training problems is seen in the final condition of Figure 1. As noted earlier, Charles and Tom retained much of their earlier improvements seen during the second intervention. John’s word problem accuracy dropped considerably but he was able to partially retain his strategy use with scores of 46% and 43% on the two follow up quizzes.

Maintenance of strategy use and word problem accuracy on the generalization problems is seen in the final condition of Figure 2. John and Tom had follow up data for
the generalization component. While both boys did not perform any of the word
problems accurately, they did retain some of the strategy steps. John took one quiz and
earned a score of 43% for strategy use, while Tom took two quizzes and earned 27% on
each quiz. Actual quiz scores for the follow up phase of the study for the training quizzes
are displayed in Table 9. Table 10 displays the actual scores for the follow up phase for
the generalization quizzes.
Table 9

*Follow Up Data Training Problems*

<table>
<thead>
<tr>
<th></th>
<th>Five-Week Follow Up</th>
<th></th>
<th>Six-Week Follow Up</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Word Problem Accuracy</td>
<td>Strategy Use</td>
<td>Word Problem Accuracy</td>
<td>Strategy Use</td>
</tr>
<tr>
<td>Charles</td>
<td>67%</td>
<td>71%</td>
<td>67%</td>
<td>86%</td>
</tr>
<tr>
<td>John</td>
<td>17%</td>
<td>46%</td>
<td>0%</td>
<td>43%</td>
</tr>
<tr>
<td>Tom</td>
<td>50%</td>
<td>60%</td>
<td>25%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Table 10

*Follow Up Data Generalization Problems*

<table>
<thead>
<tr>
<th></th>
<th>Five-Week Follow Up</th>
<th></th>
<th>Six-Week Follow Up</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Word Problem Accuracy</td>
<td>Strategy Use</td>
<td>Word Problem Accuracy</td>
<td>Strategy Use</td>
</tr>
<tr>
<td>Charles</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>John</td>
<td>NA</td>
<td>NA</td>
<td>0%</td>
<td>43%</td>
</tr>
<tr>
<td>Tom</td>
<td>0%</td>
<td>27%</td>
<td>0%</td>
<td>27%</td>
</tr>
</tbody>
</table>

*Note: NA=No quiz taken in this category.*
Chapter 5: Discussion

Mathematics standards have changed over time and are now placing a heavier emphasis on solving increasingly complex word problems rather than on computation skills (NCTM, 2000). Students with mild disabilities struggle with mathematics achievement and the new standards for a variety of reasons. For example, some students with mild disabilities have difficulty activating prior knowledge, lack metacognitive ability, have difficulties with automaticity with basic math facts, and are frequently distractible (Allsopp, McHatten, & Farmer, 2010). These factors make it particularly difficult for students with disabilities to solve math word problems.

This study sought to ascertain whether an instructional package incorporating the systematic use of the CRA sequence of instruction, schema-based strategy instruction, and self-regulation would improve the achievement of students with mild disabilities in word problem solving. Extensive research has been conducted using the CRA sequence of learning (Cass et al., 2003; Maccini & Hughes, 2000; Maccini & Ruhl, 2000; Mercer & Miller, 1992) as well as using schema-based strategy instruction (Jitendra et al., 2002; Jitendra et al., 2007; Rockwell et al., 2011). Self-regulation has been widely researched as well (Fuchs et al., 2003b; Maag et al., 1993; Montague, 2007). However, the systematic use of all three of these methods had not been explored. Drawing from the best practices in special education, the use of the CRA instructional sequence (Witzel et al., 2003) combined with schema-based strategy instruction (Jitendra et al., 2007) and
self-regulation (Montague, 2007) provided the needed structure for struggling students to understand and solve math word problems.

Previous studies using the CRA levels of learning utilized the sequence of lessons recommended by the Strategic Math Series (Mercer & Miller, 1992). In these studies, students were taught basic multiplication facts, algebraic word problem solving, or addition and subtraction computation using concrete objects for the first three lessons, while the next three lessons focused on drawing pictures or diagrams. The mnemonic strategy was not introduced until lesson seven after the concrete and representational phases of the series had been mastered (Cass et al., 2003; Maccini & Hughes, 2000; Maccini & Ruhl, 2000). The rationale for delaying introduction of the mnemonic strategy was to give students sufficient time to practice their skills at representing basic math facts or word problems both concretely and graphically. Mastery of the concrete and representational phases was required in the current study as well, so that students would have several solid methods for solving multiplication and division problems. Moreover, the addition of the CRA sequence of learning not only assisted those students who were weak in basic math fact knowledge, but it also aided students with retention of mathematics concepts through multimodal forms of learning: that is, visual, tactile, and kinesthetic (Cass et al., 2003; Engelkamp & Zimmer, 1990; Maccini & Ruhl, 2000; Witzel, 2005).

Schema-based strategy instruction (SBI) has also been well researched. Jitendra and colleagues conducted a line of research that focused on word problems that involved addition and subtraction and required that students identify the word problem type before solving the problem (Jitendra & Hoff, 1996; Jitendra et al., 1999; Rockwell et al., 2011).
While these studies focused on word problems involving addition and subtraction, the current study focused on word problems involving multiplication and division. The rationale for focusing on multiplication and division word problems was because the fifth grade mathematics curriculum emphasizes those skills. In addition, many students with mild disabilities have difficulty with basic multiplication fact fluency as well as in solving word problems involving multiplication or division (Gersten et al., 2005). Therefore, this study specifically extended the work of Jitendra et al. (2002) that focused on word problems involving multiplication or division and required students to determine the word problem type before solving the problem.

In this study, the instruction was tiered so that the self-regulation component (e.g., the PROBLEM strategy) was not fully introduced until session seven (Mercer & Miller, 1992). In addition, a single session might span several days depending on the student’s grasp of the concepts. The rationale for the instruction taking place in phases was to ensure that students understood how to set up the word problems using manipulative objects, pictures, and numbers and to ensure that students were able to identify word problem types. The PROBLEM strategy was introduced after the other two components were mastered: that is setting up the word problems and identifying the word problem type. The PROBLEM strategy incorporated a self-monitoring component that required students to check off each step as it was completed. In addition, the strategy had an evaluation component that required students to go back and check their work. Self-monitoring and self-evaluation have been well researched in terms of the successful use of student checklists (Brown & Frank, 1990; Dunlap & Dunlap, 1989; Maag et al., 1993;
Montague & Bos, 1986; Montague et al., 2011). Four research questions guided the study and their results will be discussed individually.

**Research Question 1**

*Will a training package consisting of schema-based strategy instruction, the concrete-representational-abstract instructional approach, and a self-monitoring checklist increase the independent use of a learning strategy for 1- and 2-step word problems involving multiplication and division?* Data from this study suggest that the use of the instructional package increased the use of the independent learning strategy. The strategy was taught to the students after they became proficient in the first step (i.e., modeling of the problem situation using manipulatives) of the CRA instructional sequence.

During the first intervention, there was tremendous amount of day-to-day variability. However, all three students showed a moderate degree of improvement between baseline and the first intervention. During baseline, Charles never used more than 13% of the strategy elements. However, during the first intervention, Charles reached or exceeded 21% or better of the strategy elements on 9 out of 11 days. John never used more than 4% of the strategy elements during baseline, while he used 25% or more in 8 out of 14 days. Finally, during baseline, Tom showed generally low strategy use with scores of 0% to 4% on 4 out of 9 days, with a spike to 38% on Day 9. During the first intervention, however, he never dropped below using 10% of the strategy elements and for 5 out of the 9 days, he used 25% or more of the strategy.

Looking at the mean scores for baseline to the first intervention, a moderate improvement is noted as well. Specifically, Charles had a mean score of 8% during
baseline with a mean score of 28% during the first intervention phase. John had a mean score of 2% during baseline with a mean score of 27% for the first intervention. Finally, Tom had a mean score of 13% during baseline with a mean score of 23% for the first intervention. Again, there was tremendous variation in scores throughout the first intervention.

While moderate progress was made during the first intervention, these results were disappointing and unexpected. One reason for this might be because participants did not have the opportunity to learn the entire strategy until later in the study. After Session 4, participants became proficient at selecting the correct problem type and representing the problem on the correct diagram. However, they did not learn the entire strategy until Day 14 for Charles, Day 36 for John and Day 38 for Tom. In addition, students began to be reticent about working with the researcher indicating that they would rather do the regular math intervention lesson being taught in a nearby classroom. Based on the mediocre results of the first intervention, a decision was made to implement a second intervention focusing primarily on the strategy PROBLEM and the importance of using it to solve math word problems.

Therefore, during the second intervention phase when instruction on the PROBLEM strategy intensified, scores on the strategy use component of the quizzes increased dramatically. For example, Charles began the second intervention with a score on strategy use of 44% and at the end of the second intervention his score was 67%, with a mean score of 63%. John began the second intervention with a strategy use score of 33%, and ended the second intervention with a strategy use score of 67%, and his mean score for this phase was 50%. Tom began the second intervention with a strategy use
score of 25% and ended the second intervention with a score of 96% with a mean score of 63%. From the first intervention to the second intervention, Charles increased his mean score from 28% to 63% while John increased his mean score from 23% to 50%. Finally, Tom increased his mean score from 23% to 63%.

These results were much more encouraging than results seen during the first intervention and supported the idea that the students saw value in using the strategy to solve word problems. Therefore, students mastered the steps of the strategy (i.e., selecting the correct problem types and diagrams, writing and solving the equations and checking their work) and began using it consistently to solve word problems. During this intervention, students were encouraged to explain to each other why the steps of the strategy were important. In addition, students discussed when to use the strategy in deciding what operation to use, for example, or to remind them to check their work. In other words, they were encouraged to think and verbalize in a metacognitive fashion about when and how to use the strategy.

Research Question 2

*Will an increase in strategy use result in increased accuracy in word problem solving involving multiplication and division?* The data from this study indicate that systematic strategy use increased word problem accuracy. However, during the first intervention phase, progress in word problem solving was slow. For example, at the beginning of the first intervention, Charles scored 67% on the word problem accuracy component while he scored 33% at the end of the first intervention with a mean score of 42%. John scored 17% on word problem accuracy at the beginning of the first intervention and 33% at the end of the first intervention with a mean score of 32%. Tom
scored 67% for word problem accuracy at the beginning of the second intervention and 0% at the end with a mean score of 24%. Interestingly, students were able to recite the strategy from memory after only two to three sessions. However, from the beginning to the end of the first intervention, word problem accuracy increased only slightly for John and decreased for Charles and Tom. The students were not systematically connecting the strategy application with the word problems. This was one of the reasons for the decision to bring the participants back to baseline and intensify instruction on strategy use.

During the second intervention, the three participants’ scores increased dramatically. For Charles, whenever he used 75% of the strategy elements or more, his word problem accuracy scores were 67% or better. Although John never attained 75% of the elements of strategy use, he used at least 60% of the strategy elements on 5 days during the second intervention. His word problem accuracy scores were 50% or better on 3 of these 5 days. Tom used 65% of the elements of the strategy for 5 days during the second intervention, and his word problem accuracy scores were 50% or better on 4 of these 5 days.

In addition, Charles and John scored from 50% to 75% on the word problem accuracy component from the beginning to the end of the second intervention with mean scores of 59% and 39% respectively. Tom scored 0% at the beginning of the second intervention while he scored 67% at the end of the intervention with a mean score of 39%. Therefore, Charles’s mean score increased from 42% for the first intervention to 59% for the second intervention. John’s mean scores did not improve as much as Charles’s but they did improve, increasing from 32% for the first intervention to 39% for
the second intervention. Tom’s mean score for the first intervention was 24% and 39% for the second intervention indicating that he improved almost as much as Charles.

Although not all students improved their word problem solving scores at an equal rate, scores steadily improved after the second intervention began. These results showed that emphasizing strategic learning and strategy application does have a positive impact on learning, specifically for this study on learning to solve word problems involving multiplication or division. For example, during the second intervention, the researcher and students became focused on going beyond the process of using the strategy to the conditions under which it should be used. In addition, the focus was on the steps of the strategy and why they were important.

Research Question 3

*Will the implementation of this training package affect generalization to word problems involving measurement of area?* Data indicate that the instructional package had a modest effect on word problems involving the measurement of area. At the beginning of the first intervention when instruction on the training problems was taking place, Charles earned scores of 25% on four probes for word problem accuracy. Strategy use scores ranged from 3% to 27% at the end with a mean score of 14%. At the beginning of the second intervention, Charles’ word problem accuracy scores ranged from 0% to 50%, with a mean score of 21%. Strategy use scores during the second intervention when instruction on the training problems was taking place, ranged from 0% to 77% with a mean score of 46%. While Charles’ word problem accuracy scores did not show an increase, his strategy use scores showed a modest improvement going from a
mean score of 14% from the first intervention to a mean score of 46% for the second intervention.

For John, scores ranged from 0% on word problem accuracy at the beginning of the first intervention when instruction on the training problems took place, to 50% at the end of the intervention with a mean score of 20%. John’s strategy use scores ranged from 3% to 73% during the first intervention, with a mean score of 27%. During the second intervention when instruction on the training problems was taking place, John’s word problem accuracy scores range from 0% to 75%, with a mean score of 33%. John’s strategy use scores during the second intervention ranged from 23% to 73%, with a mean score of 53%. Therefore, John’s word problem accuracy showed a moderate increase with mean scores going from 20% during the first intervention to 33% during the second intervention. John’s strategy use showed a moderate increase as well with a mean score of 27% during the first intervention and a mean score of 53% for the second intervention.

Finally, word problem accuracy scores for Tom ranged from 0% to 3%, with a mean of 2% during the first intervention when instruction on the training problems took place. Strategy use scores for Tom ranged from 10% to 23%, with a mean score of 12%. During the second intervention when instruction took place on the training problems, Tom’s word problem accuracy ranged from 0% to 50%, with a mean score of 31%, while his strategy use scores ranged from 44% to 77%, with a mean of 63%. Therefore, Tom’s word problem accuracy showed moderate improvement with mean scores increasing from 2% to 31%. In addition, Tom’s strategy use showed improvement as well, with mean scores going from 12% during the first intervention to 63% during the second intervention. Overall, this modest improvement supports the idea that the instructional
training package combining the CRA sequence of instruction, schema-based strategy instruction, and self-regulation does affect generalization.

**Research Question 4**

*How will the use of the instructional package affect maintenance?* The follow up data from this study indicate mixed results. Follow up quizzes were given both 5 weeks and 6 weeks after the study concluded. Word problem accuracy scores on the two quizzes administered to Charles were 67% on both while strategy use scores were 71% and 86% respectively. These scores indicate that Charles retained his knowledge of the strategy and his word problem accuracy progress was maintained. Word problem accuracy scores on the two quizzes administered to John were 17% and 0% respectively while strategy use scores were 46% and 43% respectively. These scores indicate that while John retained some of his knowledge of the strategy, his word problem accuracy dropped considerably. Finally, word problem accuracy scores on the two quizzes administered to Tom were 50% and 25% respectively, while strategy use scores were 60% and 47%. These scores indicate that Tom retained his knowledge of the strategy moderately well, while his word problem accuracy progress was partially maintained. For Charles and Tom, follow up results were somewhat encouraging while the results for John were disappointing.

**Observations From the Research**

Besides analyzing the data from this study, it was possible to look back on the research to identify other issues that might have influenced the outcome. Most notable are the differences between the participant characteristics and the application of self-regulation techniques within the PROBLEM strategy. There were also issues with
feedback and goals setting that are explored as well. Finally, affective factors relating to mathematics teaching and learning are analyzed as they relate to the current study.

**Differences in students with mild disabilities.** This study was conducted with three students, two of whom were students with learning disabilities (Charles and Tom) and one who had ADHD. The characteristics of students with LD and students with ADHD are similar. For example, inattention and impulsivity are noted in both students with LD and students with ADHD. However, for students with ADHD, inattention and impulsivity are experienced with greater intensity than for students with LD (DuPaul et al., 1997; Kercood, Zentall, Vinh, & Kinsey, 2012). In addition, students with ADHD frequently exhibit difficulties with persevering at assignments and maintaining effort with tasks (Johnson & Reid, 2011).

Researcher observations of John during the study indicate that John was restless and had difficulty sitting still. He tended to give up easily if a word problem seemed too hard. On the daily quizzes, he was nearly always the first one done and when encouraged to check his work, he would decline the opportunity. During the second intervention when the three students worked together, John would try to divert attention from the sessions by making unrelated comments in an effort to distract, and otherwise amuse the other students. Because of his general weaknesses in mathematics, his behavior seemed to be a function of task or work avoidance. Task avoidance nearly always undermines performance. However, in terms of math achievement, John may have perceived that task avoidance served to protect him from negative judgments of others, both peers and adults (Turner et al., 2002).
Charles and Tom on the other hand, appeared to take this learning opportunity more seriously and worked very hard on their daily quizzes. Mathematics anxiety may have played a part in all three participants’ behavior, however. For example, all three students remarked about how difficult the 2-step word problems appeared and only partially answered or ignored them as a result. According to X. Ma (1999), mathematics anxiety may be treated using strategies like self-management of emotional stress, but a more effective treatment may relate to cognitive interventions. By strengthening mathematics skill deficits, students may decrease their level of anxiety related to mathematics and improve achievement. The current study incorporated a cognitive intervention through the use of the CRA sequence of learning to improve skill at basic multiplication fact fluency. Students enjoyed working with the manipulatives and made use of them consistently when solving the word problems.

Therefore, John’s lack of perseverance as evidenced by his rapid quiz completion, along with inattention and impulsivity may have affected John’s performance on both word problem accuracy and strategy use. For example, during the second intervention, the data reveal that both Charles and Tom reached 98% to 100% in word problem accuracy and strategy use. John on the other hand reached 75% and 71% for word problem accuracy and strategy use respectively. The lower scores may be a result of the off task behavior that John exhibited throughout the study, either being disruptive during the sessions or finishing his quizzes too quickly. The inattention and impulsivity issues may also be the reason for the disappointing follow up scores for John.

**Effects of feedback.** The scripted lesson plans that were developed for this study included feedback throughout each lesson in an effort to guide student learning and to
allow students to arrive at the proper solutions for word problems. The rationale for
including feedback throughout each lesson was that immediate feedback can be powerful
when issued systematically and specifically (Hudson & Miller, 2006). Along with the
feedback that was provided with the lessons, students were required to chart their own
use of the strategy through the use of cue cards similar to student check lists. This
requirement served as a self check to ensure that students used the strategy and served as
a form of immediate feedback. However, during the course of the study, students were
not required to self graph their word problem accuracy results. The addition of the self
graphing component would have been powerful in terms of increasing motivation for
word problem accuracy (DiGangi, Maag, & Ruthorford, 1991; Fuchs et al., 2003b). In
addition, by graphing their own results, students would be in a position to set new goals
for themselves, another motivating feature of self graphing (DiGangi et al., 1991). Goal
setting was not a part of the current study. However, it should be considered in future
replications or extensions of this study.

**Affective factors and mathematics achievement.** Affective factors in
mathematics achievement may also have had an effect on the study’s results. According
to Turner et al. (2002), students who are supported both cognitively and motivationally
tend to exhibit low avoidance behaviors. Therefore, giving personal attention, supporting
effort, and providing encouragement are all seen as factors in low work avoidance which,
in turn, can lead to higher mathematics achievement. The current study sought to provide
all three affective components (e.g., personal attention, supporting effort, and providing
encouragement) by using the one on one or small group approach and providing feedback
in the form of encouragement.
There appears to be a relationship between math interest and math achievement as early as the preschool years as well (Fisher, Dobbs-Oates, Doctoroff, & Arnold, 2012). This relationship suggests that teachers might foster interest in mathematics by providing activities and problems related to students’ lives in an effort to encourage enhanced mathematics achievement. Moreover, if students acquire high interest in mathematics, mathematics anxiety is likely to be low or nonexistent. The current study sought to make the word problems relevant to the students’ lives by using familiar names of children and places as well as familiar activities: such as, skateboarding or playing video games.

In addition, X. Ma (1999) found in her meta-analysis of the relationship between mathematics anxiety and achievement that mathematics anxiety appears to intensify at the fourth grade level. Mathematics content becomes more difficult in the intermediate grades because students are expected to apply what they know about mathematics computation to word problems of more than one step. Because mathematic skills are cumulative with one set of skills building on previously learned sets of skills, many students with mild disabilities fall further and further behind (Montague, 2007). Specifically, when students have not learned basic multiplication facts with automaticity, their skill development with mathematics word problems involving multiplication is severely hindered. This study sought to compensate for this by using the CRA sequence of learning so that students could solve basic multiplication facts using manipulative objects or drawing pictures. By alleviating anxiety over the inability to fluently solve basic multiplication facts, the expectation was that students would be free to learn to solve mathematics word problems.
Limitations

Use of a multiple baseline design across participants in this experiment allowed the researcher to determine whether a functional relation existed between the intervention package and participant performance. Staggering the introduction of the intervention package, and introducing it on a one to one basis, provided an opportunity for a functional relation to be shown (if one existed). However, this design accommodates the use of a small sample size posing a threat to external validity. Systematic replications of this study are necessary to generalize the results to other students who struggle with solving math word problems. Therefore, while multiple baseline designs can be useful in applied settings like the classroom, they do pose limitations as well.

The tremendous variation in word problem accuracy and strategy use scores within each intervention phase of the study was unexpected. Part of the reason for this may have been the tiered nature of the instructional package. While instruction on selecting the correct problem type and representing the problem with manipulatives or pictures began with the initiation of the study, formal instruction on the self-regulation strategy PROBLEM was not begun until session seven. The rationale for delaying the introduction of the strategy was to ensure that students had mastered the first two components: that is, the selection of the problem type and representing the problem using manipulatives or pictures.

Unfortunately, it took longer than anticipated for participants to grasp the concepts presented in each lesson and sessions needed to be repeated until students attained the independent practice goal. Each lesson had a different independent practice goal (in the form of a decision rule to move on to the next session) based on what was
taught. Therefore, Charles began learning the PROBLEM strategy on Day 14, while John didn’t begin learning the PROBLEM strategy until Day 36. Tom began learning the PROBLEM strategy on Day 38. Therefore, the only components that students would be able to use prior to learning the strategy would be to select the correct problem type and to represent the problem using manipulatives or pictures. If the instructional package had been delivered with the three components altogether or slightly staggered, results might have been less varied.

In addition, if a multiplication math fact fluency probe had been included in the pretest, results of the probe could have been used in the design of the intervention. Math word problems could have been specially designed to target those multiplication facts that students either solved inaccurately or didn’t solve at all on the probe. Including these specially designed math word problems in the intervention may have impacted the students’ use and mastery of the strategy.

Another limitation is that the researcher was also the students’ teacher. The students had known the teacher/researcher for over a year when the study began. Results of this study may have been different if the instructional package had been delivered by a researcher who was unknown to the students. In addition, the students themselves were volunteers and were excited to work one on one with the teacher. These students also enjoyed working in small groups. If this instructional package had been used in a whole class setting, results may have been different especially for those students who learn better in small group settings.
Summary

Systematically combining the CRA sequence of instruction with schema-based strategy instruction was a combination that had not been tried before. The logic for introducing the CRA instructional sequence first was so that students who had not mastered basic multiplication facts would not be hindered in word problem solving. In addition, the CRA process allowed students to practice solving basic multiplication facts to mastery with specific feedback. Therefore, before the strategy was introduced, the CRA sequence was helpful in assisting students to solve basic multiplication facts, and laid the groundwork for strategy success. This study followed the protocols established by researchers in the CRA domain. Therefore, this study used direct, explicit instruction, advanced organizers, scripted lesson plans, and think-aloud protocols to instruct students to solve word problems (Cass et al., 2003; Maccini & Hughes, 2000; Maccini & Ruhl, 2000; Mercer & Miller, 1992; Strickland & Maccini, 2012).

Shortly after the CRA sequence was introduced, the schema-based strategy instruction began, encouraging students to distinguish between the two targeted problem types and to model the problems on the schematic diagrams. The use of schematic diagrams or graphic organizers was important because typically students with mild disabilities have difficulties organizing their thinking (Gersten & Clarke, 2007). Requiring students to write the numbers or to draw pictures in the correct places on the schematic diagrams allowed them to recognize the relationships between elements in mathematics word problems (Ives & Hoy, 2003). After students had mastered the skills of identifying the problem type and representing it on the correct schematic diagram, the mnemonic strategy PROBLEM was implemented. The PROBLEM strategy was
introduced as a self-monitoring tool to remind students of the steps necessary to solving these word problem types.

This study added to the literature by incorporating the systematic use of the CRA levels of learning sequence into instruction on math word problem solving. Making manipulative objects an integral part of instruction and requiring that students use them in representing word problems strengthened their basic math fact knowledge as well. Moreover, use of the CRA sequence offered students a viable strategy for solving multiplication and division basic math facts. Studies done on schema-based strategy instruction incorporated self-monitoring components through the use of check lists and mnemonic strategies (Griffin & Jitendra, 2009; Jitendra et al., 2007). Participants in these studies were encouraged to self-monitor their work by using the strategies and checking off items as they were completed. The current study incorporated these two components as well and required students to use a check list. By systematically using the CRA methodology, weaknesses in basic math fact fluency did not hinder students’ ability to solve the word problems. Therefore, systematically adding the CRA component to the schema-based strategy instruction and self-regulation proved to be successful for students who otherwise may not have been able to access the mathematics core curriculum.

The second baseline and intervention phase were implemented to focus on strategic instruction using the entire instructional package. Therefore, the second intervention phase included metacognitive conversations about steps of the strategy and why the strategy was important to use in solving word problems. During this phase, students were instructed as a small group, allowing them to explain to each other as well as to the researcher why each step was important to the word problem solving process.
While the small group work was similar to a cooperative learning group, students worked on their own math word problems individually, and did not have a group goal (Johnson & Johnson, 1999). In addition, the small group model allowed students to receive specific feedback on their explanations, further anchoring the strategy into their memory. Therefore, the combination of CRA, schema-based strategy instruction, and the self-monitoring through use of the PROBLEM strategy had the greatest impact on word problem accuracy. In addition, having multiple opportunities to explain their thinking, both to their peers as well to the researcher, students solidified their knowledge of the strategy and why it was important to use (Carr, 2010; L. Ma, 1999, NCTM, 2000).

Suggestions for Further Research

Further research exploring the effectiveness of this instructional package needs to be done with other students who struggle with math word problem solving. Younger students in first and second grade for example tend to be accustomed to working with manipulatives to learn basic math calculations. Systematic use of the instructional package in this study could be used with first and second graders to determine whether they would be better able to model problem types in order to solve them. There are struggling students throughout the elementary and secondary grades who are not necessarily eligible for special education programming. Research incorporating the use of the instructional package with small groups of elementary or secondary students would be helpful, especially in terms of math word problem solving.

Systematic replications of this study utilizing the instructional package should be done to determine whether more consistent results can be obtained. The variability in the results from this study, were unexpected and need to be accounted for. One change
that could be researched is to teach the use of the problem solving diagrams outside of the study, allowing the intervention to begin with all students having mastered the concrete phase of the CRA instructional process. This would allow students to fully use the strategy right away while still acquiring the CRA levels of learning. More importantly, this may produce more consistent results without much variability. A pretest focusing on word problem solving was given prior to the beginning of the current study to ascertain students’ present levels of achievement. The addition of a basic multiplication math fact probe would have made it possible to focus on those basic facts that students were not able to do with fluency. These changes would strengthen the current study’s outcomes and would impact the use of the instructional package in classroom settings.

The small group work that was incorporated into the second intervention phase was to strengthen strategy use in math word problem solving. While this collaborative work resembled cooperative learning techniques, there were major differences including the fact that group goals were not incorporated. Students worked individually on their own math word problems, as they discussed the strategy and why it was important to use. Future studies may address the use of cooperative learning strategies incorporating group goals and individual accountability to ascertain whether student achievement increases.

Mathematics journaling has been proposed as being instrumental in helping students to conceptualize what they are learning and to reduce math anxiety (Furner & Duffy, 2002). However, many students with mild disabilities have difficulties with writing in any subject area. Therefore, future research could incorporate the use of audio journals to allow students to dictate both their feelings about math and the math concepts that they are learning regarding math word problem solving. This may help to solidify
their strategy use by writing about why the strategy is important and when it should be used.

The current study incorporated learning to solve 1- and 2-step word problems. Researcher observations of students as they took their quizzes indicated that students became overwhelmed with the two step problems in particular. Therefore, many of the two step problems were ignored altogether or only partially solved. A post hoc analysis of the data from the current study could be done to ascertain exactly what mistakes were made: that is, selecting the correct operation, writing the equations correctly, selecting the correct problem type. From the post hoc analysis, specific decisions can be made about future research. For example, if most of the errors were made in solving the two step problems, the next study could target one step problems involving multiplication or division. The focus on one step word problems may eliminate the possibility that, because the students were overwhelmed, they simply gave up trying to solve the two step word problems. Then, replications with two step problems might be conducted once students demonstrated complete fluency with the one step problems.

In addition, replications of this study should be done where the teacher and students are not acquainted before the study begins. This factor would rule out the possible confounding variable in the present study, of the teacher and students having known each other for over a year prior to the beginning of the study.

Finally, use of the instructional package in other areas of mathematics should be explored as well. Word problems incorporating algebraic concepts can be problematic for many struggling students for example. The current study had a generalization
component of solving measurement of area problems which, according to the National Mathematics Advisory Panel, is an area that needs further exploration (NMAP, 2008).

Educational Implications

The instructional package that was implemented for this study can be used by teachers in general and special education settings. Teachers could use the lesson plans utilizing the components of explicit instruction and the quizzes that were prepared for this study (See Appendix H for the lesson plans and Appendix K for the quizzes). It is important to note that strategy instruction within the explicit teaching cycle follows a pattern that is evidenced in each of the prepared lesson plans (Hudson & Miller, 2006). Finally, the idea of teaching word problem solving in two components (i.e., problem representation and problem solution) can assist students at conceptualizing what they are doing and why they are doing it. Requiring students to depict the problem type and to represent it in picture form or with manipulatives allows students to examine the structure of the situation presented in the word problem (Van de Walle & Lovin, 2006). Once students recognize the word problem situation, they are better able to decide which operation to use (e.g., multiplication or division) in the problem solution process.

For this study, the instructional package was taught on an individual basis and later in a small group. The results indicated that this instructional package could be used as an intervention for Tier 2 of the response to intervention process and that it could be delivered in a small group or individually (Mellard & Johnson, 2008).

Conclusion

An instructional package taught strategically does have an impact on student learning. By beginning with the CRA sequence of learning, all students, whether they
know basic math calculation facts or not, have access to the core math curriculum. The strategy instruction portion of the instructional package follows a pattern no matter what subject area is being taught. Developing or activating prior knowledge, discussing the strategy, modeling the strategy, memorizing the strategy, supporting the strategy, and independent performance are the components of good strategy instruction (Reid & Lienemann, 2006). When the strategy instructional package is employed, the structure of the strategy becomes a tool that students can use as part of their problem solving repertoire. Additionally, students can rely on the strategy in novel situations.

This study’s results hold promise for students who struggle with math word problem solving. The mathematics reform movement stresses that students understand what they are doing and why they are doing it when solving word problems (NCTM, 2000). By requiring students to model problems before engaging in the problem solving process, teachers are better able to assess whether students understand mathematics conceptually. Additionally, the sequencing of the models (beginning with the concrete, to representational, to abstract) makes a difference. Using the CRA instructional sequence with any math strategy may have a positive impact on achievement. In addition, employing explicit instruction and teacher modeling using manipulatives and drawings is a powerful method to help students conceptualize what they are learning. Finally, metacognitive strategy instruction is a methodology that promotes student independence in learning new concepts. When applied systematically, these instructional methods promote conceptual knowledge and independence.
Appendices
Appendix A

Samples of Word Problem Types
<table>
<thead>
<tr>
<th>Samples of Word Problem Types</th>
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<tbody>
<tr>
<td><strong>Change or Difference</strong> (Fuchs, et al., 2003a)</td>
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<tr>
<td><strong>Group or Total</strong> (Fuchs, et al., 2003a)</td>
</tr>
<tr>
<td><strong>Compare</strong> (Jitendra, et al., 1998)</td>
</tr>
<tr>
<td><strong>Restate</strong> (Marshall, 1995; Riley et al., 1983)</td>
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<tr>
<td><strong>Vary</strong> (Marshall,</td>
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<td>1995; Riley et al., 1983)</td>
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<td>--------------------------</td>
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<tr>
<td>Shopping Bag (Fuchs, et al., 2003a)</td>
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<tr>
<td>Half Problem Structure (Fuchs, et al., 2003a)</td>
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<tr>
<td>Bag Problem Structure (Fuchs, et al., 2003a)</td>
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</tbody>
</table>
Jack collects stamps. He made a chart to show how many stamps he had. Each picture of a stamp stands for 5 stamps. For his birthday, Jack received 4 new stamps. How many does he have now?

<table>
<thead>
<tr>
<th>Pictograph</th>
<th>Problem Structure (Fuchs, et al., 2003a)</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Stamp" /> <img src="image2.png" alt="Stamp" /> <img src="image3.png" alt="Stamp" /> <img src="image4.png" alt="Stamp" /> <img src="image5.png" alt="Stamp" /></td>
<td><img src="image6.png" alt="Stamp" /> <img src="image7.png" alt="Stamp" /> <img src="image8.png" alt="Stamp" /> <img src="image9.png" alt="Stamp" /> <img src="image10.png" alt="Stamp" /></td>
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Appendix B

Pretest
Pretest

Read and solve the problems. Show your work. You may use additional paper if you need to. Total points: 17

(T): Training

(G): Generalization

<table>
<thead>
<tr>
<th>1. vary 2 step (G)</th>
<th>2. restate 1 step (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sally wants to plant ivy in her back yard, which is 24 feet by 6 feet. Each square foot of ivy will cost $2.00. How much will it cost, in dollars to plant enough ivy to cover the yard?</td>
<td>A season pass at Disney World costs $400.00. This is 5 times more than a monthly pass. How much does a monthly pass cost?</td>
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<thead>
<tr>
<th>3. restate 3 step (T)</th>
<th>4. Vary 3 step (T)</th>
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<tr>
<td>The family bowling center has a special on Sundays. The price is $3.00 for children under 12 and twice that much for adults. How much will it cost 3 adults and 5 children?</td>
<td>A local band sold T-shirts at a concert. On Friday night they sold 47 T-shirts. On Saturday night, they sold 53 T-shirts. If the shirts cost $10.00 each, then how much did they collect in the two nights?</td>
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<tr>
<td></td>
<td>Restate 1 step (T)</td>
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<td>Kate won 8 ribbons at the fair. The number Evan won was two times as great as the number Kate won. How many did Evan win?</td>
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<td>7</td>
<td>Vary 1 step (T) Mr. Wu has three pear trees. In one month, he picked 20 pears from each tree. How many pears did he pick that month?</td>
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<td>9</td>
<td>Restate 2 step (G) The windows in Mr. Green’s house are 18 inches wide by 12 inches long. What is the area of one of Mr. Green’s windows? Mr. Green’s neighbor has windows that are also 12 inches long but twice as wide. What is the area of one of Mr. Green’s neighbor’s windows?</td>
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<tr>
<td>10</td>
<td>Restate 1 step (T) Tom is 8 years old and his dad is four times as old. How old is Tom’s dad?</td>
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</tbody>
</table>
Appendix C

Poster With Word Problem Features
Features of a “vary” type word problem

- *When two objects are related so that*....
- *When one object increases, so does the other one*
- *When one object decreases, so does the other one*
- *Proportions or ratios*

Features of a “restate” type word problem

- *When two different things are compared at a fixed moment in time*
- *Uses phrases like “twice as much as” or “one half of”*
Appendix D

Mnemonic Strategy: Problem
Mnemonic Strategy: Problem

P= Pick out problem type

- Have I understood the problem?
- Have I selected the correct problem type?

R=Represent the problem on schematic diagram

- Have I written the correct words/numbers in the graphic organizer?
- Did I make a plan to solve the problem?

O-Operation and equation

- Have I selected the correct operation?
- Have I written the correct equation?

B=Break the code

- Have I performed the calculations correctly?
- Did I use concrete objects if necessary?

L=Learn and write the solution

- Have I written the solution correctly?
- Have I labeled the solution correctly?

E=Examine work

- Have I checked my work?

M=Make corrections

- Have I made the corrections necessary?
Appendix E

Vary Graphic Organizer: Schematic Diagram,

Vary Type Word Problem
Vary Graphic Organizer: Schematic Diagram,

Vary Type Word Problem

If

If

Then

Then
Appendix F

Restate Problem

Schematic Diagram (adapted from Marshall, 1995)
Restate Problem

Schematic Diagram (adapted from Marshall, 1995)

**Compare**

**Relation**

**Referent**
Appendix G

Self-Monitoring Cue Cards
Self-monitoring Cue Cards

Mnemonic Strategy: Training Quiz Number _____

Student Checklist: Check off each step as you complete it for each problem.

<table>
<thead>
<tr>
<th>Problem Number:</th>
<th>1</th>
<th>2</th>
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Mnemonic Strategy: Generalization Quiz Number _____

Student Checklist: Check off each step as you complete it for each problem.

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<th>Problem Number:</th>
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<td><strong>E and M</strong></td>
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Appendix H

Lesson Plan and Teacher Checklist
Lesson Plans and Teacher Checklists

Lesson 1
Lesson Plan and Teacher checklist

Date of session________________

Directions: Please mark each blank with the appropriate symbol.
Mark a + if you see the step implemented and you hear the teacher use the keyword.
Mark with a – if you did not see the step implemented or hear the key word.

Materials needed:
- Half marbles, paper plates, counters, base ten blocks
- Six vary type word problems with no missing information printed on index cards
- Poster depicting features of vary and restate word problems

1. Provides rationale for the day’s lesson:
   The teacher/researcher will state that the student will get better grades or be able to make change at the store by knowing how to solve real world problems.
   Solving word problems is hard, but we can make it easier by helping you to determine what the problem type is before asking you to solve it.
   Rationale: _____
   _____/1

2. Provides advance organizer:
   The teacher/researcher will ask students to recall times when they have needed to solve real world problems: for example, determining whether you have enough money to buy a video game.
   Remember____
   _____/1
3. Provides daily review:
   The teacher will reference times when the student has been tested: for example, the FCAT or the Benchmark testing. You may have found that the word problems were hard.
   
   Remember____
   ____/1

4. Provides lesson objective:
   The teacher/researcher will state that today you are going to learn ways to solve vary type problems using multiplication and division. You are also going to learn how to set up problems using manipulative objects so that you can better understand what you are doing.

   State____
   ____/1

5. Uses think-aloud strategies to present and model new concepts:
   The teacher/researcher will say, “Looking at the poster we can see that the outstanding characteristic of a vary word problem is that there is a relationship between two objects such as boxes of candy bars and the candy bars themselves. For example, a box a candy bars has six candy bars in it. How many candy bars would you have if you had six boxes?
   After the teacher/researcher has given the example, she will then model the problem with concrete objects by setting up six groups of half marbles on six paper plates while verbalizing each step.
   The teacher/researcher will say, “Let’s see now, this problem is telling me that one box has six candy bars. So if I pretend that the marbles are candy bars and the paper plates are boxes, I would put six marbles on one plate. So I know that each box contains six candy bars because that is what it says in the problem. In addition, it also asks me how many candy bars I would have if I had six boxes. Well, I already have one box set up here, so I will need to set up five additional
boxes. Now I have six plates with six marbles on each plate. If I count these I will get 36 candy bars. I also could add or multiply to get the answer.”

Present new____
Model new____
Think aloud____

6. Uses examples and non-examples:
The teacher/researcher will continue by reading two more vary problems with no missing information. She will set up each one using concrete materials. One problem will be set up using arrays. The instructor will make deliberate mistakes such as using multiplication when division should occur, or placing the incorrect amount of items in each area. She will then think aloud the process of correcting her mistakes. This will happen twice.

One mistake____
One mistake____

7. Provides guided practice:
The teacher/researcher will assign the student to read two problems with no missing information. In addition, the teacher will assign the student to set up the problem with concrete objects. She will also tell the students that this is guided practice and that feedback and guidance will be provided. The student will be encouraged to verbalize each step as it is completed.

Clear instructions given____
Cued guided practice____
Feedback____
Encourage verbalizations____

8. Provides independent practice:
The student will then be given two problems with no missing information to set up with concrete objects. The teacher/researcher will tell the student that this independent practice and that no assistance will be provided. The decision rule to move on the next lesson is that the student sets up the two problems with concrete materials with at least three verbalizations, with no assistance.

Clear instructions given____
Cued independent practice____
Feedback____
Encourage verbalizations____
____/4

9. Provides frequent feedback:
Feedback will be provided throughout the lesson.

Specific comments about
Think aloud____
Ex/Non-Ex.____
Guided practice____
____/3

10. Review content of the day’s lesson:
A quick review of what was learned today will be conducted. Today we learned what a vary problem looks like and how to set it up using concrete objects.

Review of current lesson____
____/1
Lesson 2

Lesson Plan and Teacher checklist

Date of session________________

Directions: Please mark each blank with the appropriate symbol.

Mark a + if you see the step implemented and you hear the teacher use the keyword.

Mark with a – if you did not see the step implemented or hear the key word.

Materials needed:

- Half marbles, paper plates, counters, base ten blocks,
- Six restate word problems with no missing information printed on index cards.
- Two vary word problems with no missing information printed on index cards
- Poster depicting features of vary and restate word problems.

1. Provides rationale for the day’s lesson:

   The teacher/researcher will remind students how important it is to be able to apply what they know about math calculations to word problems. We have learned about solving one type of word problem: that is, the vary type of word problem involving multiplication and division. Now we are going to learn about the other type of word problem: the restate type.

   Rationale____
   ____/1

2. Provides advance organizer:

   The teacher/researcher will connect today’s lesson by asking students to recall what the characteristics are of a vary type of word problem. Teacher assists as necessary. Referring to the poster that is on display, she will remind the student of the language used: for example, the if then format is used for vary type of word problems.

   Remember____
   ____/1

3. Provides daily review:
Teacher/researcher reviews the concept of the vary type of word problem. One problem with no missing information will be given for the student to read, set up with concrete objects while verbalizing each step.

Remember___
___/1

4. Provides lesson objective:
The teacher/researcher will state that today you are going to learn ways to solve restate type problems using manipulative objects so that you can better understand what you are doing.

State___
___/1

5. Uses think-aloud strategies to present and model new concepts:
Today you are going to learn to recognize a restate problem. Referring to the poster, the teacher/researcher will state that phrases like two times as much are used in restate problems. The teacher/researcher will then model reading a restate problem. She will decide what type of structural relationship exists in the story problem by identifying where the problem says twice as many. For example, the teacher/researcher will read that Jack had caught five butterflies in his butterfly net. Suzie caught twice as many. That means that Suzie caught 10 butterflies. The teacher/researcher will model setting up the problem with concrete objects, while verbalizing each step.

Present new___
Model new ____
Think aloud____
___/3

6. Uses examples and non-examples:
The teacher/researcher will continue by reading two more restate problems with no missing information. She will set up each one using concrete materials. The instructor will make deliberate mistakes such as using multiplication when
division should occur, or placing the incorrect amount of items in each area. She will then think aloud the process of correcting her mistakes. This will happen twice.

One mistake____
One mistake____
____/2

7. Guided practice:
The teacher/researcher will assign the student to read two restate problems with no missing information. She will also tell the students that this is guided practice and that feedback and guidance will be provided. The students will set up the problems with concrete objects. They will be encouraged to verbalize each step as it is completed.

Clear instructions given____
Cued guided practice____
Feedback____
Encourage verbalizations____
____/4

8. Provides independent practice:
The student will then be given two restate problems with no missing information to set up with concrete objects. The teacher/researcher will tell the student that this is independent practice and that no assistance will be provided. The decision rule to move on the next lesson is that the student sets up the two problems with concrete materials with at least three verbalizations, with no assistance.

Clear instructions given____
Cued independent practice____
No feedback____
Encourage verbalizations____
9. Provides frequent feedback:
   Feedback will be provided throughout the lesson, except for step 8.
   Specific comments about
   Think Aloud____
   Ex/Non-Ex.____
   Guided practice____
   ____/3

10. Reviews content of current lesson:
    A quick review will be conducted of what was learned today. Today we learned how to recognize a restate problem and how to set up a restate problem using concrete objects.
    Review of lesson____
    ____/1
Lesson 3
Lesson Plan and Teacher checklist
Date of session________________
Directions: Please mark each blank with the appropriate symbol.
Mark a + if you see the step implemented and you hear the teacher use the keyword.
Mark with a – if you did not see the step implemented or hear the key word.
Materials needed:
• Half marbles, paper plates, counters, base ten blocks
• Four restate problems printed on index cards with no missing information
• Three vary type word problems with no missing information printed on index cards
• Poster depicting features of vary and restate word problems
1. Provides rationale for the day’s lesson:
   The teacher/researcher will remind students how important it is to be able to apply what they know about calculations to word problems. We have learned about two different types of word problems and how to set them up with concrete objects.
   Rationale____
   ____/1

2. Provides advance organizer:
   The teacher/researcher will connect today’s lesson by asking students to recall what the characteristics are of a restate problem type of word problem. Referring to the poster that is on display, she will remind them of the language used in restate types of word problems: for example, phrases like two times as much are used in restate problems.
   Remember____
   ____/1

3. Provides daily review:
The teacher/researcher reviews the concept of problem types: vary and restate. One restate problem with no missing information will be given for the students to read, set up with concrete objects while verbalizing, and telling what problem type it is.

Remember____
____/1

4. Provides lesson objective:
The teacher/researcher will state that today we are going to learn to recognize the difference between vary and restate problems using multiplication and division. We are also going to practice setting up both types of problems using manipulative objects so that you can understand what you are doing.

State____
____/1

5. Uses think-aloud strategies to present and model new concepts:
The teacher/researcher will read and model how to identify the two problem types using one restate and one vary type word problem. She will think aloud the process of identifying the problem type, by deciding what type of structural relationship exists in the story problem, using the poster that is on display.

Present new____
Model new____
Think aloud____
____/3

6. Uses examples and non-examples:
The teacher/researcher will continue by setting up the same problems as were used in step 5: that is one restate and one vary type word problem with no missing information. She will set up one word problem using concrete materials. The teacher/researcher will make deliberate mistakes such as using multiplication when division should occur, or placing the incorrect amount of items in each area.
She will then think aloud the process of correcting her mistakes. This will happen twice.

One mistake____
One mistake____
____/2

7. Provides guided practice:
   The teacher/researcher will assign the student to read each one of each problem type with no missing information. In addition, the teacher/researcher will tell the students to identify and verbalize the problem type and tell why the decision was made. She will also tell the students that this is guided practice and that feedback and guidance will be provided. After identifying and verbalizing the problem type, the students will set up the problems with concrete objects. They will be encouraged to verbalize each step as it is completed.

   Clear instructions given____
   Cued guided practice____
   Feedback____
   Encourage verbalizations____
   ____/4

8. Provides independent practice:
   The students will then be given one of each type of word problem with no missing information to set up with concrete objects. The students will state the word problem type verbalizing why the problem fits the definition. The teacher/researcher will then tell the students that this is independent practice and that no guidance or feedback will be provided. The decision rule to move on to the next lesson is that the students set up the two problems with concrete materials with at least three verbalizations, with no assistance.

   Clear instructions given____
Cued independent practice
No feedback
Encourage verbalizations

9. Provides frequent feedback:
   Feedback will be provided throughout the lesson, except for step 8.
   Specific comments about
   Think aloud
   Ex/Non-Ex
   Guided practice

10. Reviews content of current lesson:
    A quick review of what was learned today will be conducted.
    Review of lesson
Lesson 4

Lesson Plan and Teacher checklist

Date of session________________

Directions: Please mark each blank with the appropriate symbol.

Mark a + if you see the step implemented and you hear the teacher use the keyword.

Mark with a – if you did not see the step implemented or hear the key word.

Materials needed:

- Half marbles, paper plates, counters, base ten blocks
- Seven restate problems printed on index cards with no missing information
- Eight vary type word problems with no missing information printed on index cards
- Poster depicting features of vary and restate word problems
- Post It Notes, schematic diagrams

1. Provides rationale for today’s lesson:

   The teacher/researcher will remind students how important it is to be able to apply what they know about math calculations to word problems. We have learned about two different types of word problems and how to set them up with concrete objects. Now we are going to make word problem solving even easier by connecting the words and numbers to schematic diagrams.

   Rationale____
   _____/1

2. Provides advance organizer:

   The teacher/researcher will connect today’s lesson by asking students to recall what the characteristics are of a restate type of word problem. Referring to the poster that is on display, she will remind them of the language used in each type of problem. For example, the if then format is used in vary problems, while phrases like two times as much are used in restate problems.

   Remember____
   _____/1
3. Provides daily review:
The teacher/researcher reviews the concept of problem types: that is, vary and restate. One restate and one vary type of word problem with no missing information will be given for the students to read, identify the word problem type, and set up with concrete objects while verbalizing.

Remember

/1

4. Provides lesson objective:
Today, we are going to learn how to map word problems onto the correct schematic diagrams according to problem type.

State

/1

5. Uses think-aloud strategies to present and model new concepts:
The teacher/researcher introduces the schematic diagrams. See Appendix F & G. She will connect each diagram to its problem type referring to the poster. Using a set of four problems, two vary and two restate, printed on index cards with no missing information, the teacher/researcher will model the process of sorting problems according to word problem type while thinking aloud so that the students can visualize the thinking process. She will then model how to set up one of the vary type problems with concrete materials onto the appropriate diagram. She will then do the same with the restate type problem. She will think aloud as she works.

Present new
Model new
Think aloud

/3

6. Uses examples and non-examples:

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During this time, the teacher/researcher will make two mistakes: For example, she will try to set up a vary type of word problem onto a restate diagram. She will then model her thinking to correct the mistake.

One mistake
One mistake

7. Provides guided practice:
The teacher/researcher will assign the student to sort a set of five problems with no missing information while verbalizing each of the steps involved. The student will then choose one vary and one restate problem to represent using concrete materials on the appropriate diagram. The teacher/researcher will also tell the students that this is guided practice and that feedback and guidance will be provided. Prompts will be given if needed to assist the students to verbalize their thinking.

Clear instructions given
Cued guided practice
Feedback
Encourage verbalizations

8. Provides independent practice:
Another set of five problems will be given to students to be sorted according to problem type. The students will proceed to sort them while verbalizing the steps involved. The students will then choose one vary and one restate problem to represent using concrete materials on the appropriate diagram. The teacher/researcher will tell the students that this is independent practice and no assistance will be given.
The decision rule for moving on to the next lesson will be that the students sort all problems correctly and set up the problems accurately with concrete objects on the appropriate diagram.

- Clear instructions given
- Cued guided practice
- No feedback
- Encourage verbalizations

___/4

9. Provides frequent feedback:
Feedback will be provided throughout the lesson, except for step 8.

- Specific comments about
  - Think aloud
  - Ex/Non-Ex
  - Guided practice

___/3

10. Reviews content of current lesson:
A review of the problem types and outstanding features will be done at the end of this lesson.

- Review of current lesson

___/1
Lesson 5
Lesson Plan and Teacher checklist
Date of session________________
Directions: Please mark each blank with the appropriate symbol.
Mark a + if you see the step implemented and you hear the teacher use the keyword.
Mark with a – if you did not see the step implemented or hear the key word.
Materials needed:
  • Half marbles, paper plates, counters, base ten blocks
  • Four vary type word problems with no missing information printed on index cards
  • Three restate type word problems with no missing information printed on index cards
  • Poster depicting features of vary and restate word problems
  • One copy each of vary and restate schematic diagrams, Post It Notes
1. Provides rationale for the day’s lesson:
   It is important to learn to solve word problems using various strategies. Using manipulative objects may not always be practical. Therefore, you are going to learn that there are different ways of arriving at the correct answer.
   Rationale_______
   ___/1

2. Provides advance organizer:
   The teacher/researcher connects today’s lesson with previous ones by having the students recall when they had worked with concrete objects in previous lessons.
   Remember_______
   ___/1

3. Provides daily review:
   The teacher/researcher will review work from the last lesson by having the student do a quick sort of a set of five word problems. The student will be provided with five of each graphic organizer for today’s lesson.
4. Provides lesson objective:
   Today you are going to learn to make drawings to represent word problems based
   upon your use of concrete objects.

5. Uses think-aloud strategies to present and model new concepts:
   Connections will be made in this lesson between the concrete and the
   representational levels in the following manner. Using the same word problems
   as were used step 3, the teacher/researcher will set up a vary word problem with
   concrete objects and explicitly model how to draw a picture of the concrete
   objects onto the appropriate schematic diagram. The same procedure will be
   implemented with the restate type of word problem. The teacher/researcher will
   verbalize each step as she performs it.

6. Uses examples and non-examples:
   The teacher/researcher will make deliberate mistakes in transferring from the
   concrete to the representational level. For example, a word problem may state
   that there were five cupcakes on each of three shelves. The teacher/researcher
   would make the mistake of setting up four blocks to represent the cupcakes on
   one of the shelves instead of five. She would then think aloud and model how to
   correct the error. This will happen twice.
7. Provides guided practice:

Using the same problems as were used in step 3, the students will be assigned to set up two problems with concrete objects and then draw pictures on the appropriate diagrams. The students will be given one of each type of word problem. The teacher will tell the students that this is guided practice and that feedback and guidance will be provided.

Clear instructions given____
Cued guided practice____
Feedback____
Encourage verbalizations____

8. Provides independent practice:

The students will then be provided with two additional word problems: one vary type and one restate type. Students will set up these word problems in both concrete and representational forms. The teacher/researcher will tell the students that this independent practice and that no assistance will be provided.

The decision rule to move on will be that students set up both problems correctly in both the concrete and representational form.

Clear instructions given____
Cued independent practice____
No feedback____
Encourage verbalizations

9. Provides frequent feedback:
   Feedback will be provided throughout the lesson, except for Step 8.
   Specific comments about
   Think aloud____
   Ex/Non-Ex.____
   Guided practice____
   ____/3

10. Review content of current lesson:
    Today we connected the manipulative objects strategy with the representational strategy by drawing pictures of the objects.
    Review of current lesson____
    ____/1
Lesson 6
Lesson Plan and Teacher checklist

Date of session________________

Directions: Please mark each blank with the appropriate symbol.
Mark a + if you see the step implemented and you hear the teacher use the keyword.
Mark with a – if you did not see the step implemented or hear the key word.

Materials needed:
- Half marbles, paper plates, counters, base ten blocks
- Three vary type word problems without answers printed on index cards
- Three restate type word problems without answers printed on index cards
- One problem of each type (vary and restate) with no missing information for review purposes
- Poster depicting features of vary and restate word problems
- One copy each of vary and restate schematic diagrams, Post It Notes

1. Provides rationale for the day’s lesson:
   It is important to learn to solve word problems using various strategies. Using manipulative objects may not always be practical. Therefore, you are going to learn that there are different ways of arriving at the correct answer.

   Rationale____
   ____/1

2. Provides advance organizer:
   The teacher/researcher connects today’s lesson with previous lessons by having the students recall when they drew pictures of the objects that were set up to solve word problems.

   Remember____
   ____/1

3. Provides daily review:
Students will be given one word problem (either vary or restate) with no missing information. Students will be instructed to select the correct schematic diagram according to the word problem type. Students will then be instructed to set up the word problem on the schematic diagram with concrete objects, to draw pictures of the concrete objects on the Post It Notes, and place the notes on the appropriate place on the schematic diagram.

Remember____
____/1

4. Provides lesson objective:
Today you are going to connect your drawings to actual numbers, the way we usually see word problems presented.

State____
____/1

5. Uses think-aloud strategies to present and model new concepts:
The teacher/researcher thinks aloud as she sets up a problem on a schematic diagram with concrete objects and drawings. Then she models how she counts the items in each drawing and writes the corresponding numbers down. She then demonstrates each type (vary or restate) of word problem using this method.

Present new____
Model new____
Think Aloud____
____/3

6. Uses examples and non-examples:
During modeling, the teacher/researcher makes mistakes both with identifying word problem type and with counting items. She then shows how there errors can be checked and corrected. Two mistakes will be made.

One mistake____
7. Provides guided practice:
The teacher/researcher will assign the students to set up two word problems using concrete objects and then draw the pictures on the appropriate schematic diagrams. One of the word problems will be a vary type while the other word problem will be the restate type. Then the students will be asked to count the items and write the numbers on the correct diagrams. The students will then solve the word problems. The teacher/researcher will also tell the students that this is guided practice and that feedback and guidance will be provided.

Clear instructions given
Cued guided practice
Feedback
Encourage verbalizations

8. Provides independent practice:
The students will then be provided two additional word problems (one of each type) to set up three ways: that is, concrete, representational, abstract. They will then be assigned to solve the word problems. The teacher/researcher will tell the students that this is independent practice and that no assistance will be provided.

The decision rule to move on will be that students set up both problems correctly all three ways: that is, concrete, representational, abstract. In addition, students
will solve the problems correctly by writing the correct answer on the correct schematic diagram.

Clear instructions given
Cued independent practice
No feedback
Encourage verbalizations
____/4

9. Provides frequent feedback:

Feedback will be provided throughout this lesson, except for Step 8.

Specific comments about
Think aloud
Ex/Non-Ex.
Guided practice
____/3

10. Reviews content of lesson:

Today we connected all three strategies by setting up problems three ways: that is, concrete, representational, abstract.

Review of current lesson
____/1
Lesson 7
Lesson Plan and Teacher checklist

Date of session________________

Directions: Please mark each blank with the appropriate symbol.
Mark a + if you see the step implemented and you hear the teacher use the keyword.
Mark with a – if you did not see the step implemented or hear the key word.

Materials needed:

- Half marbles, paper plates, counters, base ten blocks
- Six vary type word problems without answers printed on index cards
- Five restate type word problems without answers printed on index cards
- Poster with mnemonic strategy
- Poster depicting features of vary and restate word problems
- One copy each of vary and restate schematic diagrams, Post It Notes

1. Provides rationale for the day’s lesson:
   The teacher/researcher states that while word problem solving can be hard, we can make it easier by breaking the word problems down into parts. Then we can solve each part to arrive at the correct answer. A mnemonic strategy can help with this.

   Rationale____
   ____/1

2. Provides advance organizer:
   The teacher/researcher asks the students to recall using the concrete, representational, and abstract strategies in solving word problems. We also used the schematic diagrams to help us identify the type of problem we are being asked to solve.

   Remember____
   ____/1

3. Provides daily review:
Students will be asked to model two word problems (one vary and one restate) using the concrete, representational, and abstract strategies on the appropriate schematic diagrams.

Remember____
____/1

4. Provides lesson objective:
   Today you are going to learn to solve word problems using a mnemonic strategy. You are also going to be given word problems that you need to solve. These problems will have a missing answer.

State____
____/1

5. Uses think-aloud strategies to present and model new concepts:
   The teacher/researcher will introduce and discuss the steps of the PROBLEM strategy by referring to the poster depicting the strategy. The teacher/researcher will then model how to solve the first two problems (one vary type and one restate type) following each step of the mnemonic strategy while verbalizing the importance of the use of each step. For example, first the teacher/researcher will select the appropriate schematic diagram and place the concrete objects in the correct places on the diagram. Then the teacher/researcher will think aloud about planning for word problem solution reminding students of the relationships depicted by if then or twice as much. This is when translation occurs between the schematic diagram and writing the equation.

Present new____
Model new____
Think aloud____
____/3

6. Uses examples and non-examples:
The teacher/researcher will make deliberate mistakes like setting up a vary type of word problem on a restate type schematic diagram, for example. Mistakes will be made twice.

One mistake____
One mistake____
____/2

7. Provides guided practice:
The teacher/researcher will assign students to use the mnemonic strategy to solve the remaining four problems, while verbalizing their thinking and mapping them onto the correct schematic diagrams. She will also tell the student that this is guided practice and that feedback and guidance will be provided. Students may use the concrete objects or draw pictures to assist them.

Clear instructions given____
Cued guided practice____
Feedback____
Encourage verbalizations____
____/4

8. Provides independent practice:
The teacher/researcher will assign students to independently solve three additional problems (two vary and one restate). The teacher/researcher will also state that this is independent practice and that no assistance will be given. Students will be asked to identify the word problem type and solve the word problem using the steps or the PROBLEM strategy. The decision rule to move on will be that students solve the word problems correctly.

Clear instructions given____
Cued guided practice
No feedback
Encourage verbalizations

/4

9. Provides frequent feedback:

Feedback will be provided throughout the lesson, except for Step 8.

Specific comments about

Think aloud
Ex/Non-Ex.
Guided practice

/3

10. Reviews content of current lesson:

Review of current lesson

/1
Lesson 8
Lesson Plan and Teacher checklist

Date of session________________

Directions: Please mark each blank with the appropriate symbol.
Mark a + if you see the step implemented and you hear the teacher use the keyword.
Mark with a – if you did not see the step implemented or hear the key word.

Materials needed:
- Half marbles, paper plates, counters, base ten blocks will be available
- Six vary type word problems without answers printed on index cards
- Five restate type word problems without answers printed on index cards
- Poster with mnemonic strategy; strategy checklists
- Poster depicting features of vary and restate word problems
- One copy each of vary and restate schematic diagrams, Post It Notes

1. Provides rationale for the day’s lesson:
   The teacher/researcher states that students will not always have a poster in the classroom to remind them of the steps of the PROBLEM /strategy. It is important that we be able to solve word problems even when we can’t see the poster. Today, you are going to learn to use a strategy checklist to be sure that you are using each step of the strategy.

   Rationale____
   ____/1

2. Provides advance organizer:
   The teacher/researcher states that you have learned a variety of strategies to use when we are given word problems to solve. You have learned the concrete, representational, and abstract strategies as well as the mnemonic strategy, PROBLEM. Today, you are going to learn to use a strategy checklist to make sure that you are using each step of the strategy.

   Remember____
   ____/1

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3. Provides daily review:
   Students will be given one problem of the vary type and one problem of the restate type to solve. In addition, they will be provided with schematic diagrams and access to concrete materials if they need them. They will be reminded to look at the poster depicting the strategy steps for assistance.

   Remember
   ____/1

4. Provides lesson objective:
   Today you are going to learn to use a strategy checklist to be sure that you are using each step of the strategy.

   State
   ____/1

5. Uses think-aloud strategies to present and model new concepts
   The teacher/researcher will attempt to solve two word problems by first determining the word problem types. She will then model how to map one of the word problems onto the correct schematic diagram. Finally, she will model solving the word problem using the mnemonic strategy and checklist. As she completes each step of the strategy PROBLEM, she will check it off on the strategy checklist while thinking aloud about the importance of using the checklist to keep track of the word problem solving process.

   Present new
   Model new
   Think aloud
   ____/3

6. Uses examples and non-examples:
The teacher/researcher will make deliberate mistakes by identifying the incorrect problem type or checking off the wrong step on the strategy checklist. Two mistakes will be made.

One mistake____
One mistake____
____/2

7. Provides guided practice:
The teacher/researcher will assign the student three problems to solve using the mnemonic strategy checklist. She will also tell the students that this is guided practice and that feedback and guidance will be provided. Students will be encouraged to verbalize their thinking while using the checklist and solving the problem. Prompting will be provided as needed.

Clear instructions given____
Cued guided practice____
Feedback____
Encourage verbalizations____
____/4

8. Provides independent practice:
The students will be given four word problems (two of each type) to solve using the mnemonic strategy checklist. Students will be provided with instructions to use their strategy checklists to set up the problems using concrete objects, drawings, or numbers, and to solve the problems. The teacher/researcher will tell the students that this is independent practice and that no assistance will be provided.
The decision rule to move on will be when students represent all word problems correctly on the appropriate diagram. In addition, students will demonstrate use of the strategy checklist by checking off each step as it is completed for all four word problems. Finally, all problems need to be solved correctly.

Clear instructions given____
Cued guided practice____
No feedback____
Encourage verbalizations____
____/4

9. Provides frequent feedback:
   Feedback will be provided throughout the lesson, except for Step 8.
   Specific comments about
   Think aloud____
   Ex/Non-Ex ____
   Guided practice____
   ____/3

10. Reviews content of today’s lesson:
    The teacher/researcher will state that today you learned how to solve word problems independently in that you learned to use your strategy checklist.
    Review of current lesson____
    ____/1
Lesson 9
Lesson Plan and Teacher checklist
Date of session________________
Directions: Please mark each blank with the appropriate symbol.
Mark a + if you see the step implemented and you hear the teacher use the keyword.
Mark with a – if you did not see the step implemented or hear the key word.
Materials needed:
• Half marbles, paper plates, counters, base ten blocks will be available
• Set of 2 one step word problems, one vary and one restate without answers printed on index cards
• Set of 4 two step vary word problems without answers printed on index cards
• Poster with mnemonic strategy; strategy checklists
• Poster depicting features of vary and restate word problems
• One copy each of vary and restate schematic diagrams, Post It Notes
1. Provides rationale for the day’s lesson
   The teacher/researcher will state that many math word problems involve more than one step. It is important that we be able to solve word problems that have more than one step in real life, such as when you are figuring out if you have enough money to buy three different items at the store.
   Rationale____
   ___/1

2. Provides advance organizer:
   The teacher/researcher will remind students that they now know how to solve one step word problems using the mnemonic strategy PROBLEM and using a strategy checklist.
   Remember____
   ___/1
3. Provides daily review:
The student will receive 2 one step word problems of each type to solve using the mnemonic strategy and strategy checklist.

Remember____
____/1

4. Provides lesson objective:
Today, we are going to learn how to solve two step vary word problems.

State____
____/1

5. Uses think-aloud strategies to present and model new concepts:
The teacher/researcher will present a two step word problem where both steps involve the vary type of word problem. For example, if the ingredients for one cake call for two eggs and three cups of flour, how much of these two ingredients will be needed for three cakes?
The teacher/researcher will use two vary schematic diagrams and model how to map one step of the word problem onto each schematic diagram. This will show how both steps in the cake word problem illustrate the same word problem type. The teacher/researcher will model the thinking process by saying that we are actually being asked two questions in a two step word problem. Therefore, the teacher/researcher will state that she needs to look for the main question and then the secondary question. For example, in the cake word problem the main question is, “How much of these two ingredients will be needed?” The secondary question has to do with computing the amount of eggs and the amount of flour.
After computing the amounts of the two ingredients, the instructor will state that she will label each amount with P1 and P2 for partial answer one and partial answer two. Then the teacher/researcher will use the P1 and P2 amounts to solve the word problem.

6. Uses examples and non-examples:
   The teacher/researcher will make deliberate mistakes by misnaming the word problem type. In addition, she will make errors by not identifying the specific answers that the problem is asking for. These mistakes will happen twice.

7. Provides guided practice:
   The student will be given 2 two step vary word problems to solve. Verbalizations of steps will be encouraged and prompts provided if needed. In addition, concrete objects will be available if needed. The teacher/researcher will tell the students that this is guided practice and that feedback and guidance will be provided.
8. Provides independent practice:

The teacher/researcher will assign the students to solve 2 two step word problems. Students will be given the following instructions: (a) set up problems on the schematic diagrams, (b) check off steps of the mnemonic strategy on the strategy checklist, (c) solve the word problems. The teacher/researcher will tell the students that this is independent practice and that no assistance will be provided. The decision rule to move on will be that students will solve both problems correctly. In addition, students will use the schematic diagrams and mnemonic strategy checklist appropriately.

Clear instructions given____
Cue guided practice____
No feedback given____
Encourage verbalizations____
____/4

9. Provides frequent feedback:

Feedback will be provided throughout the lesson, except during step 8.

Specific comments about
Think aloud____
Ex/Non-Ex.____
Guided practice____
____/3

10. Reviews content of lesson:

A review will be conducted of the procedure for performing two step vary word problems.

Review of current lesson____
____/1
Lesson 10

Lesson Plan and Teacher checklist

Date of session________________

Directions: Please mark each blank with the appropriate symbol.

Mark a + if you see the step implemented and you hear the teacher use the keyword.

Mark with a – if you did not see the step implemented or hear the key word.

Materials needed:

- Half marbles, paper plates, counters, base ten blocks will be available
- Set of 2 one step word problems, one vary and one restate without answers printed on index cards
- Set of 2 two step vary word problems without answers printed on index cards
- Set of 2 two step restate word problems without answers printed on index cards
- Poster with mnemonic strategy; strategy checklists
- Poster depicting features of vary and restate word problems
- One copy each of vary and restate schematic diagrams, Post It Notes

1. Provides rationale for the day’s lesson:
   The teacher/researcher will state that many math word problems involve more than one step. It is important that we be able to solve word problems that have more than one step in real life, such as when you are figuring out if you have enough money to buy three different items at the store.

   Rationale______
   ___/1

2. Provides advance organizer:
   The teacher/researcher will remind the students that they now know how to solve one step word problems using a mnemonic strategy.

   Remember______
   ___/1

3. Provides daily review:
The teacher/researcher will have the students recall learning about vary and restate problems. In addition, the teacher/researcher will ask students to recall the definitions of each word problem type. She will also ask them to recall the strategy PROBLEM and what step each letter stands for. Students may use the mnemonic strategy poster for assistance if necessary.

Remember____
____/1

4. Provides lesson objective:
   Today, you are going to review the PROBLEM Strategy so that you have a clear picture of why each step is necessary.

   State____
   ____/1

5. Uses think-aloud strategies to present and model new concepts:
   The teacher/researcher will present a two step vary or restate word problem involving multiplication or division. For example, if the ingredients for a cake call for two eggs and four cups of flour, how many eggs and cups of flour will be needed for 14 cakes? Using two schematic diagrams, one for each step of the word problem, the teacher/researcher will select the correct schematic diagram and circle the word problem type: that is, the P step of the strategy. She will then have two vary schematic diagrams because each step of the word problem involves the vary schema. Using the portion of the strategy checklist that is designated for two step problems, she will then check off the P step in the appropriate places. She will also state that this is important because we need to know the word problem type for both steps of the word problem so that we will know how to set up the problem on the correct schematic diagrams. Then the teacher/researcher will use the vary schematic diagrams to map the numbers from the problem onto the diagrams, the R step of the strategy. She will think aloud about the fact that she could use concrete objects or pictures on the diagram if she
is not able to solve the basic math facts fluently. To find the amount of eggs that are needed for 14 cakes, she will set up the concrete objects and draw a picture on a small Post It Note to show 14 times two and place both the concrete objects and the Post It notes on the schematic diagram. She will follow the same procedure to find the number of cups of flour needed for 14 cakes. She will then check off the R step in the appropriate places on the strategy checklist. The O step involves writing the correct operation and equation. The teacher/researcher will verbalize her thinking by saying that this step is important because it is important to know whether to multiply or divide to solve the problem. She will then write the correct operation while verbalizing her thinking and check off the O step on the strategy checklist in the two designated places. The B step involves performing the correct computation. The teacher/researcher will again verbalize her thinking, repeating the concrete objects and/or pictures could help if she needs them. Also, she will state that if she performs the correct operation but has the wrong equation, she will not get the correct answer. She will then reread the problem to make sure that the equation is correct. She will think aloud about her error and correct the equation. Then she will compute correctly. She will check off the B step on the strategy checklist in the two appropriate places. The L step of the strategy involves labeling the problem correctly. At this point she will read the problem to find out exactly what is being asked for. In error, she will verbalize that the problem is asking for the number of cakes, not the number of eggs or cups of flour. She will then write cakes after her answer and check off step L in two places.
The E and M steps involve checking work and making corrections if necessary. The instructor will go over each step of the strategy to be sure that she completed each one correctly. She will think aloud about the error in the L step and make the necessary correction. Then she will make at least two checkmarks on her work. She will check off steps E and M on the strategy checklist in the appropriate places.

Present new____
Model new____
Think aloud____
____/3

6. Uses examples and non-examples:
The teacher/researcher will make a deliberate mistake by writing the incorrect equation. In addition, she will make an error by not identifying what the problem is asking for and as a result label the answer incorrectly.

One mistake____
One mistake____
____/2

7. Provides guided practice:
The students will each be given a one step vary problem involving division which we will solve together. Each student will have the mnemonic strategy checklist and the schematic diagrams of the two problem types. We will go through the steps one at a time the same way that was modeled in step 5 of this lesson plan: that is, Uses think-aloud strategies to present and model new concepts. Students will be questioned as to why each step is important. In addition, they will be asked to tell the other students why each step is important. Finally, students will be performing each step of the word problem using their schematic diagrams and strategy checklists. The same procedure will be used with a two step vary
problem. Verbalizations of steps will be encouraged and prompts provided if needed. The teacher will tell the students that this is guided practice and that feedback and guidance will be provided.

Clear instructions given
Cue guided practice
Feedback
Encourage verbalizations

8. Provides independent practice:
The teacher/researcher will assign students to solve a two step vary word problem. Students will be given instructions to set up the word problem on the schematic diagram and to use the strategy checklist to solve the problem. The teacher will tell the students that this is independent practice and that no assistance will be provided. The decision rule to move on will be that the students will solve the word problem correctly. In addition, students will use the schematic diagrams and the mnemonic strategy checklist appropriately.

Clear instructions given
Cue independent practice
No feedback given
Encourage verbalizations

9. Provides frequent feedback:
Feedback will be provided throughout the lesson, except during step 8.

Specific comments about
Think aloud
Ex/Non-Ex.
10. Review content of current lesson:
   A review will be conducted of the strategy PROBLEM and why each step is important.
Appendix I

Sample Data Collection Sheet Training
Objective: When given word problems of the vary or restate type, student will use steps 1 through 6 of the mnemonic strategy; Circle 

V for Vary; R for Restate;

<table>
<thead>
<tr>
<th>Steps</th>
<th>Prob. 1</th>
<th>Prob. 2</th>
<th>Prob. 3</th>
<th>Prob. 4</th>
<th>Prob. 5</th>
<th>Prob. 5</th>
<th>Prob. 6</th>
<th>Prob. 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
</tbody>
</table>

P=Select correct diagram from set of 2 for problem type
R=Write numbers from problems in correct place on diagram
O=Write correct operation and equation
B=performs correct calculation

| P= | 1     | | | | | | |
| R= | 2     | | | | | | |
| O= | 3     | | | | | | |
| B= | 4     | | | | | | |

190
<table>
<thead>
<tr>
<th>Steps</th>
<th>Prob. 1</th>
<th>Prob. 2</th>
<th>Prob. 3</th>
<th>Prob. 4</th>
<th>Prob. 5</th>
<th>Prob. 5</th>
<th>Prob. 6</th>
<th>Prob. 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Step 2</td>
<td></td>
<td></td>
<td>Step 2</td>
</tr>
</tbody>
</table>

L = Write correct label for the answer to the problem
E & M = Student makes at least two check marks on diagram

Circle C or I for Correct/Incorrect

<table>
<thead>
<tr>
<th>Circles</th>
<th>C</th>
<th>I</th>
<th>C</th>
<th>I</th>
<th>C</th>
<th>I</th>
<th>C</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Word Prob. correct</td>
<td>_/6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Word Problem Accuracy</th>
<th>Strategy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Correct: _/6</td>
<td>Total Correct: ____/48</td>
</tr>
<tr>
<td>Conversion to Percent:</td>
<td>Conversion to Percent:</td>
</tr>
<tr>
<td>Total number correct divided by 6 X 100=</td>
<td>Total number correct divided by 48 X 100=</td>
</tr>
<tr>
<td>___%</td>
<td>__________%</td>
</tr>
</tbody>
</table>
Sample Data Collection Sheet Training

Completed

<table>
<thead>
<tr>
<th>Steps of Strategy</th>
<th>Problem 1</th>
<th>Problem 2</th>
<th>Problem 3</th>
<th>Problem 4</th>
<th>Problem 5</th>
<th>Problem 6</th>
<th>Total Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find the total degrees from 0 to 180 for problem a</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>2</td>
</tr>
<tr>
<td>Find the minutes from problems in correct place in problem b</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>2</td>
</tr>
<tr>
<td>0 or 1200 correct answers in all equation</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>2</td>
</tr>
<tr>
<td>Replace incorrect decimals</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>2</td>
</tr>
<tr>
<td>Identify correct units for the answer to the problem</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>2</td>
</tr>
<tr>
<td>Date and write the year at least two math words on diagram</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>Y</td>
<td>R</td>
<td>2</td>
</tr>
</tbody>
</table>

Word Problem Accuracy

<table>
<thead>
<tr>
<th>Strategy Use</th>
<th>Total Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Correct</td>
<td>148</td>
</tr>
</tbody>
</table>

Conversion to Percent

<table>
<thead>
<tr>
<th>Total number correct divided by $5 \times 100$</th>
<th>Conversion to Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>$7$</td>
<td>$14$</td>
</tr>
<tr>
<td>Total number correct divided by $45 \times 100$</td>
<td>$8$</td>
</tr>
</tbody>
</table>
Appendix J

Sample Data Collection Sheet Generalization Quiz
Objective: When given word problems of the vary or restate type, student will use steps 1 through 6 of the mnemonic strategy

<table>
<thead>
<tr>
<th>Steps of Strategy</th>
<th>Problem 1</th>
<th>Problem 3</th>
<th>Problem 5</th>
<th>Problem 7</th>
<th>Problem 7</th>
<th>Total for Strategy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>V        R</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P       =Select correct diagram from set of 2 for problem type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R       =Write numbers from problems in correct place on diagram</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O       =Write correct operation and equation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B       =performs correct calculations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L       =Write correct label for the answer to the problem</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E &amp; M   =Student makes at least two check marks on diagram</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Word Problem Accuracy
Circle C or I for Correct/Incorrect

<table>
<thead>
<tr>
<th>C</th>
<th>I</th>
<th>C</th>
<th>I</th>
<th>C</th>
<th>I</th>
<th>Word Problems Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>/4</td>
</tr>
</tbody>
</table>

Word Problem Accuracy

<table>
<thead>
<tr>
<th>Total Correct:</th>
</tr>
</thead>
<tbody>
<tr>
<td>/4</td>
</tr>
</tbody>
</table>

Strategy Use

<table>
<thead>
<tr>
<th>Total Correct:</th>
</tr>
</thead>
<tbody>
<tr>
<td>____/30</td>
</tr>
</tbody>
</table>

Conversion to Percent:
Total number correct divided by 4 X 100= ____%

<table>
<thead>
<tr>
<th>Conversion to Percent:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number correct divided by 30 X 100= ____%</td>
</tr>
</tbody>
</table>
**Objective:** When given word problems of the vary or constant type, student will use steps 1 through 6 of the mnemonic strategy.

<table>
<thead>
<tr>
<th>Steps of Strategy</th>
<th>Problem 1</th>
<th>Problem 3</th>
<th>Problem 5</th>
<th>Problem 7</th>
<th>Problem 7</th>
<th>Total for Strategy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Select correct diagram from set of 2 for problem type</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1/5</td>
</tr>
<tr>
<td>2. Write number from problem in correct place on diagram</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>2/5</td>
</tr>
<tr>
<td>3. Write correct operation and equation</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>3/5</td>
</tr>
<tr>
<td>4. perform correct calculations</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>2/5</td>
</tr>
<tr>
<td>5. Write correct label for the answer to the problem</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>1/5</td>
</tr>
<tr>
<td>6. &amp; 7. Student shades at least two clock marks on diagram</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0/5</td>
</tr>
</tbody>
</table>

**Word Problem Accuracy**

<table>
<thead>
<tr>
<th>Correct/Incorrect</th>
<th>Word Problems Correct</th>
<th>9/16</th>
</tr>
</thead>
</table>

**Conversion to Percent:**

- Total correct divided by 4 x 100 = 96
- Total correct divided by 30 x 100 = 40
Generalization Phase

Student Name: __________________        Session Number: ___________________    Date of Session: __________________

Key: V=Vary; R=Restate;

Objective: When given word problems of the vary or restate type, student will use steps 1 through 6 of the mnemonic strategy

<table>
<thead>
<tr>
<th>Steps of Strategy</th>
<th>Problem 2</th>
<th>Problem 4</th>
<th>Problem 6</th>
<th>Problem 8</th>
<th>Problem 8</th>
<th>Total for Strategy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>P=Select correct diagram from set of 2 for problem type</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>__/5</td>
</tr>
<tr>
<td>R=Write numbers from problems in correct place on diagram</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>__/5</td>
</tr>
<tr>
<td>O=Write correct operation and equation</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>__/5</td>
</tr>
<tr>
<td>B=performs correct calculations</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>__/5</td>
</tr>
<tr>
<td>L=Write correct label for the answer to the problem</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>__/5</td>
</tr>
<tr>
<td>E &amp; M=Student makes at least two check marks on diagram</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>__/5</td>
</tr>
</tbody>
</table>

Word Problem Accuracy

<table>
<thead>
<tr>
<th>Word Problem Accuracy</th>
<th>C I</th>
<th>C I</th>
<th>C I</th>
<th>C I</th>
<th>Word Problems Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circle C or I for Correct/Incorrect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>/4</td>
</tr>
</tbody>
</table>

Word Problem Accuracy Strategy Use

Total Correct: _/4

Conversion to Percent:

Total number correct divided by 4 X 100= _____%

Total number correct divided by 30 X 100= _________%
**Generalization Phase**

**Figure 2: Data Collection Sheet for Strategy Use and Word Problem Accuracy**

<table>
<thead>
<tr>
<th>Student Name:</th>
<th>Session Number:</th>
<th>Date of Session:</th>
<th>3-2-12</th>
</tr>
</thead>
</table>

**Objective:** When given word problems of the vary or restore type, student will use steps 1 through 6 of the mnemonic strategy.

<table>
<thead>
<tr>
<th>Steps of Strategy</th>
<th>Problem 2</th>
<th>Problem 4</th>
<th>Problem 6</th>
<th>Problem 8</th>
<th>Total for Strategy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>S: Select correct diagram from set of 2 for problem type</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>R: Write numbers from problems to correct place on diagram</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>G: Write correct operation and equation</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>B: Performs correct calculations</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>L: Write correct label for the answer in the problem</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F &amp; M: Student makes at least two check marks on diagram</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Word Problem Accuracy**

<table>
<thead>
<tr>
<th>Word Problem Accuracy</th>
<th>Strategy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Correct: 1/4</td>
<td>Total Correct: 14/15</td>
</tr>
</tbody>
</table>

**Conversion to Percent:**

| Total number correct divided by 4 X 100%: 25% | Conversion to Percent: Total number correct divided by 30 X 100%: 47% |
Appendix K

Quizzes in Training Format
Quizzes in Training Format

Name_______________________ Date:_____________________

Quiz 1

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The Scouts washed 12 cars one afternoon. They earned $6.00 for each car they washed. How much money did they earn?</td>
</tr>
<tr>
<td>2.</td>
<td>Scott read 12 books during the month of August. He read 4 times as many books as Rodney. How many books did Rodney read?</td>
</tr>
<tr>
<td>3.</td>
<td>Cindy is driving her car at a rate of 55 miles per hour. How far will she drive in four hours?</td>
</tr>
<tr>
<td>4.</td>
<td>Evan won 26 ribbons at the fair last week. This was 2 times as great as the number that Kate won. How many ribbons did Kate win?</td>
</tr>
<tr>
<td>5.</td>
<td>Michelle found 24 shells on the beach today. She found twice as many seashells as sand dollars. How many sand dollars did she find? She also found 3 times as many pieces of sea glass as sand dollars. How many pieces of sea glass did she find?</td>
</tr>
<tr>
<td>6.</td>
<td>The Sweet Shoppe sold 350 ice cream cones over the last 7 days. How many did they sell each day on average? If the shop continued to sell ice cream cones at this rate, how many would they sell in the next 25 days?</td>
</tr>
</tbody>
</table>
Quiz 2:

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Michele is making tuna fish salad for a party. The recipe for 10 servings calls for 8 ounces of mayonnaise. She needs to make enough tuna fish salad to make 90 servings. How many ounces of mayonnaise will Michele need?</td>
<td>2. Scott is 5 years old. His Aunt Mary is 4 times as old. How old is his Aunt Mary?</td>
</tr>
<tr>
<td>3. The airplane goes 600 miles per hour. The car goes 50 miles per hour. How many times faster does the airplane go than the car?</td>
<td>4. A jumbo cookie costs $.80. How much would five cookies cost?</td>
</tr>
<tr>
<td>5. Suzie earned $24.00 for babysitting for 4 hours. How much did she earn for one hour? Next week she will babysit for 6 hours. How much will she earn?</td>
<td>6. Theresa has to make 30 bows. If she can make 6 bows in 10 minutes, how long will it take to make all of the bows?</td>
</tr>
</tbody>
</table>
### Quiz 4

Solve as many problems as you can. Use extra paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There are 6 pears in a basket of fruit. Two boys divide the pears equally. How many pears does each boy receive?</td>
<td>2. Sam picks a total of 24 oranges. He puts 4 in each box. How many boxes does he need?</td>
</tr>
<tr>
<td>3. Amy’s recipe calls for twice as many tomatoes as peppers. She uses 3 cups of peppers. How many cups of tomatoes will she use?</td>
<td>4. There are 16 fifth grade players on Jamie’s soccer team. If there are twice as many fifth graders as sixth graders on the team, how many sixth graders are there?</td>
</tr>
<tr>
<td>5. Trish’s dog had a litter of 5 puppies. How many paws do the five puppies have? How many ears do the puppies have?</td>
<td>6. Sally is 11 years old. Her dad is 4 times as old as she is. How old is her dad? Her mom is 3 times as old as Sally. How old is her mom?</td>
</tr>
</tbody>
</table>
Name_______________________ Date:_____________________

Quiz 5

Solve as many problems as you can. Use an extra sheet of paper to show your work

<table>
<thead>
<tr>
<th>1. Su Ling used 240 beads to make 8 necklaces. She put the same number of beads on each necklace. How many beads did Su Ling put on each bracelet?</th>
<th>2. Jesse needs tokens to play a video game. For every dollar that he puts in the machine, he gets two tokens. If he puts $4.00 into the machine, how many tokens will he get?</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Scott is 16 years old. His little sister Charlene is only 2 years old. How many times older is Scott than Charlene?</td>
<td>4. Cassidy used 5 beads to make a bracelet. Suki used 3 times as many beads as Cassidy. How many beads did Suki use?</td>
</tr>
<tr>
<td>5. Paul earns $60.00 per week. He works five hours each week. How much does he earn per hour? How much would he earn if he worked 8 hours per week?</td>
<td>6. Sam has 9 video games. Tommy has 54 video games. How many times more video games does Tommy have than Sam? Billy has two times as many video games as Sam. How many video games does Billy have?</td>
</tr>
</tbody>
</table>
Name_______________________ Date:_____________________

Quiz 7

Solve as many problems as you can. Use extra paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The coach of a baseball team needs to buy 16 baseballs. If each baseball costs $2.00, how much did the coach need to spend?</td>
</tr>
<tr>
<td>2.</td>
<td>Mary’s mom is 4 times as old as she is. Her mom is 36 years old. How old is Mary?</td>
</tr>
<tr>
<td>3.</td>
<td>An adult horse eats 20 pounds of hay each day. Sandy has the job of feeding the horse for three days. How much hay will she need?</td>
</tr>
<tr>
<td>4.</td>
<td>There are 12 gold stars to be given out equally to 4 students. How many stars does each student receive?</td>
</tr>
<tr>
<td>5.</td>
<td>Tony collected 140 cans on Monday for the annual food drive. He collected twice that many on Wednesday and 3 times as many on Thursday. How many did he collect on Wednesday? How many did he collect on Thursday?</td>
</tr>
<tr>
<td>6.</td>
<td>Debbie has a recipe for pumpkin pie. This recipe calls for 2 cups of pumpkin puree and 3 eggs. How much pumpkin puree and how many eggs will she need if she wants to make three pies?</td>
</tr>
</tbody>
</table>
Quiz 10

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<table>
<thead>
<tr>
<th>1. A carrying case holds 5 CDs. How many cases would be needed to hold 350 CDs?</th>
<th>2. There are three times more apples than bananas left after lunchtime each day in the school cafeteria. If there are 15 apples, how many bananas are left?</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. A poultry farmer bought 2,000 chicks at $0.45 each. How much did he pay for the chicks?</td>
<td>4. Holly sold 8 magazines. Her friend sold 10 times as many magazines as Holly. How many magazines did Holly’s friend sell?</td>
</tr>
<tr>
<td>5. Barney has 120 pumpkin seeds. This is 2 times as many pumpkin seeds as Sandy has. Tommy has 3 times as many pumpkin seeds as Sandy has. How many pumpkin seeds does Sandy have? How many seeds does Tommy have?</td>
<td>6. Billy washes cars to earn money. If he washes two cars he earns $12.00. How much will he earn if he washes 6 cars?</td>
</tr>
</tbody>
</table>
Name_______________________ Date:_____________________

Quiz 11

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<table>
<thead>
<tr>
<th>1. A car is driven around a 4 mile racetrack 4 times. How far did the car travel?</th>
<th>2. There are three times as many Palm Trees as Coconut Trees in Mr. Allen’s Nursery. There are 45 Palm Trees. How many Coconut Trees are there?</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. There are 3 buses to transport 120 students. How many students will ride on each bus if each bus has the same number of students?</td>
<td>4. For the fund raiser at school, Zach and Billy sold candy bars. Zach sold 21 boxes of candy bars. This was 3 times as many as Billy sold. How many did Billy sell?</td>
</tr>
<tr>
<td>5. Julie went to the grocery store and bought $15.00 worth of fruit. She spent 3 times that much on meat. She also spent two times as much on vegetables as she did on meat. How much did she spend on meat? How much did she spend on vegetables?</td>
<td>6. A landscaping company ordered 210 bags of mulch at a cost of $4.00 per bag. What was the total cost of the mulch? Suppose the mulch cost $5.00 per bag. How much would the total cost be?</td>
</tr>
</tbody>
</table>
Quiz 13

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Carrie counts 32 seats in each row of the theater. There are a total of 40 rows in the theater. How many seats are there altogether?</td>
</tr>
<tr>
<td>2.</td>
<td>There are 360 students in a spelling bee. The students are put into 6 equal groups. How many students are in each group?</td>
</tr>
<tr>
<td>3.</td>
<td>Carley’s mom is three times as old as Carley. If Carley is 16, how old is her mom?</td>
</tr>
<tr>
<td>4.</td>
<td>While on a trip, Sue bought 3 postcards. Willa bought twice as many. How many postcards did Willa buy?</td>
</tr>
<tr>
<td>5.</td>
<td>Cara earns $35.00 a week for 7 hours of babysitting. How much does she earn per hour? If she babysits for 14 hours, how much will she make?</td>
</tr>
<tr>
<td>6.</td>
<td>Amanda grew 3 different types of plants for the science fair. The first plant was 4 centimeters tall. The second was twice as tall. The third was 4 times as tall as the second one. How tall were the second and third plants?</td>
</tr>
</tbody>
</table>
Quiz 14

Solve as many problems as you can. Use an extra sheet of paper to show your work.

| 1. | A school uniform costs $40.00. How much would it cost to buy uniforms for 52 students? |
| 2. | Jay and Ruth each grew a pumpkin. Ruth’s pumpkin weighs 3 times as much as Jay’s pumpkin. Jay’s pumpkin weighs 3 pounds. How much did Ruth’s pumpkin weigh? |
| 3. | There are three times as many blue balloons as green balloons. There are 4 green balloons. How many blue balloons are there? |
| 4. | Scott spent 8 hours driving to college. If his average speed was 55 miles per hour, how many miles did Scott drive? |
| 5. | Felix has 9 pairs of socks that he needs to sort. How many socks does Felix have? If his mom gave him three more pairs that she bought at the store how many socks would Felix have then? |
| 6. | Jill picked twice as many apples as Mona. Mona picked 13 apples. How many apples did Jill pick? Sam picked 3 times as many apples as Mona. How many apples did Sam pick? |
Quiz 16

Solve as many problems as you can. Use an extra sheet of paper to show your work.

1. Nan needs 4 times as much flour as sugar. She needs 4 cups of sugar. How much flour does she need?

2. Mark and five of his friends are practicing kicking goals in a soccer game. The boys have 24 balls altogether. If they want to divide the balls equally among them, how many balls will each boy have to practice with?

3. Mrs. Smith needs to rent some tables for a party that she is having. Each table will seat 8 guests. She is inviting 48 guests to the party. Assuming that everyone accepts her invitation, how many tables will she need?

4. Steven paid $0.75 for a rubber spider. This was 3 times the amount that Paul paid for a rubber snake. How much did Paul pay for his snake?

5. There are 45 boxes of history books in the school book room. Each box contains 9 books. How many boxes of history books are there in all? If 3 more boxes are added to the closet, how many books are there in all?

1. Mr. Jensen’s classroom has four tables with 6 students at each table. How many students are there altogether?

2. There are three times as many ducks as geese living on a nearby farm. There are 5 geese. How many ducks are there on the farm?

3. Allison has 3 buckets of seashells. If each bucket holds 10 shells, how many shells does Allison have?

4. There are four times as many basketballs as soccer balls in the school gym. If there are 5 soccer balls, how many basketballs are there?

5. A store had some basketballs to sell at $20.00 each. This store also had 15 football helmets. Each helmet is worth twice as much as a basketball. If the store sells all of its helmets, how much money will the store make on the helmets?

6. The Bessey Creek Basketball team scores an average of 60 points per game. How many points would they score over 5 games? How many points would they score over 10 games?
Quiz 19

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Joan has two baskets and 10 flowers. She wants to put an equal number of flowers in each basket. How many flowers will she put in each basket?</td>
</tr>
<tr>
<td>2.</td>
<td>There are twelve stickers on each sheet. There are four sheets in one pack. How many stickers are in one pack?</td>
</tr>
<tr>
<td>3.</td>
<td>Joe drew 32 pictures in his sketch book. He drew 4 times as many pictures as Kelly. How many pictures did Kelly draw?</td>
</tr>
<tr>
<td>4.</td>
<td>Melanie has scored an average of 18 points in her last 6 baseball games. This is 3 times as much as Stephanie scored. How many points did Stephanie average over the last 6 games?</td>
</tr>
<tr>
<td>5.</td>
<td>Allison made 3 times as many chocolate cupcakes as vanilla cupcakes. She also made twice as many spice cupcakes as chocolate cupcakes. She made 4 vanilla cupcakes. How many of each type did she make?</td>
</tr>
<tr>
<td>6.</td>
<td>Mark earns $5.00 a week for doing his chores. How many weeks will he have to save his money in order to buy a baseball glove for $80.00? If Mark decides he wants to buy the baseball glove and a baseball bat for $20.00, how many weeks will he have to save?</td>
</tr>
</tbody>
</table>
Quiz 20

Solve as many problems as you can. Use an extra sheet of paper to show your work.

1. Lee bought 3 times as many red apples as green apples. He bought 18 red apples. How many green apples did he buy?

2. A baker had three cakes and only 12 candles. He wanted to put the same number of candles on each cake. How many candles did he put on each cake?

3. Phil scored 180 points on his video game. Two weeks later, Phil’s score was 20 times as great. What was his later score?

4. A teacher gives quizzes that are worth 13 points each. If the teacher gave three quizzes how many points are all of the quizzes worth?

5. Sheila wanted to send 5 invitations to her birthday party through the mail. It would cost $.47 to send each invitation. How much will it cost Sheila to send these invitations? A few days later Sheila discovered that she had forgotten to invite 3 of her friends. How much more money would she have to pay to send the additional 3 invitations?

6. Kim has quarters, dimes, and nickels in her piggy bank. She has twice as many quarters as dimes and 3 times as many nickels as quarters. She has 3 dimes. How many quarters and nickels does she have?
Quiz 22

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Jill can go 7 times as fast on her motorcycle than Chris can go on his bicycle. Chris can go 10 miles per hour on his bike. How fast can Jill go on her motorcycle?</td>
</tr>
<tr>
<td>2.</td>
<td>Kelly had 4 boxes of cookies. There are five cookies in each box. How many cookies does she have?</td>
</tr>
<tr>
<td>3.</td>
<td>Ten boy scouts were going on a camping trip. Each of the scouts had flashlights and had to carry extra batteries. The scout leader gave them 40 batteries and wanted each scout to carry an equal amount. How many batteries does each boy have to carry?</td>
</tr>
<tr>
<td>4.</td>
<td>Bob’s mom is four times as old as Bob. She is 36 years old. How old is Bob?</td>
</tr>
<tr>
<td>5.</td>
<td>Anna has 36 inches of shelf space in her cupboard to store jelly jars. If each jar is three inches wide, how many jars can she store? If she has two 36 inch shelves, how many jars could she store?</td>
</tr>
<tr>
<td>6.</td>
<td>One day Grandpa said he could make soup from a stone. After Grandpa’s quick trip to the grocery store, the kids were ready to help make the soup. They filled a huge pot with water and Grandpa’s big magic stone. Now he needed 31 stalks of celery and 5 times as many carrots. How many carrots were used in the stone soup? He also needed potatoes. The kids cut 72 slices of potato. If each potato was cut into 8 slices, how many potatoes did they use?</td>
</tr>
</tbody>
</table>
Quiz 23

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sally and her friends have $40.00 to buy movie tickets. If each ticket costs $5.00, how many tickets can they buy?</td>
</tr>
<tr>
<td>2.</td>
<td>A rabbit can go two feet in one jump. A kangaroo can go five times as far as a rabbit. How far can a kangaroo go in one jump?</td>
</tr>
<tr>
<td>3.</td>
<td>Linda can solve three multiplication problems in one minute. Jim can solve multiplication problems four times as fast as Linda can. How many multiplication problems can Peter solve in one minute?</td>
</tr>
<tr>
<td>4.</td>
<td>Carlo took 33 minutes to spray paint 3 chairs. He worked on each chair the same number of minutes. How long did each chair take?</td>
</tr>
<tr>
<td>5.</td>
<td>Mary is saving money to go on a trip. This month she saved 3 times as much money as she saved last month. Last month she saved $25.00. How much did she save this month? How much money has she saved altogether?</td>
</tr>
<tr>
<td>6.</td>
<td>The bakery can make 15 apple pies and 8 blueberry pies every hour. How many apple pies can the bakery produce in 16 hours? How many blueberry pies can the bakery produce in 16 hours?</td>
</tr>
</tbody>
</table>
Quiz 25

Solve as many problems as you can. Use extra paper to show your work.

| 1. Sally sold 12 subscriptions to magazines. Her friend Jane sold 3 times as many subscriptions. How many subscriptions did Jane sell? |
| 2. Matt picks 16 oranges. He puts 4 in each box. How many boxes does he need? |
| 3. There are nine bananas in a basket of fruit. Three boys divide the bananas equally. How many bananas does each boy receive? |
| 4. Katie spends 20 cents on erasers. She spends 3 times that amount on pencils. How much money does Katie spend on pencils? |
| 5. Alex’s basketball team washed cars to raise money for new equipment. They charges $5.00 for each car that they washed. On the first day they washed 24 cars and on the second day they washed 35 cars. How much money did they make on the first day? How much money did they make on the second day? |
| 6. Alexandra has 10 All Star Baseball cards. Her friend, Barbara has 3 times as many. Their cousin, Ellie has half as many as Barbara has. How many All Star Baseball Cards does Barbara have? How many All Star Baseball cards does Ellie have? |
Name_______________________ Date:_____________________

Quiz 26

Solve as many problems as you can. Use extra paper to show your work.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>There are 48 colorful Easter Egg Stickers to decorate 6 bulletin boards. If each bulletin board gets the same number of Easter Egg Stickers, how many will each bulletin board have?</td>
</tr>
<tr>
<td>2.</td>
<td>The coach of a tennis team needed to replace 40 tennis balls with new ones. New tennis balls cost $2.98 each. How much will it cost to replace all 40 tennis balls?</td>
</tr>
<tr>
<td>3.</td>
<td>Bert and Sophie walk to school. Sophie walks two times as far as Bert. Bert walks 4 blocks. How far does Sophie walk?</td>
</tr>
<tr>
<td>4.</td>
<td>There were 15 soccer balls that sold in the local sports store. This was three times as many as the tennis balls that sold. How many tennis balls were sold?</td>
</tr>
<tr>
<td>5.</td>
<td>On Monday morning, 6 eggs hatched. By the evening 9 times as many eggs hatched. This was 2 times the amount of eggs that were hatched on Tuesday. What is the total number of eggs hatched on Monday? What was the total amount of eggs hatched on Tuesday?</td>
</tr>
<tr>
<td>6.</td>
<td>A store had a sale on toasters and coffee makers. It sold 53 toasters for $30.00 each. The store also sold 18 coffee makers for $20.00 each. How much money did the store make on the sale of toasters? How much did the store make on the sale of coffee makers?</td>
</tr>
</tbody>
</table>
Name_______________________ Date:_____________________

Quiz 28

Solve as many problems as you can. Use extra paper to show your work.

<table>
<thead>
<tr>
<th>1. Shelley picked 3 times as many boxes of strawberries as Max. Shelley picked 36 boxes. How many boxes did Max pick?</th>
<th>2. The bookstore sells school sweatshirts for $10.00 each. How much does it cost to buy 10 sweatshirts?</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Eric won 16 ribbons at the fair last week. This was 4 times as great as the number that Laura won. How many ribbons did Laura win?</td>
<td>4. Veronica’s mom bought 4 books of stamps. Each book contains 20 stamps. How many stamps did she purchase in all?</td>
</tr>
<tr>
<td>5. Juan has 2 times as many books as Antonio. Antonio has 3 times as many books as Jose has. Jose has 3 books. How many books does Antonio have? How many books does Juan have?</td>
<td>6. Each row of petunias has 18 flowers. Each row of tulips has 15 flowers. Four rows are planted of each type of flower. How many petunias are planted? How many tulips are planted?</td>
</tr>
</tbody>
</table>
Quiz 29

Solve as many problems as you can. Use extra paper to show your work.

1. There are 4 times more pears than oranges left after lunchtime each day in the school cafeteria. If there are 28 pears, how many oranges are left?

2. If Andy reads two pages per minute how many pages will he read in 5 minutes?

3. Paula walks at a rate of 4 miles per hour. If she continues at this rate how far will she walk in five hours?

4. Amanda found 15 shells on the beach today. She found 3 times as many seashells as pieces of sea glass. How many pieces of sea glass did she find?

5. A family ordered 1 large pizza and two medium pizzas. The medium pizzas were cut into 6 slices each and the large pizza was cut into 8 slices. How many slices did the family get from the medium pizzas? How many slices did they get from the large pizza?

6. This year, Randy’s garden has 3 rows of carrots with 3 plants in each row. Next year, he plans to plant 4 times as many rows. How many carrot plants will he have this year? How many carrot plants will he have next year?
Quiz 31

Solve as many problems as you can. Use extra paper to show your work.

<table>
<thead>
<tr>
<th>1. Ellen has two ribbons. One ribbon is 8 inches long. The other ribbon is 4 times as long. How long is the longer ribbon?</th>
<th>2. In the science lab, Mr. Jensen has a class of 30 students and five tables. If he divides the students equally so that they may be seated at the tables, how many students will sit at each table?</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Allie has thirty shells and three buckets. If she divides the shells evenly into the three buckets, how many shells will she put in each bucket?</td>
<td>4. A ranch has 2 times as many sheep as dairy cows. If the ranch has 32 dairy cows, how many sheep are on the ranch?</td>
</tr>
<tr>
<td>5. A school will send 10 busloads of students to a field hockey match. Each bus can hold 50 students. How many students can travel to the match? Another school will send 8 buses to the match. How many students will this school send?</td>
<td>6. Tina is twice as old as her cousin, Sally. Tina’s brother, Bill is twice as old as Tina. Tina is 10 years old. How old is Sally? How old is Bill?</td>
</tr>
</tbody>
</table>
Quiz 32

Solve as many problems as you can. Use extra paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Children should get at least 9 hours of sleep each night. At this rate, what is the least number of hours of sleep a child should get each week?</td>
</tr>
<tr>
<td>2.</td>
<td>Jenna spends $8.00 on lunch. Her new pair of jeans cost 3 times that much. How much did she spend for jeans?</td>
</tr>
<tr>
<td>3.</td>
<td>Sean has 28 sports cards. Billy has twice that many cards. How many cards does Billy have?</td>
</tr>
<tr>
<td>4.</td>
<td>A plumber charges $35.00 an hour for repair work. At this rate, how much would a repair cost if the job takes 3 hours?</td>
</tr>
<tr>
<td>5.</td>
<td>Tommy sees 4 different groups of ducks at the pond on Saturday. There are 12 ducks in each group. On Sunday, there are 3 groups of ducks with 9 in each group. How many ducks did he see on Saturday? How many ducks did he see on Sunday?</td>
</tr>
<tr>
<td>6.</td>
<td>Hot dogs are sold in packages of 10. Hot dog rolls are sold in packages of 12. Scott bought 9 packages of hot dogs for a family reunion. How many hot dogs did he buy? He also bought 8 packages of hot dog rolls. How many packages of hot dog rolls did he buy?</td>
</tr>
</tbody>
</table>
**Quiz 34**

Solve as many problems as you can. Use extra paper to show your work.

| 1. | Arthur reads every day. On weekdays he reads 30 minutes a day. How long does he read in 5 weekdays? |
| 2. | Mario needs 3 times as many onions as peppers for his stew. If he needs 8 peppers, how many onions does he need? |
| 3. | Paul needs to buy boxes of juice. Boxes of juice come in packages of 6. There are 48 people to serve. How many boxes must Paul purchase so that each person has one box of juice? |
| 4. | Kyle has 15 model cars. His friend Zach has 3 times as many model cars. How many cars does Zach have? |
| 5. | A guitar has 6 strings. A violin has 4 strings. In Tim’s music school there are 3 guitars and 4 violins. How many strings are on the guitars? How many strings are on the violins? |
| 6. | Frank sold 4 scented candles and 9 unscented candles. The scented candles cost $12.00 each and the unscented candles cost $10.00 each. How much money did Frank collect for the scented candles? How much money did Frank collect for the unscented candles? |
### Quiz 35

Solve as many problems as you can. Use extra paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> In softball, a runner touches 4 bases each time she scores. How many bases does a runner touch if she scores 5 runs?</td>
<td><strong>2.</strong> Alex is twice as old as Karen is. Karen is 7 years old. How old is Alex?</td>
</tr>
<tr>
<td><strong>3.</strong> A bathtub can hold 50 gallons of water. How many gallons of water will 6 bathtubs hold?</td>
<td><strong>4.</strong> Franklin has 16 football cards and 5 times as many baseball cards. How many baseball cards does Franklin have?</td>
</tr>
<tr>
<td><strong>5.</strong> Leon has 3 packages of erasers. Florence has 4 packages of erasers. Each package has 6 erasers. How many erasers does Leon have? How many erasers does Florence have?</td>
<td><strong>6.</strong> There are 16 people at a party where pizza will be served. Each pizza can be cut into 8 equal pieces. How many pizzas will be needed if each person eats one piece of pizza? How many pizzas would be needed if each person ate two pieces of pizza?</td>
</tr>
</tbody>
</table>
Name_______________________ Date:_____________________

Quiz 37

Solve as many problems as you can. Use extra paper to show your work.

<table>
<thead>
<tr>
<th>1. Max needs to water each of his pepper plants with 2 cups of water. How many cups will he need to water 5 pepper plants?</th>
<th>2. Ed has 16 eggs that he needs to divide equally into 4 baskets. How many eggs did he put in to each basket?</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. The supply store gives 4 pencils for each notebook that you buy. Mia buys 8 notebooks. How many free pencils does Mia receive?</td>
<td>4. Paula has 18 dolls in her collection. She has 3 times as many dolls as stuffed animals. How many stuffed animals does she have?</td>
</tr>
</tbody>
</table>
1. Bill’s father bought a total of 49 nuts at the hardware supply store. He bought twice as many washers as nuts. How many washers did he buy?

2. Tessa’s online photo album holds 50 pictures. She has 6 albums. How many pictures does she have in all?

3. When making 1 meatloaf Robert uses 12 ounces of breadcrumbs. His mother uses the same recipe to make 4 meatloaves to serve at a party. How many ounces does his mother use?

4. Ricky is making sandwiches for a banquet. Each package of cheese has 8 slices. He uses 6 packages. How many slices of cheese did he use in all?

5. Sue’s mom made cereal bars for Sue’s class. She arranged them in 3 rows of 7. How many bars did she make? Dianne’s mom made two times that amount of brownies. How many brownies did Dianne’s mom make?

6. Each boy has 5 balloons and each girl has 3 balloons. If there are 3 boys how many balloons do the boys have? If there are 9 girls, how many balloons do the girls have?
Quiz 40

Solve as many problems as you can. Use extra paper to show your work.

1. Corinne drank five sodas at the party on Saturday. Her cousin Brian drank twice as many. How many sodas did Brian drink?

2. There were 60 people at a hotel. Then three times that number checked in. How many people are in the hotel now?

3. It takes 5 gallons of paint to paint each room at the school. There are 9 rooms to be painted. How many gallons of paint will be needed to paint 9 rooms?

4. A Stegosaurus was 5 times as long as a Velociraptor. If a Velociraptor was 6 feet long, how long was the Stegosaurus?

5. Sally buys 3 books for $5.00 each ad 2 newspapers for $2.50 each. How much does Sally spend?

6. Lee made 3 birdhouses each day. How many birdhouses did Lee make in 4 days? His friend Sam made 2 times as many as Lee did during the same 4 days. How many did Sam make?
<table>
<thead>
<tr>
<th>Problem</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>An orchard has 3 times as many apple trees as cherry trees. If there are 52 cherry trees, how many apple trees are there?</td>
</tr>
<tr>
<td>2.</td>
<td>Allie is baking muffins for students in her class. There are 6 muffins in each baking tray. She bakes 4 trays of muffins. How many muffins does she bake in all?</td>
</tr>
<tr>
<td>3.</td>
<td>Bill wants to buy 4 paintbrushes. Each brush will cost $6.00. How much will he need to pay?</td>
</tr>
<tr>
<td>4.</td>
<td>Mrs. Long made some cookies. She put the cookies on 3 plates. Each plate had 5 cookies on it. How many cookies did she make in all?</td>
</tr>
<tr>
<td>5.</td>
<td>Robert has twice as many white socks as brown socks. If he has 10 brown socks, how many white socks does he have? He has three times as many blue socks as white socks. How many blue socks does he have?</td>
</tr>
<tr>
<td>6.</td>
<td>Sandy has 7 chairs in her kitchen. How many chair legs are in her kitchen? She buys 3 new chairs. Now how many chair legs are in her kitchen?</td>
</tr>
</tbody>
</table>
Quiz 43

Solve as many problems as you can. Use extra paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> Sam picked 4 times as many boxes of oranges as Bill. Bill picked 3 boxes. How many boxes did Sam pick?</td>
<td><strong>2.</strong> The school supply store sells packages of black and white composition books for $3.00 each. How much does it cost to buy 9 packages?</td>
</tr>
<tr>
<td><strong>3.</strong> Derrick won 12 races at the track meet last week. This was 4 times as great as the number that Bob won. How many races did Bob win?</td>
<td><strong>4.</strong> Jimmy’s mom bought 5 books of stamps. Each book contains 10 stamps. How many stamps did she purchase in all?</td>
</tr>
<tr>
<td><strong>5.</strong> James has 3 times as many books as Allen has. Allen has 2 times as many books as Jill has. Jill has 3 books. How many books does Allen have? How many books does James have?</td>
<td><strong>6.</strong> Each row of carrots has 18 plants. Each row of onions has 15 plants. Four rows are planted of each type of vegetable. How many carrot plants are planted? How many onion plants are planted?</td>
</tr>
</tbody>
</table>
Appendix L

Quizzes in Generalization Format
Quizzes in Generalization Format

Name_______________________ Date:_____________________

Quiz 3

Solve as many problems as you can. Use an extra sheet of paper to show your work

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Anna hikes 7 miles each day for 3 days. How many miles does she hike in all?</td>
<td>2. Dr. Smith wanted to calculate the area of a sample he was testing. The sample was shaped like a rectangle 7 centimeters long and 5 centimeters wide. What was its area?</td>
</tr>
<tr>
<td>3. Joe makes $12.00 for each lawn that he mows. He mowed 8 lawns. How much does he make altogether?</td>
<td>4. Jan plans to paint one wall of her bedroom blue. The wall measures 12 feet by 8 feet. How many square feet does Jan have to paint?</td>
</tr>
<tr>
<td>5. Sandy is 35 inches tall. Her brother, Bill is 70 inches tall. How many times taller is Bill than Sandy?</td>
<td>6. Anna wants to cover a 4 foot by 6 foot long area in her yard with mulch. How many square feet of mulch should she buy?</td>
</tr>
<tr>
<td>7. A total of 6 buses carrying 50 students each arrived at Lawnwood Elementary School on Tuesday. How many students came to school on Tuesday? On Wednesday, each of the 6 buses had 40 students aboard. How many students came to school on Wednesday?</td>
<td>8. Mr. Smith is putting tile down in his kitchen. The kitchen is 16 feet long and 8 feet wide. The tile costs $5.00 per square foot. How much will it cost to tile his kitchen?</td>
</tr>
</tbody>
</table>
Quiz 6

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>This morning a total of 8 buses brought students to Bessey Creek Elementary School. If each bus holds a total of 60 students how many students came to Bessey Creek this morning?</td>
</tr>
<tr>
<td>2.</td>
<td>A playground has an area of 400 square feet. If the playground has a length of 80 feet, how wide is it?</td>
</tr>
<tr>
<td>3.</td>
<td>Lydia read 35 pages of her book on Saturday. This was five times the number of pages she read on Friday. How many pages did Lydia read on Friday?</td>
</tr>
<tr>
<td>4.</td>
<td>Jane’s garden is 4 feet wide and has an area of 28 square feet. What is the length of the garden?</td>
</tr>
<tr>
<td>5.</td>
<td>Charles wants to plant 35 flowers in 5 flower beds. He decides to plant the same number in each flower bed. How many does he plant in each one?</td>
</tr>
<tr>
<td>6.</td>
<td>Sam measured a slice of bread from his sandwich. It was five inches long and 4 inches wide. What is the area of his slice of bread?</td>
</tr>
<tr>
<td>7.</td>
<td>Nora is twice as old as her brother, Derrick. Their cousin, Thomas is 3 times as old as Nora. Derrick is 3 years old. How old is Nora? How old is Thomas?</td>
</tr>
<tr>
<td>8.</td>
<td>The stained glass window at the back of the library is in the shape of a rectangle. The width of the window is 3 feet and the height is 8 feet. The width of the window at the front of the library is two times as wide as the window at the back. What is the area of the window at the back of the library? What is the width of the window at the front of the library?</td>
</tr>
</tbody>
</table>
Name________________________________ Date:________________________________

Quiz 9

Directions: Solve as many problems as you can. Use the extra paper provided for you to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The cheetah is the world’s fastest land animal. A cheetah can run about 100 feet in one second. How far would the cheetah run in 20 seconds?</td>
<td>2. A playground is 9 feet long and 6 feet wide. What is the area of the playground?</td>
</tr>
<tr>
<td>3. Grandma Taber was making big gingerbread boy cookies. She used 9 cups of sugar and 7 times as many cups of flour. How many cups of flour did she use to make the gingerbread cookies?</td>
<td>4. Billy wants to put outdoor carpeting on the floor of his tree house. If the length of the floor is 6 feet and the width is 5 feet, how many square feet of carpeting will he need?</td>
</tr>
<tr>
<td>5. Devon spends $18.75 to buy three used CDs. Each CD costs the same amount. How much does each CD cost?</td>
<td>6. New flooring is being installed in the school foyer. The area is 15 feet long by 30 feet long. How many square yards of flooring are needed?</td>
</tr>
<tr>
<td>7. Manuel has a collection of nickels, dimes, and quarters. He has 8 nickels and 3 times as many dimes. He also has twice as many quarters as nickels. How many dimes does he have? How many quarters does he have?</td>
<td>8. What is the area of this figure?</td>
</tr>
</tbody>
</table>

```
[Diagram: 20 ft. x 12 ft.]
[Diagram: 6 ft. x 12 ft.]
```
## Quiz 12

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ellen wants to buy 5 shirts. After tax, each shirt will cost $12.00. How much will she need to pay?</td>
<td>2. Pam bought a poster to hang in her room. The area of the poster was 6 square feet. Her sister bought a poster that was two times the area of Pam’s poster. What was the area of her sister’s poster?</td>
</tr>
<tr>
<td>3. Megan spent 36 hours volunteering at a community center last summer. This is 3 times the number of hours that Becky spent volunteering. How many hours did Becky spend volunteering?</td>
<td>4. John needs to paint a chalkboard that measures 8 feet by 6 feet. How many square feet will John need to paint?</td>
</tr>
<tr>
<td>5. Dan sells a total of 32 candy bars to 8 neighbors. Each neighbor buys the same number of candy bars. How many candy bars does each neighbor buy?</td>
<td>6. Bobbie measured the outside edges of a tic tac toe game. If each side measured 9 inches then what was the area of the game?</td>
</tr>
<tr>
<td>7. Eric and Lisa ride their bikes at a rate of 12 miles per hour. If they each ride for three hours at this pace, how far will they both travel? What if they rode for two hours? How far could they travel then?</td>
<td>8. Mr. Taber grows cucumbers and tomatoes in his garden. The area for the cucumbers is two times the area for the tomatoes. The section for the tomatoes is 6 feet long by 4 feet wide. What is the area for the cucumbers?</td>
</tr>
</tbody>
</table>
Quiz 15

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<table>
<thead>
<tr>
<th>1. There are 16 fifth grade players on Jamie's soccer team. If there are twice as many fifth graders as sixth graders how many sixth graders are on the team?</th>
<th>2. Harry is cutting a rectangle that is 4 inches long by 3 inches wide. What is the area of the rectangle?</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. One seal weighs 22 pounds. Another seal weighs three times as much. How much does the other seal weigh?</td>
<td>4. Mrs. Smith wants new carpeting for her living room. Her living room is 5 yards by 10 yards. How much carpeting in square yards does she need to buy to cover her entire living room?</td>
</tr>
<tr>
<td>5. Mrs. Smith buys 848 purple and orange pencils because they are on sale. How many pencils will each of her 8 employees receive?</td>
<td>6. Thomas is making a display board for the elections. The display board is a 10 foot by 6 foot area. How much paper will she need to cover the entire bulletin board?</td>
</tr>
<tr>
<td>7. Kendra has 18 beads. She wants to make 3 bracelets, each with the same number of beads. How many beads will be on each bracelet? Kendra decides she wants to put 9 beads on each bracelet. How many bracelets can she make?</td>
<td>8. Tiffany is making two display boards for the school elections. The first display board is 5 feet long by 3 feet high. The second display board has twice the area of the first board. What is the area of each of the boards?</td>
</tr>
<tr>
<td>1.</td>
<td>A small cruise ship leaving from the Port of Miami can transport 240 passengers. If 8 people can be seated at each table in the dining room, and each table is filled, how many tables are there?</td>
</tr>
<tr>
<td>2.</td>
<td>A rectangular park measures 12 feet by 10 feet. What is its area?</td>
</tr>
<tr>
<td>3.</td>
<td>There are four times as many basketballs as soccer balls in the school gym. If there are 5 soccer balls, how many basketballs are there?</td>
</tr>
<tr>
<td>4.</td>
<td>Jack has a rectangular herb garden that is 6 feet long and 11 feet wide. What is the area of the garden?</td>
</tr>
<tr>
<td>5.</td>
<td>Bob has a goal of reading 42 books over the next 7 weeks. How many books will he have to read on average each week in order to make his goal?</td>
</tr>
<tr>
<td>6.</td>
<td>Terry painted a rectangle in art class. The rectangle’s width is exactly three times its length. The width is 15 inches. What is the length of the rectangle?</td>
</tr>
<tr>
<td>7.</td>
<td>During his last typing test, James was able to correctly type 38 words per minute. The length of the test was five minutes. How many words did James type in five minutes? How many words could James type in 10 minutes?</td>
</tr>
<tr>
<td>8.</td>
<td>Betty wants new carpeting for her bedroom. Her bedroom is a 9 meter by 7 meter rectangle. If carpeting costs $2.00 per square meter, how much will it cost to lay carpet for her entire bedroom?</td>
</tr>
</tbody>
</table>
Quiz 21

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ed has 14 eggs. He puts an equal amount of eggs in two baskets. How many eggs are in each basket?</td>
</tr>
<tr>
<td>2.</td>
<td>The area of a rectangular field is 20 meters squared. If the width of the field is 10 meters. What is the length of the field?</td>
</tr>
<tr>
<td>3.</td>
<td>Luis counted all of the wheels on the 8 bicycles in the bike rack in the park. How many wheels did he count?</td>
</tr>
<tr>
<td>4.</td>
<td>Sam has a rectangular garden that has an area of 80 square meters. One bag of fertilizer can cover 10 meters squared. How many bags will he need to cover the entire garden?</td>
</tr>
<tr>
<td>5.</td>
<td>Lauren’s piece of wire in 5 times as long as Larry’s wire. Lauren’s wire is 8 cm long. How long is Larry’s wire?</td>
</tr>
<tr>
<td>6.</td>
<td>The school’s playground is a rectangle with an area of 4,000 square yards. The length of the playground is 80 yards. What is the width?</td>
</tr>
<tr>
<td>7.</td>
<td>Sally is baking cookies and can fit 24 cookies in her oven at a time. The cookies take ten minutes to bake. How many cookies can Sally bake in 40 minutes? How many cookies can she bake in 60 minutes?</td>
</tr>
<tr>
<td>8.</td>
<td>Jesse has a rectangular flower garden that is 7 feet long and 9 feet wide. One bag of soil can cover 21 square feet. How many bags will he need to cover the entire garden?</td>
</tr>
</tbody>
</table>
Quiz 24

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sean divides $54.00 equally among six people. How much money did each person get?</td>
<td>2. Chrissy has a picture on her wall that measures 8 inches by 10 inches. What is the area in square inches of the picture?</td>
</tr>
<tr>
<td>3. Phil scored 180 points on his video game. Two weeks later, Phil’s score was 20 times as great. What was his later score?</td>
<td>4. A playground has an area of 100 square feet. Each bottle of fertilizer will cover 25 square feet. How many bottles of fertilizer is needed to fertilize the playground?</td>
</tr>
<tr>
<td>5. Oranges cost $3.00 a dozen. How much would 3 oranges cost?</td>
<td>6. Mark and his brother have bedrooms that are next to each other. The area of Mark’s bedroom is twice that of his brother’s bedroom. If the area of Mark’s bedroom is 48 square feet, what is the area of his brother’s bedroom?</td>
</tr>
<tr>
<td>7. Tommy is 6 years old. His Aunt Eleanor is 4 times as old. How old is his Aunt Eleanor? How old would she be if she were five times his age?</td>
<td>8. Wendy is making a bulletin board for the school talent show. The display board is a 6 meter by 3 meter rectangle. The material to cover the board costs $3.00 per square meter. How much will it cost to cover the entire board?</td>
</tr>
</tbody>
</table>
**Quiz 27**

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Monday through Friday Mrs. Smith canned 85 jars of peaches. If she canned the same amount each day, how many jars did she can in 3 days?</td>
</tr>
<tr>
<td>2.</td>
<td>There are 12 times as many players as coaches. There are 9 coaches. How many players are there?</td>
</tr>
<tr>
<td>3.</td>
<td>A team of baseball players purchased bats and balls for a total cost of $270.00. If the 9 players shared the costs equally, how much was each player’s share?</td>
</tr>
<tr>
<td>4.</td>
<td>Ann has a garden that is 4 feet wide and has an area of 28 square feet. What is the length of the garden?</td>
</tr>
<tr>
<td>5.</td>
<td>Holly sold 8 magazines. Her friend sold 10 times as many magazines as Holly. How many magazines did Holly’s friend sell?</td>
</tr>
<tr>
<td>6.</td>
<td>Mrs. William’s flower garden is 8 feet wide and 6 feet long. What is the area of the garden?</td>
</tr>
<tr>
<td>7.</td>
<td>Gerry buys 2 video tapes. Each videotape costs $15.00. How much does he have to pay for the two videotapes? How much would he have to pay if he wanted to buy 4 videotapes?</td>
</tr>
<tr>
<td>8.</td>
<td>Marion is making a display board for the school talent show. The display board is a 10 foot by 9 foot rectangle. The material to cover the board costs $2.00 per square foot. How much will it cost to cover the whole board?</td>
</tr>
</tbody>
</table>
Name_______________________ Date:_____________________

Quiz 30

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<table>
<thead>
<tr>
<th>1. Taylor’s dad bought 3 times many nuts as washers at the hardware store. He bought 9 washers. How many nuts did he buy?</th>
<th>2. The area of a rectangle is 54 square yards, the length is 9 yards. What is the width?</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 times</td>
<td>9 yards</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Ned runs 45 km each week. How many km does he run in 50 weeks?</th>
<th>4. The distance around a window in Peter’s house is 12 feet. Each side has the same length. What is the length of each side?</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 km</td>
<td>12 feet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Each box holds 8 decorations. How many boxes does it take to hold 48 decorations?</th>
<th>6. What is the area of the family room?</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 yards</td>
<td>4 yards</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Mrs. Kendall’s fish tank contains 3 types of fish. There are 3 times as many goldfish as koi. There are twice as many guppies as goldfish. There are 12 goldfish. How many are koi and how many are guppies?</th>
<th>8. Sally wants to plant ivy in her back yard, which is 24 feet by 6 feet. If each square foot of ivy will cost $2.00, how much will it cost to plant enough ivy to cover the yard?</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 goldfish</td>
<td>24 feet</td>
</tr>
</tbody>
</table>
Quiz 33

Solve as many problems as you can. Use extra paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cecilia is burning a new CD for a friend. The CD can record 60 minutes. How many 3 minute songs can Cecilia burn onto the CD?</td>
</tr>
<tr>
<td>2.</td>
<td>Sam wants to put indoor carpeting on the floor of his sunroom. If the length of the floor is 5 feet and the width is 7 feet, how many square feet of carpet will he need?</td>
</tr>
<tr>
<td>3.</td>
<td>A dodgeball team has 7 players. In Juan’s school, 63 students want to form a dodgeball league. How many teams can there be in the league?</td>
</tr>
<tr>
<td>4.</td>
<td>Allison has a garden that is 5 feet wide and 6 feet long. What is the area of her garden?</td>
</tr>
<tr>
<td>5.</td>
<td>Jerry works at a gas station and earns $9.00 per hour. How much does he earn if he works for 3 hours?</td>
</tr>
<tr>
<td>6.</td>
<td>Marion bought a poster to hang in her room. The length was 4 feet and the width was 3 feet. What was the area of the poster?</td>
</tr>
<tr>
<td>7.</td>
<td>The Fairlawn Golf Club has been getting ready to open 5 new golf courses this spring. There are 36 holes on each course. If 9 holes make one round of golf, how many rounds could Mr. Allison play on one course? How many rounds could he play if he played on all 5 courses?</td>
</tr>
<tr>
<td>8.</td>
<td>Sam wants to paint a room that is 8 feet long and 6 feet wide. How many square feet will Sam need to paint? If one gallon will cover 24 square feet, how many gallons will Sam need?</td>
</tr>
</tbody>
</table>
Name_______________________ Date:_____________________

Quiz 36

Solve as many problems as you can. Use extra paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mr. Senko purchased 15 staplers for the school. Each stapler cost $5.00. What was the total cost of the staplers?</td>
</tr>
<tr>
<td>2.</td>
<td>Tim’s tree house is shaped like a rectangle. Tim knows that the front of the tree house is twice the length of the side of the tree house. If the side of the tree house is 6 feet wide, how long is the front of the tree house?</td>
</tr>
<tr>
<td>3.</td>
<td>If one playground ball sells for $8.00, what is the total cost of 8 playground balls?</td>
</tr>
<tr>
<td>4.</td>
<td>Amy plans to paint one wall of her bedroom pink. The wall measures 8 feet by 11 feet. How many square feet does Amy have to paint?</td>
</tr>
<tr>
<td>5.</td>
<td>Hank read 3 times as many pages on Wednesday as on Tuesday. He read 15 pages on Wednesday. How many pages did he read on Tuesday?</td>
</tr>
<tr>
<td>6.</td>
<td>Mr. Rollins grows sunflowers and daisies in his garden. The area for the sunflowers is 3 times the area for the daisies. The area for the sunflowers is 9 square feet. How much is the area for the daisies?</td>
</tr>
<tr>
<td>7.</td>
<td>There are 9 boxes of 4 red pens and 2 boxes of 8 blue pens. How many red pens are there? How many blue pens are there?</td>
</tr>
<tr>
<td>8.</td>
<td>Jack wants to paint a room that is 7 feet long by 6 feet wide. What is the area of the room Jack wants to paint? If one gallon of paint will cover 21 square feet, how many gallons will Jack need?</td>
</tr>
</tbody>
</table>
1. 42 children are spending a week at camp. There are 7 cabins at the camp. An equal number of campers will sleep in each cabin. How many campers will sleep in each cabin?

2. The table in the dining room has a length of 7 feet and a width of 5 feet. What is its area?

3. Ridgewood Middle School uses buses to take fifth graders on a field trip. One bus holds 40 students. How many buses will be needed to take 320 fifth graders on a field trip?

4. A rectangular park measures 32 feet by 20 feet. What is its area?

5. Tammy wants to make a bracelet for 9 of her friends. It takes 12 beads to make a bracelet. How many beads does Tammy need?

6. Kathy’s bedroom is 11 feet wide and 10 feet long. What is its area in square feet?

7. Mrs. Brown bought snack bars, candy bars, and drinks to sell at the soccer games. She bought 3 times as many snack bars as candy bars. She bought 2 times as many drinks as candy bars. She bought 30 candy bars. How many snack bars did she buy? How many drinks did she buy?

8. Kelly bought a poster to hang in her room. The length was 3 feet and the width was 4 feet. What was the area of the poster? Her sister bought a poster that was 3 times the area of Kelly’s poster. What was the area of her sister’s poster?
## Quiz 42

Solve as many problems as you can. Use extra paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> Niki is a baby and is 21 inches tall. Her father Miles is 3 times as tall as Niki. How tall is Miles?</td>
<td><strong>2.</strong> Miguel’s backyard is 28 feet long and 30 feet long. What is the area of the backyard?</td>
</tr>
<tr>
<td><strong>3.</strong> A snack package has 4 cheese sticks. How many cheese sticks are in 5 packages?</td>
<td><strong>4.</strong> Mrs. William’s flower garden is 8 feet wide and 6 feet long. What is the area of the garden?</td>
</tr>
<tr>
<td><strong>5.</strong> A school bookstore sells sweatshirts for $9.00 each. How much would it cost to buy 6 sweatshirts?</td>
<td><strong>6.</strong> Cheryl wants to cover a 3 foot wide by 5 feet long area of her yard with mulch. How many square feet of mulch should she buy?</td>
</tr>
<tr>
<td><strong>7.</strong> It takes Bill 4 minutes to paint one section of a fence. The fence is five sections long. How long will it take Bill to paint it? Another fence is 8 sections long. How long will it take to paint it?</td>
<td><strong>8.</strong> Mrs. Brown is putting tile down in her living room. The living room is 20 feet long and 9 feet wide. The tile costs $6.00 per square foot. How much will it cost to tile her living room?</td>
</tr>
</tbody>
</table>
Appendix M

Schematic Diagram Sheet: Training
Schematic Diagram Sheet: Training

Circle the correct problem type and represent the problem on the diagram.

<table>
<thead>
<tr>
<th></th>
<th>Problem Type</th>
<th>Diagram</th>
<th>Problem Type</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>restate</td>
<td><img src="image1" alt="Diagram" /></td>
<td>Vary</td>
<td><img src="image2" alt="Diagram" /></td>
</tr>
<tr>
<td>2.</td>
<td>Restate</td>
<td><img src="image3" alt="Diagram" /></td>
<td>Vary</td>
<td><img src="image4" alt="Diagram" /></td>
</tr>
<tr>
<td>3.</td>
<td>Restate</td>
<td><img src="image5" alt="Diagram" /></td>
<td>Vary</td>
<td><img src="image6" alt="Diagram" /></td>
</tr>
<tr>
<td>4.</td>
<td>Restate</td>
<td><img src="image7" alt="Diagram" /></td>
<td>Vary</td>
<td><img src="image8" alt="Diagram" /></td>
</tr>
<tr>
<td>5.</td>
<td>Restate</td>
<td><img src="image9" alt="Diagram" /></td>
<td>Vary</td>
<td><img src="image10" alt="Diagram" /></td>
</tr>
<tr>
<td></td>
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<tr>
<td>-------</td>
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<tr>
<td>6. Restate</td>
<td>Vary</td>
<td>6. Restate</td>
<td>Vary</td>
<td></td>
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<tr>
<td>Problem</td>
<td>Vary</td>
<td>Vary</td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>1. restate</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Restate</td>
<td>✔</td>
<td>✔</td>
<td></td>
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<tr>
<td>3. Restate</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Restate</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Restate: 4 > bases, 5 > runs. 40 > runs. 40 ÷ 5 = 8. 8 x 5 = 40.

2. Restate: 7 > years, 14 > years. 14 ÷ 2 = 7. 7 x 7 = 49.

3. Restate: 50 > balls, 6 > balls. 50 ÷ 6 = 8.33. 8.33 x 6 = 50.

4. Restate: 16 > cards, 16 > cards. 16 ÷ 5 = 3.2. 3.2 x 5 = 16.
Appendix N

Schematic Diagram Sheet: Generalization
Circle the correct problem type and represent the problem on the diagram.

<table>
<thead>
<tr>
<th></th>
<th>Restate</th>
<th>Vary</th>
<th>Restate</th>
<th>Vary</th>
<th>Restate</th>
<th>Vary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image1" alt="Restate Diagram" /></td>
<td><img src="image2" alt="Vary Diagram" /></td>
<td><img src="image3" alt="Restate Diagram" /></td>
<td><img src="image4" alt="Vary Diagram" /></td>
<td><img src="image5" alt="Restate Diagram" /></td>
<td><img src="image6" alt="Vary Diagram" /></td>
</tr>
<tr>
<td>2</td>
<td><img src="image7" alt="Restate Diagram" /></td>
<td><img src="image8" alt="Vary Diagram" /></td>
<td><img src="image9" alt="Restate Diagram" /></td>
<td><img src="image10" alt="Vary Diagram" /></td>
<td><img src="image11" alt="Restate Diagram" /></td>
<td><img src="image12" alt="Vary Diagram" /></td>
</tr>
<tr>
<td>3</td>
<td><img src="image13" alt="Restate Diagram" /></td>
<td><img src="image14" alt="Vary Diagram" /></td>
<td><img src="image15" alt="Restate Diagram" /></td>
<td><img src="image16" alt="Vary Diagram" /></td>
<td><img src="image17" alt="Restate Diagram" /></td>
<td><img src="image18" alt="Vary Diagram" /></td>
</tr>
<tr>
<td>4</td>
<td><img src="image19" alt="Restate Diagram" /></td>
<td><img src="image20" alt="Vary Diagram" /></td>
<td><img src="image21" alt="Restate Diagram" /></td>
<td><img src="image22" alt="Vary Diagram" /></td>
<td><img src="image23" alt="Restate Diagram" /></td>
<td><img src="image24" alt="Vary Diagram" /></td>
</tr>
<tr>
<td>5</td>
<td><img src="image25" alt="Restate Diagram" /></td>
<td><img src="image26" alt="Vary Diagram" /></td>
<td><img src="image27" alt="Restate Diagram" /></td>
<td><img src="image28" alt="Vary Diagram" /></td>
<td><img src="image29" alt="Restate Diagram" /></td>
<td><img src="image30" alt="Vary Diagram" /></td>
</tr>
<tr>
<td></td>
<td>Restate</td>
<td>Vary</td>
<td></td>
<td>Restate</td>
<td>Vary</td>
<td></td>
</tr>
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<td>---</td>
<td>---------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td></td>
<td><img src="image3" alt="Diagram" /></td>
<td><img src="image4" alt="Diagram" /></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><img src="image5" alt="Diagram" /></td>
<td><img src="image6" alt="Diagram" /></td>
<td></td>
<td><img src="image7" alt="Diagram" /></td>
<td><img src="image8" alt="Diagram" /></td>
<td></td>
</tr>
</tbody>
</table>
Circle the correct problem type and represent the problem on the diagram.

<table>
<thead>
<tr>
<th></th>
<th>Vary</th>
<th>2. Restate</th>
<th>Vary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. restate</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td>30 feet, 2 feet, long, tall</td>
</tr>
<tr>
<td>2. Restate</td>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
<td></td>
</tr>
<tr>
<td>3. Restate</td>
<td><img src="image5.png" alt="Diagram" /></td>
<td><img src="image6.png" alt="Diagram" /></td>
<td>54, 20, 20, 30 feet, 2 feet, long, tall</td>
</tr>
<tr>
<td>4. Restate</td>
<td><img src="image7.png" alt="Diagram" /></td>
<td><img src="image8.png" alt="Diagram" /></td>
<td></td>
</tr>
</tbody>
</table>
Appendix O

Observer Training Quizzes
Observer Training Quizzes

Name_______________________ Date:_____________________

Observer Training Quiz #1

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
|1. | The Scouts washed 8 cars one morning. They earned $5.00 for each car they washed. How much money did they earn?  
$5.00 x 8=$40.00  
Vary |
|2. | Scott read 15 books during the month of August. He read 3 times as many books as Rodney. How many books did Rodney read?  
15/3=5 books for Rodney  
Restate |
|3. | Suzie is driving her car at a rate of 50 miles per hour. How far will she drive in 3 hours?  
50 x 3=150 miles  
Vary |
|4. | Courtney won 12 ribbons at the fair last week. This was 2 times as great as the number that Kate won. How many ribbons did Kate win?  
Restate  
12/2=6 ribbons for Kate |
|5. | Michelle found 12 seashells on the beach today. She found twice as many seashells as sand dollars. How many sand dollars did she find? She also found 3 times as many pieces of sea glass as sand dollars. How many pieces of sea glass did she find?  
Step 1: 12/6=2 sand dollars; restate  
Step 2: 2 x3=6 sea glass; restate |
|6. | The Ice Cream Shop sold 30 ice cream cones over the last 3 days. How many did they sell each day on average? If the shop continued to sell ice cream cones at this rate, how many would they sell in the next 4 days?  
Step 1: 30/3= 10 ice cream cones; vary  
Step 2: 10 x 4= 40 ice cream cones; vary |
Observer Training Quiz #2

Solve as many problems as you can. Use extra paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>There are 8 apples in a basket. Two boys divide the apples equally. How many apples does each boy receive?</td>
</tr>
<tr>
<td></td>
<td>Vary</td>
</tr>
<tr>
<td></td>
<td>8/2=4 apples</td>
</tr>
<tr>
<td>2.</td>
<td>Sam picks a total of 12 oranges. He puts 3 in each box. How many boxes does he need?</td>
</tr>
<tr>
<td></td>
<td>Vary</td>
</tr>
<tr>
<td></td>
<td>12/3=4 boxes</td>
</tr>
<tr>
<td>3.</td>
<td>Amy’s recipe calls for twice as many cups of tomatoes as cups of peppers. She uses 2 cups of peppers. How many cups of tomatoes will she use?</td>
</tr>
<tr>
<td></td>
<td>Restate</td>
</tr>
<tr>
<td></td>
<td>2 x 2=4 cups of tomatoes</td>
</tr>
<tr>
<td>4.</td>
<td>There are 16 fifth grade players on Jamie’s soccer team. If there are twice as many fifth graders as sixth graders on the team, how many sixth graders are there?</td>
</tr>
<tr>
<td></td>
<td>Restate</td>
</tr>
<tr>
<td></td>
<td>16/2=8 sixth grade players</td>
</tr>
<tr>
<td>5.</td>
<td>Trish’s cat had a litter of 5 kittens. How many paws do the five kittens have? How many ears do the kittens have?</td>
</tr>
<tr>
<td></td>
<td>Step 1: 5 x 4=20 paws; vary</td>
</tr>
<tr>
<td></td>
<td>Step 2: 5 x 2=10 ears; vary</td>
</tr>
<tr>
<td>6.</td>
<td>Sally is 12 years old. Her dad is 4 times as old as she is. How old is her dad? Her mom is 3 times as old as Sally. How old is her mom?</td>
</tr>
<tr>
<td></td>
<td>Step 1: 12 x 4=48 years old (dad) restate</td>
</tr>
<tr>
<td></td>
<td>Step 2: 12 x 3=36 years old (mom) restate</td>
</tr>
</tbody>
</table>
Observer Training Quiz #3

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> A carrying case holds 8 CDs. How many cases would be needed to hold 24 CDs?</td>
<td><strong>2.</strong> There are 3 times more apples than bananas left after lunchtime each day in the school cafeteria. If there are 15 apples, how many bananas are left?</td>
</tr>
<tr>
<td>$24/8=3$ CD Cases; vary</td>
<td>$15/3=5$ bananas restate</td>
</tr>
<tr>
<td><strong>3.</strong> A poultry farmer bought 20 chicks at $0.50 each. How much did he pay for the chicks?</td>
<td><strong>4.</strong> Holly sold 6 magazines. Her friend sold 10 times as many magazines as Holly. How many magazines did Holly’s friend sell?</td>
</tr>
<tr>
<td>Vary</td>
<td>$6 \times 10=60$ magazines restate</td>
</tr>
<tr>
<td>$20 \times 0.50=10.00$</td>
<td></td>
</tr>
<tr>
<td><strong>5.</strong> Barney has 120 pumpkin seeds. This is 2 times as many pumpkin seeds as Sandy has. Tommy has 3 times as many pumpkin seeds as Sandy has. How many pumpkin seeds does Sandy have? How many seeds does Tommy have?</td>
<td><strong>6.</strong> Billy washes cars to earn money. If he washes one car he earns $4.00. How much will he earn if he washes 6 cars? How much will he earn if he washes 12 cars?</td>
</tr>
<tr>
<td>Step 1: $120/2=60$ pumpkin seeds (Sandy) Step 2: $60 \times 3=180$ pumpkin seeds (Tommy) Both steps restate</td>
<td>Step 1: $4.00 \times 6=24.00$ for 6 cars Step 2: $4.00 \times 12=48.00$ for 12 cars Both steps vary</td>
</tr>
</tbody>
</table>
Observer Training Observer Quiz # 4

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mr. White’s classroom has four tables with 7 students at each table. How many students are there altogether?</td>
<td>2.</td>
</tr>
<tr>
<td></td>
<td>7 x 4=28 students</td>
<td>9 x 3=27 ducks</td>
</tr>
<tr>
<td>3.</td>
<td>Allison has 5 buckets of seashells. If each bucket holds 9 shells, how many shells does Allison have?</td>
<td>4.</td>
</tr>
<tr>
<td></td>
<td>5 x 9=45 seashells</td>
<td>6 x 4=24 basketballs</td>
</tr>
<tr>
<td>5.</td>
<td>A store had some basketballs to sell at $20.00 each. This store also had 10 football helmets. Each helmet sells for twice as much as a basketball. If the store sells all of its helmets, how much money will the store make on the helmets?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Step 1: $20.00 x 2=$40.00 price of helmet: restate</td>
<td>6.</td>
</tr>
<tr>
<td></td>
<td>Step 2: $40.00 x 10=$400.00 for all helmets: vary</td>
<td>Step 1: 60 x 5= 300 points</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Step 2: 60 x 10= 600 points</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both steps vary</td>
</tr>
</tbody>
</table>
Observer Training Quiz # 5

Solve as many problems as you can. Use an extra sheet of paper to show your work.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A small cruise ship leaving from the Port of Miami can transport</td>
<td>240/6=40 tables</td>
</tr>
<tr>
<td>240 passengers. If 6 people can be seated at each table in the dining</td>
<td>vary</td>
</tr>
<tr>
<td>room, and each table is filled, how many tables are there?</td>
<td>vary</td>
</tr>
<tr>
<td>2. A rectangular park measures 12 feet by 10 feet. What is its area?</td>
<td>12 x 10= 120 square feet</td>
</tr>
<tr>
<td></td>
<td>vary</td>
</tr>
<tr>
<td>3. There are 4 times as many volleyballs as soccer balls in the school</td>
<td>5 x 4=20 volleyballs</td>
</tr>
<tr>
<td>gym. If there are 5 soccer balls, how many volleyballs are there?</td>
<td>vary</td>
</tr>
<tr>
<td>4. Jack has a rectangular herb garden that is 6 feet long and 11 feet</td>
<td>6 x 11=66 square feet</td>
</tr>
<tr>
<td>wide. What is the area of the garden?</td>
<td>vary</td>
</tr>
<tr>
<td>5. Terry painted a rectangle in art class. The rectangle’s width is</td>
<td>15 x 3= 45 length of rectangle</td>
</tr>
<tr>
<td>exactly three times its length. The width is 15 inches. What is the</td>
<td>restate</td>
</tr>
<tr>
<td>length of the rectangle?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. During his last typing test, James was able to correctly type 30 words per minute. The length of the test was five minutes. How many words did James type in five minutes? How many words could James type in 10 minutes?

Step 1: 30 \times 5 = 150 \text{ words in five minutes; vary}

Step 2: 30 \times 10 = 300 \text{ words in 10 minutes; vary}

8. Betty wants new carpeting for her bedroom. Her bedroom is a 9 meter by 7 meter rectangle. If carpeting costs $2.00 per square meter, how much will it cost to lay carpet for her entire bedroom?

Step 1: 9 \times 7 = 63 \text{ square meters; vary}

Step 2: 63 \times $2.00 = $126.00 \text{ cost for carpet; vary}
Observer Training Quiz #6
Solve as many problems as you can. Use an extra sheet of paper to show your work.

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<tr>
<td><strong>1.</strong> Sean divides $42.00 equally among six people. How much money did each person get?</td>
<td><strong>2.</strong> Chrissy has a picture on her wall that measures 8 inches by 10 inches. What is the area in square inches of the picture?</td>
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<tr>
<td>$42.00/6 = $7.00 per person</td>
<td>8 x 10 = 80 square inches</td>
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<td><strong>3.</strong> Phil scored 180 points on his video game. Two weeks later, Phil’s score was 2 times as great. What was his later score?</td>
<td><strong>4.</strong> A playground has an area of 100 square feet. Each bottle of fertilizer will cover 25 square feet. How many bottles of fertilizer are needed to fertilize the playground?</td>
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<td>180 x 2 = 360 points</td>
<td>100/25 = 4 bottles</td>
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<td><strong>5.</strong> Apples cost $4.00 a dozen. How much would 4 apples cost?</td>
<td><strong>6.</strong> Mark and his brother have bedrooms that are next to each other. The area of Mark’s bedroom is twice that of his brother’s bedroom. If the area of Mark’s bedroom is 48 square feet, what is the area of his brother’s bedroom?</td>
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<tr>
<td>$4.00/4 = $1.00 for 4 apples</td>
<td>48/2 = 24 square feet</td>
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<tr>
<td><strong>7.</strong> Tommy is 5 years old. His Aunt Eleanor is 4 times as old. How old is his Aunt Eleanor? How old would she be if she were five times his age?</td>
<td><strong>8.</strong> Wendy is making a bulletin board for the school talent show. The display board is a 6 meter by 3 meter rectangle. The material to cover the board costs $3.00 per square meter. How much</td>
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<tr>
<td>Step 1: $5 \times 4 = 20$ years old; restate</td>
<td>will it cost to cover the entire board?</td>
</tr>
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<tr>
<td>Step 2: $5 \times 5 = 25$ years old; restate</td>
<td>Step 1: $6 \times 3 = 18$ square meters</td>
</tr>
<tr>
<td></td>
<td>Step 2: $$3.00 \times 18 = $54.00$</td>
</tr>
<tr>
<td></td>
<td>Both steps vary</td>
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</table>
References


third grade students with math and reading difficulties. *Exceptional Children, 74,* 155–173.


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