The Effects of Simplified Schema-Based Instruction on Elementary Students' Mathematical Word Problem Solving Performance

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THE EFFECTS OF SIMPLIFIED SCHEMA-BASED INSTRUCTION ON ELEMENTARY STUDENTS’ MATHEMATICAL WORD PROBLEM SOLVING PERFORMANCE

by

Houbin Lewis Fang

Abstract of a Dissertation Submitted to the Graduate School of The University of Southern Mississippi in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

December 2011
ABSTRACT

THE EFFECTS OF SIMPLIFIED SCHEMA-BASED INSTRUCTION ON ELEMENTARY STUDENTS’ MATHEMATICAL WORD PROBLEM SOLVING PERFORMANCE

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This study is an evidence-based mathematical intervention in word problem solving for elementary students. One of the purposes of teaching mathematics is to help students apply mathematics to real life situations. As we know, teaching word problem solving is a very suitable format for this purpose. Schema-based instruction (SBI) is one of the most supported methods for teaching word problem solving. In the current literature, there are four steps in SBI: identifying the problem type, applying corresponding method, determining an operation, and solving the problem. The problem with the current SBI is that there are no agreed-upon definitions for word problem types. As a result, researchers categorize word problems into different categories. Further, it is a complicated cognitive process for elementary students to learn and identify the problem types.

Therefore, in this study, the researchers simplified SBI and referred it to SSBI. The purpose of this study was to test the effectiveness of this new method with second grade students. Participants, using SSBI method, did not need to identify categories. Results demonstrated that all four participants’ word problem solving skills were significantly improved. The results also evidenced that students not only mastered SSBI, but also maintained the skills.
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A Dissertation
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December 2011
DEDICATION

To My Son--Tongtong, and daughter--Naja
ACKNOWLEDGMENTS

I would like to thank my dissertation chair, Dr. Sherry Herron, and the committee members, Dr. Richard Mohn, Dr. Taralynn Hartsell, Dr. Ding and Dr. Jacob Blickenstaff, for their advice and support for this project. I will always take with me what I have learned from conducting this project. I would especially like to thank Dr. Sherry Herron for her inspiration, guidance, and insightful advice throughout the project. The endless time, effort, and patience she has put into this project will be forever appreciated.
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CHAPTER I

INTRODUCTION

Mathematics is an important subject for all students in modern society and very practical in solving problems in the workplace and business settings when coming to finances. Mathematics is not only part of everyday life, but also a major subject for the progress of science and technology. Furthermore, mathematics is also fundamental to national prosperity in providing tools for understanding science, engineering, technology, and economics. In the United States, mathematics is frequently a subject area that is difficult for many students at all levels of grades to comprehend and perform. In addition, internationally, students in the United States perform significantly poorer on math tests than students from other industrialized nations. In response to the nationwide mathematical difficulties, the National Council of Teachers of Math (NCTM) developed curricula and evaluation principles and standards to guide teaching and learning of mathematics in the United States (NCTM, 1989, 2000, 2005).

Word problem solving is one of the weak areas that need to be improved in mathematics learning. According to the National Assessment of Educational Progress (NAEP) (1992), word problem solving has become a very difficult subject for students across ability and all age levels. More than ten years later, in 2005, the National Center for Educational Statistics (NCES) reported that approximately two-thirds of the fourth grade students in the United States could not perform proficiently in solving word problems. In an effort to increase students’ word problem solving skills, many interventions have been developed during the past decades (De Corte, Greer, & Verschaffel, 1996; Jitendra & Hoff, 1996; Jitendra, George, Sood, & Price, 2010; Jitendra, Griffin et al., 2005; Neef, Nelles, Iwata, & Page, 2003). Among all these word problem
interventions, schema-based instruction (SBI) has been widely recognized as a very successful strategy in helping improve students’ word problem solving skills (Jitendra et al., 2005, 2010; Jitendra, Di Pipi & Peroon-Jones, 2002; Jitendra & Hoff, 1996; Neef et al., 2003).

In the extant SBI literature, word problems are usually categorized into two to four types, and each type of word problem corresponds to a specific solving method. Therefore, students have to be able to identify the problem type before they can attempt to solve them. This is a complicated cognitive procedure, especially for the lower grade elementary students who are beginning learners. In addition, researchers are not consistent on how word problems should be categorized (Neef et al., 2003; Xin, Wiles, & Lin, 2008).

In the current study, SBI was simplified in the way that word problems were not divided into categories. Because lower grade students are beginning learners, they can only solve very limited types of word problems: one-step addition and subtraction involving small numbers. In addition, the procedure of identifying word problems is complicated for most students. Thus, it is important to simplify the current SBI and provide a new strategy that does not need to categorizing word problems. In this study, a “one size fits all” schema was taught to participants for solving all one-step addition and subtraction word problems. The researcher hypothesized that the simplified SBI (SSBI) is still effective in improving students’ word problem solving performance at the lower grade level in general education.

Purpose of the Study

In order to broaden students’ schema in word problem solving and help them improve the ability to recognize the connection to the novel problems (Fuchs et al., 2004), the
current project provided students a “one cover all” strategy, Simplified Schema-based Instruction (SSBI), in solving one-step addition and subtraction word problems at the second grade level in general education. Using this new method of SSBI, students do not need to categorize those word problems, instate they need to read and retell the word problem first, then they will determine the operation and solve the word problems based on their understanding of the word statement. Thus, the purpose of this study was to test and verify the effectiveness of SSBI at the second grade in general education. In addition, the investigators also intended to discover if participants could maintain SSBI strategy after the intervention is terminated.

Research Questions

1. Will SSBI be effective in increasing for beginning learners’ mathematic word problem solving performance?

2. Will SSBI be effective in increasing mathematic word problem solving performance in students in general education?

3. Will SSBI skills be maintained after the intervention terminated?
CHAPTER II

REVIEW OF THE LITERATURE

Overview

As was already discussed in Chapter I that the mathematics is an important and hard subject to students at all levels. Among all the difficult areas in mathematics learning, word problem solving is one of the weak areas that need to be improved. In an effort to improve students’ word problem solving skills, many intervention strategies have been developed during the past decades. Many researchers have reported their research results in this area. The current students’ performance in mathematics learning and the previous studies on students’ performance in mathematics learning and word problem solving skills are discussed in this chapter.

Mathematics Performance in K-12

There is no doubt that mathematics is one of the most important subject areas to students in all levels of education. Mathematics not only helps with everyday life situations, but is also the major subject for the progress of science and technology. Mathematics is used throughout the world as an essential tool in many fields, including natural science, engineering, medicine, and the social sciences. Therefore, efficient mathematics instruction for all students in K-12 is very essential in helping students improve their performance in school. However, in the United States, mathematics is a difficult area not only for students who are eligible for special education services, but also for general students as well. Reed (1999) pointed out that, for many years, test scores have been showing students’ low performance in mathematics in the United States (US), and the graduators working in the business area have been criticized.
because of their lack of ability to communicate with mathematical skills and solve a variety of complex problems.

In 1996, Gross-Tsur, Manor, and Shalev found out that approximately 6% of school-age children have substantial math difficulties. And this situation remained in 2006, ten years later, there were approximately 6% of school-age children experiencing significant math deficits (Neidorf, Binkley, & Stephens, 2006). According to NAEP (2005), there were 20% of fourth grade students who scored below the basic level in math. From the same report, this percentage increased to 31% for 8th grade students, and 39% for the 12th grade students. Oftentimes, many students with learning disabilities are identified as having difficulties with math learning (Rhymer, Dittmer, & Skinner, 2000). That is also why more than half of the students with learning disabilities need help in mathematics through their Individual Education Program (Kavale & Reece, 1992). Even in general education there are many students who require assistance with mathematics. Take computation skills as an example, Cawley, Parmar, Yan, & Miller (1998) found that among the 14-year old students in general education in the United States, only 85% of them mastered computational addition skills, 81% mastered subtraction skills, 54% mastered multiplications skills, and 54% mastered division skills. The low performance in computation skills is one of the barriers in learning word problem solving. This is why many researchers chose to evaluate students’ computation skills before teaching them word problem solving strategies (Jitendra & Hoff, 1996; Jitendra et al., 2010; Neef et al., 2003).

Further, in the international level, researchers have been discovered that students in the United States perform significantly poorer on math tests than students from other industrialized nations, specifically, students’ average math performance in 8th grade in the
US is approximately two years poorer than students from other countries (Jitendra, Salmento, & Haydt, 1999). In an effort to improve students’ math performance in the United States, the National Council of Teachers of Mathematics (NCTM) developed curricula and evaluation principles and standards to raise the level of academic achievement in math (NCTM, 1989, 2000, 2005).

Word problem solving is an important skill that students learn during their school years. However, word problem solving is also one of the difficult areas in mathematics learning. The importance of word problem solving in mathematics has been emphasized since the beginning of the 1980s (De Corte et al., 1996). Students were believed to handle word problems after they gained addition and subtraction computational skills, and therefore, during the 1990s many mathematics curricula began to include word problems for the application math knowledge (De Corte, Greer, & Verschaffel, 1996). National Council of Teachers of Mathematics (1989) suggested instructors teach students mathematics word problems starting in elementary and throughout high school. Additionally, NCTM (1989) suggested that word problems should be related to children’s everyday experience, so students could be promoted to learn more concepts, operations, and arithmetic symbols relevant to real-world situations. This may help students practice the skills of computation, operation, and application of math knowledge in real life situations. However, according to NAEP (1992), word problems have become a very difficult area for students across ability and all age levels. In 2005, the National Center for Educational Statistics (NCES) reported that roughly two-thirds of the fourth grade students in the United States could not perform proficiently in word problem solving (Perie, Grigg, & Dion, 2005). Researchers have been attempting to develop effective word problem solving instruction. Unfortunately, not much progress was made during the
1990s (Lester & Kehle, 2003). Word problem solving remains a difficult area among elementary and high school students (De Corte, Greer, & Verschaffel, 1996; Jitendra & Hoff, 1996; Neef et al., 2003). One of the reasons is that researchers did not develop new strategies that could be used to effectively teach students word problem solving skills (Lester and Kehle, 2003). This situation changed recently with new research contributing to this area and newly developed strategies (Jitendra et al., 2005, 2010; Neef et al., 2003).

Teaching and Research in Word Problem Solving

There is no clear definition on what word problems include. Neither is there clear definition for problem-solving (Lester & Kehle, 2003). Usually, word problems are from real life situations and they have significant background information presented as text rather than in mathematical notations. So, word problems are also known as story problems. In order to solve a word problem, students need to read them first to gain the background information, and then transfer the English language into mathematics language to solve them. The situations in word problems are from real world which are also related to students' everyday lives. Word problem solving is also a skill of applying classroom mathematics knowledge into real world. It is a fundamental skill that students should learn during their school time.

During the 1950s, researchers had already conducted studies in mathematical problem-solving (Lesh & Zawojewski, 2007). However, word problem solving was not emphasized by traditional curriculum which paid too much attention to the procedures and declarative knowledge, mathematical concepts, and emphasized a great deal on the memorization of math facts and computational skills (Montague, Warger, & Morgan, 2000). This is believed to be partially responsible for students’ low performance in solving word problems in all grades (García, Jiménez, & Hess, 2006) because of the
focus on rote memorization of formulas. The National Research Council (Kilpatrick, Swafford, & Findell, 2001) conducted a study at the state, national, and international levels over 30 years to discover students’ performance in mathematics including word problem solving skills. They concluded that students’ computation skills in the United States do not match their capabilities in word problem solving, they even have a limited understanding of basic math concepts and limited abilities to apply mathematical knowledge to find the solutions for even some simple problems.

Later on, during the 1970s and 1980s, researchers and educators found that students exhibited difficulties, not only in mathematical problem-solving, but experiencing much more difficulties in word problem solving (De Corte, Greer, & Verschaffel, 1996). In response to the substantial difficulties experienced by students, more and more attention has been paid to word problem solving in school curricula since later 1980s, and word problem solving began to be included in exercises in elementary and high school curricula (García, Jiménez, & Hess, 2006).

There are multiple skills needed to solve word problems successfully. For example, Lester (1980) found that word problems solving is a complex process which requires capabilities in both reading comprehension and computation skills. Further, solving word problems also requires students to transform words and numbers into appropriate mathematic sentences with accurate operations (Levingston, Neef, & Cihon, 2009). Zentall and Ferkis (1993) summarized that there were three major factors affecting students’ performance in word problem solving:

1. The difficulties in discriminating the correct operation;
2. The order of operation (when placement of the unknown within the problem differs);
3. Extraneous information and problems with computational speed. Researchers also found that semantic structure, mathematical relations, and the knowledge of basic numerical skills are all involved in word problem solving (Griffin & Jitendra, 2008; NCTM, 2000).

Furthermore, Knifong, & Holtan (1976) analyzed some previous studies and pointed out that there were four major reasons that caused difficulties in word problem solving:

1. Instructors could not provide effective instructions.
2. Different constructions of words may affect students’ understanding, asking questions at first or at last, for instance.
3. Researchers find that students’ capabilities in word problems are related to their test scores, that is, students with high scores intend to solve word problems better.
4. The incorrect evaluation (methods) system is used in word problem solving.

Among them, effective instructions are considered by many researchers as an approach to improving students’ performance in word problem solving. Similarly, mathematical educators and researchers think that instructors should carefully design problem-solving instruction to help students learn better processes of word problem solving (Griffin & Jitendra, 2008; Rudnitsky, Etheredge, Freeman, & Gilbert, 1995).

Besides the research and curricula, the methods of teaching word problem solving are also affected by the NCTM standards and curricula. The NCTM standards have impacted the mathematics education in the United States for many years. Both the 1989 standards and the 2000 standards emphasize problem solving, especially the use of word problems (NCTM, 1989, 2000). Word problem solving is an approach to teaching students to solve practical problems, one of the goals of mathematics education (NCTM, 1989, 2000).
Word problems are problems presented to students in forms of everyday activities such as cooking, shopping, budgeting, and time management (Neef et al., 2003). In 2006, the NCTM published the Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics which once again emphasized the importance of word problems. In this document, procedural knowledge in mathematics such as learning how to perform or apply algorithms, is regarded a useful way to reinforce and “promote problem solving, reasoning, communication, making connections, and designing and analyzing representations” (NCTM, 2006, p. 34).

Reed (1999) studied the NCTM standards and concluded that NCTM emphasized the importance of problem-solving and the importance of instructional format. However, the current and traditional mathematics textbooks did not provide students with the instructions recommended by NCTM, but instead, efficient computation and mathematical orientation were the primary focus of these textbooks (Jitendra et al., 2005; Reed, 1999). Further, other researchers (Griffin & Jitendra, 2008; Jitendra et al., 2005) investigated traditional textbooks and also found that those textbooks inadequately addressed the NCTM standards, due to the fact that more than half of those types of textbooks did not offer students enough opportunities for reasoning skill which was considered an important skill for solving word problems. Fortunately, the more recent commonly used textbooks were adhering to the NCTM standards better after 2006, given the fact that some mathematics textbooks began to recommend instructors to use a multitude of strategies to help students approach problem solving (Griffin & Jitendra, 2008).

Effective instruction in mathematics classrooms would promote the development of students’ skills in solving word problems and also support students to explore more
reasoning strategies in mathematics (Carpenter, Fennema, Franke, Levi, & Empson, 1999). In fact, not only mathematics educators are conducting studies in word problem solving, psychologists are also researching this area from a psychological view (De Corte et al., 1996; Dodd & Bourne, 1973; Neef et al., 2003; Rudnitsky et al., 1995; Schul, Shinn, & Smolkowski, 2002). The cognitive psychology is the fundamental theory support for most of the models used for understanding and assessing students’ solution of problems (Carpenter & Moser, 1984; Riley, Greeno, & Heller, 1983). Most of the studies have been based on the theories of cognitive science in which researchers try to help students acquire and apply mathematics knowledge in real world through modeling the cognitive process for solving word problems. The models and strategies developed in the past three decades include conceptual-based instruction, pre-current behavior instruction, self-generated drawings strategy, self-regulation strategy, and schema-based instruction (SBI). Among all those strategies, SBI has been recognized as an effective instructional strategy in teaching word problem solving since the last decade (Jitendra et al., 2010).

Many studies evaluating the effects of SBI on students’ word problem solving performance have produced positive results (Garcia et al., 2006; Jitendra & Hoff, 1996; Jitendra et al., 2010; Neef et al., 2003; Xin et al., 2009;). In addition, Xin et al. (2008) demonstrated that SBI is effective in improving word problem solving performance in students both with and without disabilities.

Schema-Based Instruction

Gick and Holyoak (1980) defined problem schema as a general description of two or more problems, which can be used to group problems into types that require similar solution methods (Chi, Feltovich, & Glaser, 1981; Gick & Holyoak, 1980; Quilici & Mayer, 1996). Therefore, the broader the schema students have, the more chances
students will have to recognize a novel word problem and higher possibility to solve it (Fuchs, Fuchs, Finelli, Courey, & Hamlett, 2004). The current method of SBI for word problem solving was originally adapted from a schema model developed by Marshall (1988) and Gick (1986). Gick (1986) pointed out that in order to develop a problem representation, the learners first need to find the structure of a problem and connect this new problem to the prior knowledge, then create a personal interpretation (network) of this new problem. Then, the use of existing strategies is applied to find the solution to this new problem. This process is also called schema activation (connect new problem to prior existing knowledge and build a new larger network) through which students should be able to find the schema for solving the new problem (Gick, 1986). So the most important aspect in using SBI solving word problems is the development of schemas (Fuchs, Fuchs, Prentice, Hamlett, Finelli, & Courey, 2004; Kintsch, 1994). Obviously, the broader the schema is the more general the description of the problem category must be, and more likely a student tends to find connections between novel and existing solving methods. However, the development of broader schemas for word problem solving does not occur naturally (Fuchs et al., 2004).

Learners encode the cluster knowledge they learned into memory as experiences and use them to comprehend new problems in the future (Reed, 1999). This is also the reason why the word problem structures are always emphasized in SBI for recognizing new problems through the schemata in existence (Jitendra et al., 2010; Marshall, 1988). Studies show that students can understand and assess word problem solving through the SBI environment (Griffin & Jitendra, 2009; Jitendra et al., 2010; Riley, Greeno, & Heller, 1983). For example, by providing appropriate context and background information before
presenting the word problems to students, recalling previous useful information and comprehending the current problem occur (Reed, 1999).

Marshall (1988) gives a more detailed explanation of the implementation of SBI and outlines four components that constitute a schema. The first component is the descriptive component. This consists of all the facts about the situation to which the schema applies. The next component contains all of the restrictions and conditions that must be met if the schema is to be used. Marshall (1988) describes this component as testing the “goodness of fit” of the first component (p. 13). The third component is the planning component. This has all the mechanisms related to forming goals and sub-goals that are to be expected in the given situation. Finally, the last component consists of the actions and procedures that would be used in the implementation of the schema. SBI focuses on identifying the schema used in the problem-solving process when trying to solve word problems. This is done with strategic instruction. Through the use of diagrams and repeated practice, the child is taught how the semantic structure of the word problem translates onto elements of the schema. Therefore, in the real teaching process, teachers would highlight the structure of a problem and help students identify different types of questions through use of schematic diagrams and then, students would determine an appropriate solution procedure to solve the problem completely (Jitendra et al., 2010). Actually, the elements are the problem schemata, the action schemata, and strategic knowledge. These elements are essentially the first, second, and third components of Marshall’s (1988) model. The problem schemata contain the same elements that are involved in the first component. The action schemata are the same elements as the third component. Finally, strategic knowledge contains the same elements that are involved in the last two components (Jitendra & Hoff, 1996).
Categories of One-step Addition and Subtraction Word Problems

Many studies used SBI to solve one-step addition and subtraction word problems (Garcia et al., 2006; Jitendra & Hoff, 1996; Jitendra et al., 2010; Neef et al., 2003; Xin et al., 2009). Among those studies, researchers usually divide addition and subtraction word problems into three categories: change problems, group (combine) relation problems, and compare problems (Garcia et al., 2006; Jitendra & Hoff, 1996; Jitendra et al., 2010). Others would like to divide one-step addition and subtraction word problems into four categories: change problems, group (combine) relation problems, compare problems, and equal problems (Neef et al., 2003; Xin et al., 2009). These problem types (either three categories or four categories) are accepted widely among researchers even though they differ in some regards (García, Jiménez, & Stephany, 2006; Riley, Greeno, & Heller, 1983). According to Carpenter, Hiebert and Moser (1983), Garcia et al. (2006), Griffin and Jitendra (2008), and Neef et al. (2003), the four types of word problems are described below.

A change problem is normally about increasing or decreasing an initial quantity to a new quantity. For example, the problem would read as, “Pablo had 18 stickers. His friend Juan gave him 6 more stickers. How many stickers does Pablo have altogether?” Three sets involved in this type of problems include beginning set (18 stickers), change set (6 more stickers), and ending set (altogether).

A combine (group) problem includes two distinct groups or subsets (parts) combined together to form a new group as a whole or a new set. For example, the problem would read as, “There are 12 sheep in a van; 4 are black, and the rest are white. How many white sheep are there?” There are two sub-sets in this problem: one subset includes 4 black sheep, the other one includes unknown white sheep and the 12 sheep is the total set.
In a compare problem, two disjoint sets (compared and referent) would be compared, and the three sets of information involved in a compare problem include a compared set, a referent set, and a difference set. For example, the problem would read as, “Olivia’s bicycle has 14 gears, and Alba’s bicycle has 9 gears. How many less gears does Alba’s bicycle have than Olivia’s?” There are also three sets in this problem: the compared set is 9 gears, the referent set is 14 gears, and the deference set is the unknown.

An equalize problem is the combination of a change problem and a compare problem. One can find the same sort of action in a equalize problem as found in a change problem, and it is based on the comparison of two disjoint sets. For example, the problem would read as, “My dress has 12 buttons. If my sister’s dress has 5 buttons more, it will have the same number of buttons as my dress. How many buttons does my sister’s dress have?” There are two equalize sets in this problem: one is 12 buttons and the other one is the unknown set which needs five more buttons to be equal to 12 buttons.

In addition to the above categorizing methods (three or four categorizes), Xin et al. (2008) divided one-step addition and subtraction word problems into two large categories: Part-Part-Whole (PPW) and Additive Compare (AC). Then, these two kinds of word problems are divided into several more detailed sub-categories. For example, PPWs are categorized into three sub-categories: (a) combine (Jamie and Daniella have found that together they have 92 books. Jamie says that he has 57 books. How many books does Daniella have?), (b) change-join (Luis had 73 candy bars, then another student, Lucas, gave him some more candy bars. Now he has 122 candy bars. How many candy bars did Lucas give Luis?), and (c) change-separate (Davis had 62 toy army men. Then, one day he lost 29 of them. How many toy army men does Davis have now?). Xin et al. also categorized the AC word problems into two sub-categories: (a) compare-more (Denzel
went out one day and bought 54 toy cars. Later, he found out that this friend Gabrielle has 56 more cars than he bought. How many cars does Gabrielle have?) and (b) compare-less (Ellen ran 62 miles in one month. Ellen ran 29 fewer miles than her friend Cooper. How many miles did Cooper run?). Furthermore, according to the different positions of unknown in the word problems, each sub-category can be divided into two to three sub-sub-categories.

Generally, different researchers have different idea with the categories of one-step addition and subtraction word problems. Most of the researchers would support the three categories or four categories methods.

SBI Studies

The use of schema diagrams in SBI distinguishes this method from other instruction for word–problem solving. Diagrams in SBI help students organize the information in a word problem and therefore, help them find the solution to the problem (Jitendra et al., 1999). Zawaiza and Gerber (1993) compared the effectiveness of diagram strategy in word problem solving with other strategies. Their study included three different strategies in solving two-step word problems: translation training, diagram training, and attention-control conditions. The participants included thirty-eight college students with learning disabilities who were randomly assigned to the above three experimental conditions. During the intervention, only compare word problems were used. Participants in the translation training group were trained to translate, explain, and find the relationship among variables in compare word problems; while in the diagram training group, participants received training to use diagrams to represent, interpret, and rephrase problems; and the participants in the attention-control group were not taught any strategies in solving word problems, instead, they were asked to complete a worksheet
simply after they discussed their strengths, weaknesses, concerns, and perceptions of problem solving. A pre- and post-test comparison was used to evaluate the effects of the three conditions. Results indicated a marked decrease in errors in the diagram group, whereas the other two groups made only moderate decreases in errors compared to the diagram group. And consequently, the diagram group's performance was substantially better than the performance of other two groups in the posttest. Based on the results, Zawaiza and Gerber concluded that SBI was effective in improving word problem solving for students with learning disabilities.

Jitendra and Hoff (1996) tested the effectiveness of a schema-based direct instruction strategy on the word problem solving performance in three elementary students with learning disabilities. One-step addition and subtraction word problems were divided into three types in this study: change problems, group problems, and compare problems. The investigation included five procedures. First, participants were screened for prerequisite two digit addition and subtraction computation skills. During baseline tests, participants scored an average of 42% accuracy in all three types of problem solving. During the SBI intervention, participants were first trained to identify the schemata (problem schema) of word problems until participants can get 100% right in two consecutive days of training. During the intervention process, diagrams were used to help recognize story types (Figure 1). Participants were also taught how to determine what operation should be used according to the features of a word problem (action schema). For example, after participants recognized a change problem, instructors may ask them to read the problem again to find the “change word,” or the word that caused the change action. After this, participants were instructed to find the total amount and to decide if there was an increase or decrease in change. If the change led to the ending amount that was more than the
beginning amount, then the addition operation would be applied. Otherwise the subtraction should be used. Maintenance data were collected two or three weeks (varied among participants) following the intervention. Results showed that the SBI successfully helped those students improve their abilities in solving word problems evident by the increased percentages of correct answers. Also, participants maintained the skills during the two or three week follow-ups.

Figure 1. Schemata diagrams for change, group, and compare problem types (Jitendra & Hoff, 1996).

In the study by Hutchinson (1993), the participants also included students with learning disabilities. There were a total of 20 students with learning disabilities who were divided into two groups. In the experimental group, students were taught to solve word
problems using a cognitive strategy that incorporated schema identification. Specifically, the experimental group was asked to solve three types of word problems: relational, proportion, and two-variable, two-equation. For relational problems, schema identification required students to find out the "relational statement that provided information about one unknown quantity in terms of its relationship to another unknown quantity" (Hutchinson, 1993, p. 39). While the "complete, incomplete, and equivalent ratios and a new case ratio, which required introduction of a symbol to represent an unknown" (Hutchinson, 1993, p. 39) were emphasized for proportion problems. For the problems of two-variable, two-equation students were asked to identify the “two equations in two unknowns, one an elaboration of the other" (Hutchinson, 1993, p. 40). In the other condition, students were not taught any method for solving word problems besides the instruction on word problem solving they received in school. Significant differences between those two groups in word problem solving performance were found: the experimental group scored 66% on an open assessment measure which included items from a standardized test, while the comparison group only scored 40%. Additionally, the experimental group scored higher in skill maintenance six weeks after the intervention compared to the control group. These results demonstrated the effectiveness of SBI in increasing word problem solving performance in students with learning disabilities.

Jitendra et al. (1998) compared the effectiveness of SBI and traditional instruction on students’ acquisition, maintenance, and generalization of simple mathematical one-step word problem solving skills. In this study, participants were divided into two groups. In the experimental group, there were 34 students with mild disabilities or at risk for mathematics failure. The comparison group consisted of 24 third-grade students in general education. The experiment included two conditions: schema training condition
and traditional condition. The problems they used in the training were simple one-step addition and subtraction word problems divided into three categories: change problems, group problems and compare problems. In the experimental group, participants were first taught to identify the features of the semantic relations (problem schema) in the problem and determine the problem type (change, group, and compare). Then, the instructors began to teach participants to find an appropriate operation through using the diagram strategy (action schema). There were total 17-20 training phases and each phase lasted 40-45 minutes. Participants were divided into small groups (six to seven participants) when receiving SBI training. The pre- and post-tests were used in monitoring the progress of the participants. An instruction from the Addison-Wesley Mathematics basal mathematics program was adopted to be used with the comparison group. This instruction also included two phases. In the first phase the instructor presented and directed the Think Math activities. In the second phase, instructors used a five-step checklist procedure to solve word problems. This five-step strategy included: (a) understanding the question, (b) finding the needed data, (c) determine operation, (d) solve equation, and (e) checking the answer. Participants were tested at the end of each phase of the training during the second phase and received feedback of their solutions. In addition, participants in both of the two conditions were tested after the intervention to see maintenance of the skills they learned from training. Results demonstrated a remarkable increase in students’ performance in word problem solving in the experimental group. Although participants from both groups made progress and maintained their acquired skills in word problem solving, the growth rate of the participants in experimental group was significantly more rapid than the control group in posttest and maintenance test.
Neef et al. (2003) conducted a study to help students improve solving adding and subtracting word problems. Two students with developmental disabilities participated in this study. The intervention Neef et al. used in this study is pre-current behavior reinforcement strategy which is a variation of the SBI. Neef et al. divided all one-step addition and subtraction word problems into four categories: change problems, group problems, compare problems, and equal problems. Students were first trained to recognize five components in sample word problems. These five components include initial set, change set, operation, resulting set, and solution. Participants were trained to recognize those three sets for word problems presented to them. There were three phases in the treatment process. In the first phase, the target component (the component being trained, the three sets) was always a known quantity in the problems. During the second phase, however, the target component was randomly presented in the problem as either known or unknown quantity. During these first two phases, verbal prompts were provided to the participants. The last phase was a combination of the first two phases in which the unknown quantity was randomly presented in the problem and no prompts were provided. After the students learned to identify the three sets (pre-current behaviors), they were trained to determine the operation (current behaviors). A diagram system was used to help participants’ organization problem information and form mathematic equations. Students were asked to take both the pre-tests and post-tests to assess progress during the study. Results demonstrated that participants’ ability in solving word problems was improved. The results also showed that training students with learning disabilities can lead to a systematic pre-current behavior of recognizing the each part of word problems that would help students generalize the learned skills.
As already discussed prior, some researchers divided one-step addition and subtraction word problems into two categories. For example, Xin et al. (2008) first divided one-step addition and subtraction word problems into two large categories: Part-Part-Whole (PPW) and Additive Compare (AC). Then, they divided PPW and AC problems into a several detailed sub-category. Thus, different researchers have different ways to divide word problems into different number of categories, and this is basically done according to the convenience of the studies. Different type of word problems correspond to different solving strategies, so the purpose of categorizing of word problems is to help students recognize what type word problem it belongs to and then use the corresponding strategy. Further, all those studies showed the effectiveness of SBI in word problem solving, however, none of these studies were conducted on students in general.

The studies addressed above share the following common characteristics. First, word problems were divided into two to four categories and the categorization varied from study to study. Students were taught to first recognize the type of a word problem and then used a corresponding strategy to solve that specific type of word problem. The results of all those studies are positive in terms of the effectiveness of SBI in increasing participants’ skills in word problem solving which indicate that categorizing word problems might not be a necessary component to be included in SBI, especially to the students at the lower grade level in elementary schools. Second, participants included in those studies are students with special needs (learning disabilities or developmental disabilities). Actually, there are only few studies using SBI strategy in general education (Fuchs et al., 2004). Therefore, the effectiveness of SBI in improving word problem solving in this population is well-established, however, a need to investigate if SBI is
effective for students without special needs in general education exists. Third, participants were screened for prerequisite skills before they were recruited into those studies. Some of the studies screened the students’ reading skills, some screened computation skills, or screened both. This is a necessary procedure to ensure that students’ difficulties with word problem solving are not caused by a lack of these prerequisite skills. Fourth, the diagram strategy was employed by all the studies. This indicates the importance of diagram strategy in SBI. Finally, students’ performance during and after intervention in these studies indicated the effectiveness of SBI in increasing students’ word problem solving skills and maintenance data suggested that students were able to generalize their learned skills to novel problems.

As research projects have already shown that categorizing word problems was a hard cognitive procedure for many students (Neef et al., 2003; Xin, Wiles, & Lin, 2008). Especially, as we know that the lower grade elementary students only need to solve very limited types of word problems. The second grade students, for example, only need to solve one-step addition and subtraction word problems. Therefore, it might not be necessary for these lower grade students to categorize these simple word problems. In current project, the investigators simplified the SBI (SSBI) method for lower grade elementary students. In SSBI, participants did not need to categorize the word problems into different categories, instead, they were asked to solve the problems base on reading comprehension of the problems. The investigator recruited four elementary students in the second grade to test the effectiveness of SSBI in this project.
Summary

In summary, all the above mentioned studies supported the effectiveness of SBI in improving students’ word problem solving performance regardless how the word problems were categorized. Participants were taught different methods to use diagrams according to the different types of word problems. Participants had to first recognize the type of a word problem before they decided what strategy to use for that certain type. This is an extra procedure that complicates the problem solving process because no matter how many categories the word problems were divided in previous studies, the effectiveness of SBI was supported. And this problem type determining procedure can be especially complicated for students who are not doing well in reading because there is no clear definition of what type a word problem should belong to. Actually, there even no strict definition of the problem solving, for example, Lesterand and Kehle (2003) pointed out that the conceptual definition of problem solving is too complex and varied, and there is no a strict definition that widely used in the word problem solving area. According to Fuchs et al. (2004), “The broader the schema (i.e., the more general the description of the problem category), the greater the probability individuals will recognize connections between novel and familiar problems, so they will know when to apply the solution methods they have mastered” (p. 635). Therefore, teaching students a broader schema through which students do not need to recognize different types of word problems must simplify the SBI instruction and improve the effectiveness of SBI. Taken this limitation into consideration, the current study did not teach students to divide word problems into categories; instead students were taught a broader schema that can be used for solving all types of one-step addition/subtraction word problems. Additionally, the participants in this study were elementary students without special needs, but are experiencing
difficulties in word problem solving. Participants were all screened to ensure they do not have problems in reading comprehension and computation skills.
CHAPTER III

METHOD

Overview

Single subject design is becoming more and more popular nowadays in classroom-based research projects (Birnbauer, Peterson, & Solnick, 1974; Gay & Airasian, 2000; Richards, Taylor, Ramasamy, & Richards, 1999). The data, in single subject design, are individually analyzed (Barger-Anderson, Domarachi, Kearney-Vakulick, & Kubina, 2004) which is important to the academic interventions because researchers want to make sure each of the participants could make progress. In this research study, the investigators utilized a single subject design (multiple-baseline across participants) to test the effectiveness of SSBI. Four second grade students from a school district in the south of the United States participated in this project. The project design and the methods were reported in this chapter.

Participants and Settings

Participants were four second grade students in general education settings. Participants were recruited from one local elementary school located in a southeastern state. All four participants were from the same classroom. Participant A was a male Caucasian student, seven years, three months old. Participant B was a male African American student, seven years, five months old. Participant C was a female African American, seven years, one month old. Participant D was a male Hispanic student, seven years, nine months old.

Participants were selected based on the following criteria: (a) student was nominated by his or her teacher for word problem solving difficulties (this was determined by teachers according to participants’ performance in math word problem solving); (b) the
four participants mastered prerequisite oral reading and mathematics computation skills determined by the screening test (described below); and (c) the teacher and students’ parents consented to participation in the study. In addition, a university-based Institutional Review Board approved the investigation prior to its onset (see Appendix E). After the screening test, students were first trained individually by the primary investigator to use the SSBI procedure (described below) to solve word problems. All screening, baseline, intervention and maintenance phases were conducted at a quiet location in participant’s school by the primary investigator and by another graduate student.

Materials

A series of worksheets containing one-step addition and subtraction word problems using the equations $A+B = C$ or $A-B = C$ were created and adapted from Free Math Word Problem Worksheets (http://www.softschools.com/math/word_problems/worksheets/). There were five problems on each sheet (each sheet contained only five problems). Training and testing probes used in all the phases were selected from these worksheets. Considering the participants were in the first semester of second grade, one-step addition and subtraction word problems used in this project involved mixed single- and double-digit addition and subtraction computations with total no greater than 20. Furthermore, in order to keep the consistency of the word problems’ difficulty level, there were always three subtraction word problems and two addition word problems selected on each worksheet. An example of a typical worksheet is shown in Appendix A.

Dependent Variables, Data Collection, and Inter-Observer Agreement

Accuracy percentages were used to measure students’ word problem solving performance. An accuracy percentage was calculated by using total earned points dividing
by total potential points and then multiplying by 100%. Correct responses were defined as: the larger number was at the beginning of the equation, the smaller number was behind the operation symbol, correct operation (addition or subtraction), correction solution, and correct use of label. Each of the response was worth two points and therefore, each word problem was worth 10 points in total. Students’ worksheets were collected at the end of each session by the primary investigator. The investigator and/or trained graduate student graded the worksheets independently.

*Inter-Observer Agreement (IOA) Data Collector Training*

Inter-observer variation is frequently used in the situation that involves two or more independent observers who are evaluating the same thing (SSBI intervention in this study). Inter-observer agreement (IOA) was defined as the percent of observed agreement of correct responses to the percent the expected agreement (Viera & Garrett, 2005). Thus, the USE of IOA in this project helped the researchers to make sure the data were collected correctly. In this study, the standard of IOA was set at 90%. A graduate student was trained to identify correct and incorrect responses on word problem worksheets. The graduate student training included three steps. Step 1, the primary investigator verbally described the grading procedures to the graduate student. Step 2, the primary investigator demonstrated the procedure by grading three sample worksheets. Step 3, the graduate student and the primary investigator Graded Three same worksheets independently to calculate IOA. The agreement means the points that primary investigator and the graduate student agreed with each other in grading specific problems. The disagreement means the total points that the primary investigator and the graduate student have different opinions to either add or deduct. IOA was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100. If
the average agreement percentage is 90% or above, the graduate student is considered having mastered the grading skills and the training is completed. Otherwise the training continues until the 90% criterion is met.

Experimental Procedures

Experimental Design

A multiple baseline across participants design was employed to investigate the effects of the SSBI on students’ mathematic word problem solving performance. In this design, the intervention was implemented in a staggered manner across participants. The intervention was implemented with the first participant following a low stable or decreasing trend during baseline, whereas the other three participants remained in the baseline. Intervention was not introduced to the other three participants until there was an increasing trend in accuracy percentage during intervention in the previous participant’s data.

Screening of Participants

Participants were screened on oral reading fluency and math computation using standard Curriculum-based measurement (CBM) procedures. In this project, mathematics intervention, only the students who can meet the reading and computation CBM criterion can be treated. So the screening on reading and math computation are required in this project. CBM includes standardized measures for reading, mathematics, writing, and spelling. CBM was developed by Deno and colleagues in the early 1970s (Shinn, 1989). CBM was original designed for the teachers in special education area. Nowadays, CBM is widely used in both general and special education settings.

The screening test was conducted prior to the baseline. The purpose of the screening test was used to make sure the students’ lower performance in word problem solving was
not caused by reading comprehension and/or computation skills. Considering the reading fluency is an indicator of overall reading competence (Fuchs, Fuchs, Hosp, & Jenkins, 2001) and the major concern in this project is word problem solving, the oral reading fluency test has been adopted to test students’ reading comprehensions. Oral reading fluency and computation skills were both measured by using curriculum-based measurement (CBM) procedures. CBM was developed by Deno and colleagues in the early 1970s (Shinn, 1989) and it is widely used in both general and special education settings, even though it was originally designed to provide special education teachers with standardized, simple, and accurate approaches to measure students’ skills in basic academic areas (Hintze, Christ, & Methe, 2006). In the current project, participants were asked to read reading probes, and the words correct per minute (WCPM) and error per minute (EPM) using standard CBM procedures were scored by the experimenter.

Each of the four participants was asked to read three passages at their grade levels (see Appendix B for administration and scoring instructions). WCPM and EPM were recorded for each passage, and the median scores were used as to identify fluency level. Students who did not met the fluency standards of their corresponding grade levels (40-60 WCPM for second grade and 70-100 WCPM for third grade) were excluded out of the study. For computation skills, three probes containing mixed single and double digits and double digits addition and subtraction math problems were administered and scored using standard CBM procedures (see Appendix B for administration and scoring instructions). The median score of Correct Digit per Minute (CDPM) and Digit Incorrect Per Minute (DIPM) were used to determine if the students met the fluency standards of their corresponding grade levels (10-19 CDPM and 3-7 DIPM for grades one through three). Students who did not meet the criteria were excluded from the study. There were total
seven students attended the screening tests and only four of them meet the criterion. So there were four students participated this study.

**Determining Baseline**

During baseline, no instruction or feedback was provided to students. Students were given one worksheet containing five mixed one-step single- and double-digit addition and subtraction word problems to solve. If a participant has stable performance or a decreasing performance during the baseline phase, the intervention (independent variable) can be introduced to this participant (Cooper, Heron & Heward, 2007). In this study, all the four participants received the baseline at the same week in a classroom in their schools. Each participant was give one worksheet containing five word problems each time. There were two to three times of baseline sessions were conducted in each week and every time the participants received different worksheets. Standard procedures were used for worksheet administration and scoring (see Appendix C).

**Intervention or Treatment**

The SSBI was used to teach students to solve word problems individually two to three times a week. In SSBI, students do not need to learn problem types as in the previous studies (Jitendra & Hoff, 1996; Neef et al., 2003; Garcia et al., 2006; Xin et al., 2009; Jitendra et al., 2010). A schema was taught to students for solving all problem types. Specifically, there were four steps in this simplified SBI. During Step 1, students were instructed to read the word problem out loud a couple of times to identify the following components of the problem, the larger number, the smaller number, the unknown number, and the label of interest. In addition, students were asked to rephrase the word problems to the experimenter in their own words. In Step 2, students were taught to fill the diagram in the order that the larger number in the first box, the smaller number in the
second box, the unknown number in the box behind the equation, and the label in the parenthesis at the end of diagram:

\[
\begin{array}{c}
\square \\
\bigcirc \\
\square
\end{array}
= \square
\] 

During the third step, students were taught to decide the operation of choice. Students were taught that if the total or the sum of two numbers is unknown, addition is the choice of operation; however, if the total is known and the problem is to find one of the smaller numbers; or if the difference between two numbers is asked for, subtraction is required to solve the problem. Then, students were instructed to read the problem again to make a choice of operation. At last, students were required to solve the equation and check the answer. After the student was certain that the solution is correct, he or she would retell the solved problem to the primary investigator using the result to replace the unknown (e.g., Lucy has 12 cookies, she gave 3 to her little sister, and now she has 9 cookies left).

Verbal praise was provided for correct responses and corrective feedback for incorrect responses during the entire phase. One worksheet containing five word problems were taught in each session. Following instruction, students were asked to solve the same five problems independently. The problems were administered and scored in the same manner as in the baseline. Accuracy percentages were calculated and recorded for data collection purpose.

When the stable or increasing performance have been observed for the first the participant, the intervention is applied to another participant who has a steady responding or decreasing performance in baseline phase, and so on (Cooper, Heron & Heward, 2007).
Maintenance

Maintenance of learned skills was evaluated one month after the termination of the intervention. During the maintenance phase, participants were asked to complete one worksheet containing five word problems. The probes used in the maintenance stage were similar to the probes used during the previous phases. Worksheets were administered in the same manner as in baseline. Only one maintenance session was conducted per week and the maintenance phase continued for four weeks. In total, there were four worksheets completed by each participant. The probes used in the maintenance phase were graded in the same fashion as in previous phases.

Treatment Integrity

An independent observer attended at least 33% of the intervention phases for each student to complete the treatment integrity checklist (Appendix D). A trained graduate student directly observed the primary experimenter conducting intervention phases with one student and completed the checklist. The percentage of treatment integrity was calculated by the number of steps correctly implemented dividing by the total number of analysis steps and multiplying 100.

Data Analysis

The data were analyzed by visual inspection of students’ accuracy percentages on word problem worksheets across all experimental phases (baseline, intervention, and maintenance). Data analysis included the evaluation of level, trend, and variability. During the visual inspection, each data point was compared with the previous point to see if there is descending, ascending or equal trends existed. Additionally, the data points’ level and variability were also considered. The level of data points means the data intervals and the data variability means the data ranges. In addition, considering the effect
size emphasizes the size of the difference rather than confounding this with sample size and the small sample size and the limited data points collected in each phase in this study, the F test and Cohen’s d were both calculated to analyze the differences between the data from the baseline and the maintenance phases.

In order to find out the Effect sizes the magnitude of the SSBI intervention in this study from baseline phase to the maintenance phase, the F test and Cohen’s d were used in this study. These two tests can help the investigators understand the size of the experimental effect.

Summary

The research was implemented to the methods discussed above. After the screening tests, there were four participants qualified to this project. Then after the screening tests, participants were first introduced to the baseline session in which they were asked to do one worksheet at a time for several times to see their performance before the intervention. After the baseline, the participants were introduced to the intervention session one by one. During the interventions sessions, the participants were trained first and then were asked to complete the same worksheet. The last session was the maintenance session which was conducted one month after the completion of intervention. All the data collected according to the requirement of the methods step by step were reported in next chapter.
CHAPTER IV

RESULTS

The purpose of this project was to obtain the evidence of the effectiveness of SSBI in word problem solving in second grade students in general education. All the data including the screening tests, baseline phase, intervention phase, maintenance phase, IOA and research integrity data were all reported in this chapter. The data were reported into three parts in this chapter. The first part of this chapter is the screening data. The second part of this chapter is the individual data in all the phase phases. At the end of this chapter, the results from all the participants were reported together.

Screening Tests

The screening test was conducted prior to the baseline. Students’ oral reading fluency was measured as an indicator of their reading competency (Fuchs et al., 2001). CBM reading and computation probes were administered using standardized CBM procedures. The median of the three scores were used to determine if the student met the criteria of possessing reading and computation skills at their grade level. The CBM standards in reading and computation fluency were listed below:

Table 1

<table>
<thead>
<tr>
<th>Grade Level of Materials</th>
<th>Level</th>
<th>CWPM</th>
<th>ICWPM</th>
<th>Comprehension (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frustrational</td>
<td>&lt;40</td>
<td>&gt;4</td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>1-2</td>
<td>Instructional</td>
<td>40-60</td>
<td>4 or less</td>
<td>80</td>
</tr>
<tr>
<td>Mastery</td>
<td>60+</td>
<td>2</td>
<td></td>
<td>80</td>
</tr>
</tbody>
</table>

*Note: Adapted from Deno & Mirkin (1977).*
Table 2

*CBM Standards of Computation Fluency*

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Level</th>
<th>CDM</th>
<th>IDPM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frustrational</td>
<td>0-9</td>
<td>8+</td>
</tr>
<tr>
<td>1-3</td>
<td>Instructional</td>
<td>10-19</td>
<td>3-7</td>
</tr>
<tr>
<td></td>
<td>Mastery</td>
<td>20+</td>
<td>2 or less</td>
</tr>
</tbody>
</table>

*Note:* Adapted from Deno & Mirkin (1977).

In total, eight students were screened, but only four students demonstrated they mastered prerequisite reading and computation skills. The four participants’ scores are listed in Table 1.

Table 3

*Screening Results*

<table>
<thead>
<tr>
<th>Name</th>
<th>Reading (median)</th>
<th>Computation (median)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Correct Word Per Minute)</td>
<td>(Digits Correct Per Minute)</td>
</tr>
<tr>
<td>Participant A</td>
<td>50</td>
<td>22</td>
</tr>
<tr>
<td>Participant B</td>
<td>55</td>
<td>18</td>
</tr>
<tr>
<td>Participant C</td>
<td>56</td>
<td>18</td>
</tr>
<tr>
<td>Participant D</td>
<td>57</td>
<td>10</td>
</tr>
</tbody>
</table>

After the screening test, the baseline was introduced to those four participants, followed by the intervention and maintenance phases. The results of all three phases of the four participants’ performance reported individually like case studies. The results include students’ word problem solving accuracy data in baseline, intervention and maintenance phases. The results of F test and Cohen’s d were reported individually later.
Baseline, Intervention, and Maintenance Phases

*Participant A*

Figure 2 illustrates Participant A’s performance during the three phases. Participant A’s scores ranged from 16% to 84% during baseline with an average score of 53.3%. A decreasing trend was observed during the baseline phase. Participant A was the first student to enter the intervention (Cooper, Heron & Heward, 2007).

During the intervention phase, Participant A received seven sessions. Participant A’s scores ranged from 84% to 100% with a mean score of 96.6%. There was slight variability during in the intervention phase, but scores remained at a very high level and showed increase at the end.

The maintenance phase was conducted one month later after the intervention. Participant A’s scores ranged from 72% to 100% with an average score of 89%.

Because $F < F_{crit}$ (8.34 < 9.55) and $p \text{ value } > a$ (.06 > 0.05), the null hypothesis saying that there was no difference between the data from the baseline phase and the maintenance phase should be accepted. Thus, there was no significant improvement for Participant A from the baseline phase to the maintenance phase (Figure 3).

The Cohen’s $d = -1.38$ was also calculated to analyze the effect size between the baseline and the maintenance.

The trained graduate student regarded 35.7% (five worksheets) of all the worksheets in three phases. The average score of IOA is 94%.
**Figure 2.** Results in all phases for Participant A.

![Graph showing accuracy percentages over sessions](image)

<table>
<thead>
<tr>
<th></th>
<th>Baseline A</th>
<th>Maintenance A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>53.3333</td>
<td>89</td>
</tr>
<tr>
<td>Variance</td>
<td>1189333</td>
<td>1426667</td>
</tr>
<tr>
<td>Observations</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>df</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td>1.34</td>
<td></td>
</tr>
<tr>
<td>P(F&gt;c) one-tail</td>
<td>0.060</td>
<td>0.119 Two-tail</td>
</tr>
<tr>
<td>F Critical one-tail</td>
<td>9.55</td>
<td>16.04 Two-tail</td>
</tr>
<tr>
<td>One-tail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accept Null Hypothesis</td>
<td>because p &gt; 0.05 (Variances are the same)</td>
<td></td>
</tr>
<tr>
<td>Two-tail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accept Null Hypothesis</td>
<td>because p &gt; 0.05 (Variances are the same)</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3.** Results of F-test for Participant A.

**Participant B**

Figure 4 illustrates Participant B’s performance during the three phases. Participant B’s scores ranged from 0% to 32% during baseline with an average score of 22.9%.

During the intervention phase, Participant B received nine sessions. Participant B’s performance was very stable and remained at a high level of 100% during the entire intervention phase.

During the maintenance phase, Participant B’s scores ranged from 84% to 92% with an average score of 90%.
Because $F > F_{\text{crit}} (15.24 > 8.94)$ and $p \text{ value} < a (.002 < 0.05)$, the null hypothesis saying that there was no difference between the data from the baseline phase and the maintenance phase should be rejected. Thus, there was significant improvement for Participant B from the baseline phase to the maintenance phase (Figure 5).

The Cohen’s $d = -5.9$ was also calculated to analyze the effect size between the baseline and the maintenance.

The trained graduate student regarded 30% (six worksheets) of all the worksheets in three phases. The average score of IOA is 90%.

![Figure 4](image)

*Figure 4. Results in all phases for Participant B.*

<table>
<thead>
<tr>
<th>F-Test Two-Sample for Variances</th>
<th>$\alpha$</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td><strong>Maintenance</strong></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>22.85714</td>
<td>90</td>
</tr>
<tr>
<td>Variance</td>
<td>243.8095</td>
<td>16</td>
</tr>
<tr>
<td>Observations</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>cf</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>$F$</td>
<td>15.24</td>
<td></td>
</tr>
<tr>
<td>$F(F &lt; f)$ one-tail</td>
<td>0.024</td>
<td>0.04</td>
</tr>
<tr>
<td>$F$ Critical one-tail</td>
<td>2.94</td>
<td>14.7</td>
</tr>
<tr>
<td>One-tail</td>
<td>Reject Null Hypothesis because $p &lt; 0.05$ (Variances are Different)</td>
<td></td>
</tr>
<tr>
<td>Two-tail</td>
<td>Reject Null Hypothesis because $p &lt; 0.05$ (Variances are Different)</td>
<td></td>
</tr>
</tbody>
</table>

![Figure 5](image)

*Figure 5. Results of F-test for Participant.*
Participant C

Figure 6 illustrates Participant C’s performance during the three phases. Participant C’s scores ranged from 16% to 48% in baseline with an average score of 30.2%.

During the intervention phase, Participant C received seven sessions. Participant C’s scores ranged from 96% to 100% with a mean score of 99.4%. There was slight variability (within 4%) existed, but it remained at a very high level during the entire intervention phase.

Maintenance phase was conducted one month later after the intervention. Participant C’s scores ranged from 92% to 100%. The average score for Participant C during the maintenance phase was 96%.

Because F < Fcrit (8.67 < 8.85) and p value > a (.051 > 0.05), the null hypothesis saying that there was no difference between the data from the baseline phase and the maintenance phase should be accepted. Therefore there was no significant improvement for Participant C from the baseline phase to the maintenance phase (Figure 7).

The Cohen’s d = -9.16 was also calculated to analyze the effect size between the baseline and the maintenance.

The trained graduate student regarded 30% (six worksheets) of all the worksheets in three phases. The average score of IOA is 95%.
Figure 6. Results in all phases for Participant C.

![Figure 6](image)

F-Test Two-Sample for Variances  
\[ \alpha = 0.05 \]

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Maintenance</th>
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<tbody>
<tr>
<td>Mean 30.2222</td>
<td>96</td>
</tr>
<tr>
<td>Variance 92.4444</td>
<td>10.6666</td>
</tr>
<tr>
<td>Observations 9</td>
<td>4</td>
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<tr>
<td>df 8</td>
<td>3</td>
</tr>
<tr>
<td>F 4.67</td>
<td>4.85</td>
</tr>
<tr>
<td>F(\geq f) one-tail 0.051</td>
<td>0.10: Two-tail 14.54: Two-tail</td>
</tr>
<tr>
<td>F Critical one-tail 4.85</td>
<td>4.85</td>
</tr>
<tr>
<td>One-tail Accept: Null Hypothesis because ( p &gt; 0.05 ) (Variances are the same)</td>
<td></td>
</tr>
<tr>
<td>Two-tail Accept: Null Hypothesis because ( p &gt; 0.05 ) (Variances are the same)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7. Results of F-test for Participant C.

Participant D

Figure 8 illustrates Participant D’s performance during all three phases. Participant D’s scores ranged from 46% to 60% during the baseline with an average score of 53.7%.

During the intervention phase, after Participant D received four sessions, the researchers found that there is stable trend at a high level of accuracy in word problem solving. Thus the intervention was terminated after the participant completed seven sessions. Participant D’s scores ranged from 96% to 100% with a mean score of 98%.
There was slight variability (within 4%) existed, but it remained at a very high level with an increasing trend during the entire intervention phase.

During the maintenance phase, Participant D’s scores ranged from 84% to 100%. The average score for Participant D during the maintenance phase was 92%.

Because $F < F_{\text{crit}} (1.24 < 8.76)$ and $p \text{ value} > a (.483 > 0.05)$, the null hypothesis should be accepted. Therefore, there was no significant improvement for Participant D from the baseline phase to the maintenance phase (Figure 9).

The Cohen’s $d = -3.92$ was also calculated to analyze the effect size between the baseline and the maintenance.

The trained graduate student regarded 30% (five worksheets) of all the worksheets in three phases. The average score of IOA is 90%.

Figure 8. Results in all phases for Participant D.
All Participants

As illustrated in Figure 10, it is clear that all the participants’ performance in word problem solving immediately increased during the intervention. It is highly likely that the intervention was the only contribution to the effects rather than other factors (Richards, Taylor, Ramasamy, & Richards, 1999). Even three out of four participants did not show significant improvement from baseline phases to maintenance phases, the values of Cohen’s d demonstrated that there were very strong relationships between these two groups of data. This is another evidence of a strong treatment effect. Researchers also found that participants remained SSBI skills at a high level during maintenance phases (92% on average). Therefore, SSBI cannot only help students with their word problem solving, but also can be mastered by students.
Figure 10. Participants’ performance in all phases.
Inter-Observer Agreement and Treatment Integrity

*Inter-Observer Agreement (IOA) Training Data*

The graduate student and the primary investigator graded three same worksheets independently to collect IOA data. The percentages of the agreement were 95%, 100%, and 90% with an average of 95%. Therefore, only one training session was conducted. The IOA data were reported individually above.

*Treatment Integrity Data*

Treatment integrity was evaluated for 30% of the intervention phases. A trained graduate student directly observed the primary experimenter conducting intervention phases nine times in total with all four students and completed the checklist (Appendix D). The percentage of treatment integrity was calculated by the number of steps correctly implemented dividing by the total number of steps and multiplying 100%. Treatment integrity was 96% averagely for all the intervention phases for all four participants.

**Summary**

The results of this study are encouraging. In general, the results evidenced that the SSBI is effectiveness in the second grade with the students who are at risk in word problem solving. The results also indicated that the SSBI can also be maintained among those participants. These findings provide support to the use of SSBI in the second grade in general education. The following chapter discussed the students’ performance individually and more detailed.
CHAPTER V

DISCUSSION

The purposes of this research project were to test the effectiveness of the SSBI method in word problem solving at the second grade level, to verify the effectiveness of SSBI for students in general education, and third, to investigate if participants can maintain the SSBI strategy over time after the intervention. Consistent with previous studies (De Corte et al., 1996; Fuchs et al., 2004; Jitendra & Hoff, 1996; Jitendra et al., 2005, 2010; Neef et al., 2003), the results of this study demonstrated the effectiveness of SSBI strategy in which students did not need to categorize one-step addition and subtraction word problems. Performance on each session of mathematical word problems for all students improved successfully after the SSBI was implemented. In addition the participants maintained the SSBI skills successfully after the intervention was completed. The positive results of SSBI in this study extended the Schema-based Instruction strategy from special education into general education. Therefore, SSBI is effective for students at risk of failure and/or general education students who lack basic word problem solving skills (Kouba, Brown, Carpenter, Lindquist, Silver, & Swafford, 1988).

The three research questions were all answered in this study. First, because the SSBI is a simplified SBI, it was important to test its effectiveness, especially for the beginning learners. The results of this study illustrated the effectiveness of SSBI in word problem solving at Grade Two level. Second, the majority of previous SBI studies were conducted with students in special education (De Corte et al., 1996; Jitendra & Hoff, 1996; Jitendra et al., 2005, 2010; Neef et al., 2003). The investigators of this study intended to test and verify the effectiveness of SSBI in general education. The results of this study demonstrated that SSBI was effective in improving students’ word problem solving in
general education settings. Third, the word problems for maintenance were novel word problems with similar difficulty level. The results indicated that participants not only maintained the SSBI strategy in word problem solving, but also generalized their learned skills to those novel word problems.

Individual Results

In this study, participants’ performance varied. In order to have a better understanding of each individual’s performance in this study, the results were discussed separately below.

Participant A

Participant A’s average score was 53.3% with a lowest score at 16% during baseline. Participant A seemed to have difficulties with both addition and subtraction word problems before the intervention. Additionally, Participant A appeared to have a difficult time in recognizing the labels in the baseline. For most of the word problems, Participant A only gave final answers without any procedures. During the first session of the intervention, Participant A scored 84% correct. He missed some of the subtraction word problems. Starting from the second intervention session, he began to perform better on subtraction word problems. As a result, Participant A scored and maintained at a high level of scores (close to 100%) from the second intervention session and throughout the entire intervention. During the maintenance phase, Participant A’s lowest performance was 72%. The average score Participant A achieved during maintenance phase was 89% which is much higher than his performance during the baseline. We concluded that SSBI increased Participant A’s skills in solving word problems. In addition, even though variability in Participant A’s performance was observed during the intervention and maintenance phases, the levels of scores in these two phases were visually higher
compared to the baseline scores. According to the results of F test, there was no significant improvement for Participant A from baseline phase to maintenance phase. However, the value of Cohen’s d is -1.38 which means there were very strong differences between these two phases (according to Cohen (1988) that effect sizes as "small, d = .2," "medium, d = .5," and "large, d = .8. p. 21).

**Participant B**

Participant B’s average score during the baseline was 22.9% which was also the lowest score among all the participants. One reason was because Participant B scored 0% accuracy on the second worksheet during the baseline. Participant B tried to work the second worksheet out however, he got nothing correct. It seems that that Participant B lacked basic word problem solving skills. For example, he did not know how to give the procedures of solving a word problem. He could just simply give the final answer of each word problem directly. Participant B achieved 100% accuracy during the entire intervention phase. He also maintained a high level of accuracy (approximately 90%) during the maintenance phase. His performance varies at the beginning of the maintenance phase and stayed stable during the rest of the sessions which means he gained SSBI skills. Participant B’s had a significant improvement when comparing baseline scores to the intervention and maintenance phases. According to the results of F test, there was significant improvement for Participant B from baseline phase to maintenance phase. The value of Cohen’s d is -5.9 which means there were very strong differences between these two phases.

**Participant C**

Compared with all the other participants in this study, Participant C’s performance during the baseline phase was the most stable one. There was slight variability at the
beginning during the baseline phase. Similar to Participant B, Participant C also gave the final answer of word problems directly during the baseline. During the intervention phase, Participant C had excellent performance with 99% accuracy approximately with very slight variability (within 4%). Participant C also did very well during the maintenance phase. So she gained the skills in solving word problems step-by-step after completing the intervention instead of only giving the final results before. According to the results of F test, there was no significant improvement for Participant C from baseline phase to maintenance phase. However, the value of Cohen’s d is -9.16 which means there were very strong differences between these two phases.

Participant D

Participant D was the last one who was introduced to the intervention. In total, he was given 12 worksheets during the baseline. There was some variability during the baseline with the percentage ranging from 32% to 68%. From the baseline phase, we can tell that Participant D knew the basic methods in solving word problems. He was able to list the equations and give answers. However, he was not able to do well in subtraction word problems. Another weakness that Participant D had in word problem solving was computation skills. This could also be seen during the intervention phase. Considering the limited time during the intervention phase (the end of the fall semester), Participant D was only trained 4 times. Participant D maintained 92% accuracy during the maintenance phase. The points that Participant D lost was also from the subtraction word problems. According to the results of F test, there was no significant improvement for Participant D from baseline phase to maintenance phase. However, the value of Cohen’s d is -3.92 which means there were very strong differences between these two phases.
Conclusions

The success of the SSBI in this project will be attributed to several factors. First, in order for students to have the prerequisite skills of reading and computation, the screening test was implemented first. The investigator could exclude the other factors which could not be solved in this project, such as their poor reading skills and/or computation skills.

Second, the SSBI was effective in this study. Mathematical problems solving can be difficult for students, especially, for lower grade elementary students who are also beginners in this area (Lester, 1980). The results of this study supported that SSBI was effective to those lower graders. In addition, the results of this study also demonstrated the effectiveness to the participants who are at risk of failure in mathematical word problem solving and/or lack basic word problem-solving skills (Kouba et al., 1988) at the second grade level. Four participants’ skills in word problem solving were all improved from the baseline phase to the maintenance phase (Figures 3, 5, 7, and 9), especially, all the participants remained a very high percentage (close to 100% averagely) level during the intervention phase.

Third, the participants in this study not only gained the SSBI skills in solving word problem, but also maintained the skills with high percentage accuracy from 72% to 100% with an average score of 92%. Even though the probes used during the maintenance phase were at similar difficulty level with the probes used in previous phases, the maintenance probes were all novel problems. Therefore, students also demonstrated the skills of generalizing the SSBI to those novel problems. That is SSBI helped students broaden their schema in word problem solving (Jitendra & Hoff, 1996).

Fourth, this study replicated the findings of some of the previous studies that the subtraction word problems are harder than addition word problems (Cawley et al., 1998;
Jitendra et al., 2005; Neef et al., 2003). The difficulties of solving subtraction word problems remained among almost all of the elementary students. In this study, students’ performances in solving one-step addition and subtraction word problems were improved using SSBI. The improvement can be observed from the differences of percentages. Therefore, in this study, the values of Cohen’s d were all large enough to demonstrate a very strong difference between the baseline phase to the maintenance phase for all the participants. These improvements from all the participants were higher than many previous studies (De Corte et al., 1996; Fuchs et al., 2004; Jitendra & Hoff, 1996; Jitendra et al., 2005, 2010; Neef et al., 2003).

Fifth, the major difference of SSBI and SBI is the categorizing method. In previous SBI studies researchers always categorized word problems into different categories (De Corte et al., 1996; Fuchs et al., 2004; Jitendra & Hoff, 1996; Jitendra et al., 2005, 2010; Neef et al., 2003). At the same time, categorizing word problems was also a complicated cognitive strategy for students, especially for those early grade students (Fuchs et al., 2004). Additionally, researchers categorized word problems in different ways in previous studies (Jitendra & Hoff, 1996; Jitendra et al., 2005, 2010; Fuchs et al., 2004; Neef et al., 2003; Xin et al., 2008). The positive results of this study indicated that, at least at the second grade, the way of categorizing word problems was unnecessary. Students can solve word problems based on their reading comprehension skills at the second grade level in general education.

Summary

The present study provided preliminary findings regarding the utility of a SSBI as an instructional technique in facilitating word problem solving in general education at Grade Two level. In addition, the positive results with the four participants expanded previous
research studies performed in this area of study (De Corte et al., 1996; Fuchs et al., 2004; Jitendra & Hoff, 1996; Jitendra et al., 2005, 2010; Neef et al., 2003).

The present study has several limitations. First, all student participants involved in this study were elementary students at the second grade from general education. Unknown is to what extent this model of word problem intervention could have similar effects on students at different grade levels and those with disabilities. Second, there only four participants with similar mathematics word problem solving background were included. Therefore, great caution should be used when generalizing the findings of this study to other students.

Despite the above mentioned limitations, merits exist in the study. The present study provides support for SSBI. The study supports the demand of integrating a scientist-practitioner strategy into mathematics word problem solving by conducting carefully controlled research in natural settings. Additionally, necessary procedures were utilized to minimize various threats to internal validity and therefore, strengthened the study methodologically. These procedures include the use of a multiple baseline procedure across participants, the use of CBM tests in screening test, and the use of baseline, intervention, and maintenance.

One contribution of the study is documentation that, with training and support, students from relatively low performance in word problem solving in general education gained and improved their skills in solving word problems. As discussed earlier, it is important to help these students from the beginning (lower grade elementary students). Comparing to previous SBI strategy, students did not need to identify categories of each word problem using SSBI. The traditional SBI was improved and simplified and proved to be effective in general education.
The current study contributes to the growing body of SBI in mathematics intervention. The study fits in with schema and explicit teaching concept and framework. The current study extends the SBI research which is widely used in mathematics intervention area by simplifying its procedures and demonstrating the effectiveness in mathematics word problem solving.

Further Research

With respect to future research in word problem solving, the results of the present study suggest the following directions. There are some good models that are effective in other areas, peer tutoring, for example. Those models might also be effective in word problem solving using SSBI. Further, considering the limited external validity of this study, it is necessary to test if this strategy is still effective in the third grade. In special education, other methods may be employed to test the effectiveness of SSBI on a large sample of students.
APPENDIX A

EXAMPLE OF WORD PROBLEM WORKSHEET

Name ___________________  Date _________________  Note_______________

1. Tom has 10 books. Tom gave his sister 3 books. How many books does Tom have now?

2. Lee has 10 bags. His sister gave him 8 bags. How many bags does he have now?

3. Tom had 11 blocks. He gave Paul 7 blocks. How many blocks does Tom have now?

4. Scot has 14 cups. His sister gave him 3 more cups. How many cups does Scot have now?

5. Sidd has 12 bags. His brother takes away 8 of his bags. How many bags does Sidd have now?
APPENDIX B

EXPERIMENT PROCEDURE

Randomly select one worksheet containing 5 mixed addition and subtraction word problems.

Standardized administering directions: I will give you 5 word problems to solve. You will have 15 minutes to solve them. I want you to solve as many problems as you can. Work carefully, and do your best. Remember to start with the first problem at the top of the page (demonstrating by pointing), and move to the next one.

Some problems may be easy for you, some may be harder. When you come to a problem you know you can, do it right away. When you come to a problem that is hard for you, skip it and come back to it later.

If you need help reading a problem, raise your hand.

When I say “Begin”, start to work and work for the whole 15 minutes. Write down your complete answer in the space below the problem. The complete answer includes the equation and the solution. If you finish early, check your answers. When I say, “Stop,” please stop working and put your pencil down. Do you have any questions?

Scoring procedure: Each problem will be worth 10 points, 2 points for larger number at the beginning of the equation, 2 points for the smaller number after the operation symbol, 2 points for correct operation symbol, 2 points for correct solution, and 2 points for correct label. Add all points earned on 10 problems and divide by 100 to obtain an accuracy percentage on the probe. Record the percentage at the top of the first worksheet.
APPENDIX C

CBM STANDARDS OF READING FLUENCY AND COMPUTATION FLUENCY

Curriculum-Based Measurement Procedures of Oral Reading Fluency and Math Fluency

A direct reading assessment involves administering a series of short oral reading probes. There are standard passages, but in general, use passages that come from the child’s reading curriculum.

Information that you can obtain:

- Correct Words per Minute (CWPM)
- Incorrect Words per Minute (ICWPM)

General instructions:

1. Select level that corresponds to suggested placement. You will present 3 passages for each level assessed.

2. Place student copy in front of student. Have your own copy in front of you. Your copy should include numbered lines and comprehension questions. Do not allow student to see your copy.

3. Say:

   “When I say ‘begin,’ start reading aloud at the top of this page. Read across the page [demonstrate by pointing]. Try to read each word. If you come to a word you don’t know, I’ll tell it to you. Be sure to do your best reading. Are there any questions?” [pause here]

4. Say “Begin” and start your stopwatch. Follow along on your copy, marking incorrectly read or skipped words as outlined in the scoring procedures. When one min. has elapsed, make a slash (/) after the last word read.
5. Allow the student to finish reading the entire probe. When finished, present the comprehension questions. Record the student’s answers.

If a student reads very slowly or poorly, you may elect to stop the student after one minute due to potential frustration of the reader, time issues, etc.

6. Count the total number of words correct and the number of errors for each passage. Score the percent correct on comprehension questions. Record scores and identify median correct, median incorrect (both per min), and median comprehension for each level assessed.

**Scoring:**

As the student reads, mark the following errors:

1. **Omissions:** if the student leaves out the entire word (/)
   
   If the student omits the entire line, redirect him/her to the line as soon as possible and count ONLY ONE error (not as an error for each word missed). Subtract the number of words skipped in the line from the total number of words read in the passage. If you cannot redirect the student, count only as one error, not as an error for each word.

2. **Substitutions/Mispronunciations:** if the student says the wrong word (\)
   
   If the student mispronounces a proper noun (1st time only), count it as an error the 1st time and provide the correct pronunciation; accept as correct all subsequent presentations of the same noun.

   If the student mispronounces a word, give the child the correct word and instruct them to go to the next word if they hesitate.

   If the student deletes suffixes (e.g., -ed, -s) the deletion **IS NOT** counted as an error.
3. **Additions/Insertions**: if the student adds a word or words not in probe (/ between words)

4. **Pauses/Hesitations**: after 3 s (5 S?), supply word and count the pause as an error (P)

5. **Transpositions**: count as 1 error (~)

**DO NOT COUNT THE FOLLOWING AS ERRORS:**

- Repetitions
- Self-corrections: (circle if self-correct)

**How to Categorize Scores**

<table>
<thead>
<tr>
<th>Grade Level of Materials</th>
<th>Level</th>
<th>CWPM</th>
<th>ICWPM</th>
<th>Comprehension (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frustrational</td>
<td>&lt;40</td>
<td>&gt;4</td>
<td>80</td>
</tr>
<tr>
<td>1-2</td>
<td>Instructional</td>
<td>40-60</td>
<td>4 or less</td>
<td>80</td>
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<tr>
<td></td>
<td>Mastery</td>
<td>60+</td>
<td>2</td>
<td>80</td>
</tr>
<tr>
<td>3+</td>
<td>Frustrational</td>
<td>&lt;70</td>
<td>8+</td>
<td>&lt;80</td>
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<td>Instructional</td>
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<td>6 or less</td>
<td>80</td>
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<tr>
<td></td>
<td>Mastery</td>
<td>100+</td>
<td>2</td>
<td>80</td>
</tr>
</tbody>
</table>

*Fuchs & Deno (1982)*

**Mathematics**

A direct assessment of mathematics involves administering “end of book” math tests and timed computation probes.

**General Instructions for “End of Book”:**
1. Identify grade level which corresponds to student’s suggested placement. To begin assessment, administer end of book test for immediately preceding grade level.

Example: If recommended placement is Grade 5 (up to midbook), administer end of book test for midbook test for Grade 4.

Example: If suggested placement is Grade 5 (second half of book), administer midbook test for Grade 5.

2. Mastery criterion on end of book tests should be set at 80%. Subsequent tests should be administered until a book placement is found.

3. When scoring, report: Percentage of total problems completed AND percentage correct of problems completed.

4. Examine items completed by student. Look for a pattern of errors. Some students may have a specific computation problem or they may be unable to complete certain types of problems (e.g., metric problems, word problems, etc.). The identification of a specific area of weakness will allow for more precision in placement of students.

**General Instructions for Time Computation Probes:**

These types of probes are useful for providing very specific recommendations regarding deficient and mastered math skills. Sheets can also be valuable in monitoring the acquisition of newly taught skills.

1. Determine the specific types of math problems in which you are interested. This can be determined by examination of end of book tests, local school district year-end objectives, etc.
2. Use 3 different probe sheets for each skill. Give a probe to the student and say:
   Single skill probe: “The sheet on your desk is math facts. All of the problems are [addition, subtraction, multiplication, division] facts.”

   Multi-skill probe: “The sheet on your desk is math facts. There are several types of problems on the sheets. Some are [insert types of problems included]. Look at each problem carefully before you answer it.”

   Then say: “When I say ‘begin,’ start answering the problems. Begin with the first problem and work across the page [demonstrate by pointing]. Then go to the next row [demonstrate by pointing]. If you cannot answer a problem, mark an ‘X’ through it and go to the next one.

3. Say “Begin” and start timing. When 1 min. has elapsed, ask student to stop and mark sheet where they stopped.

4. If a student’s score on the probe is significantly below instructional level, only give one additional probe of those skills. If the child score close to or within the instructional/mastery level, administer the remaining 2 probes of the same level. Continue to move up or down in levels as indicated by performance. Discontinue when you obtain an instructional level followed by a frustrational level.

   Scoring:
   1. Count the separate digits in an answer.

   2. For all skills, except long division, only digits below the line are counted. For example, in a 2-digit addition problem with regrouping, digits written above the 10’s column are not counted. In complicated problems such as long division, all digits (above and below) the line are counted.
3. Count the number of digits correct and incorrect for each probe.

4. If the child completed the worksheet before the 1 min elapsed, the evaluator should divide the number of digits by the total number of seconds and multiple by 60.

5. The median score for all probes at a level or skill serves as the score for that skill or level.

6. Omitted problems are counted as errors. This will inflate the number of incorrect digits per min. and deflate the number of correct digits per min, however, because skipping usually indicates that a student has mastered only certain skills assessed on the worksheet. Be sure to note inflation on report if skipped problems are excessive.

7. When a student makes an error in multiplication, digits should be scored as correct or incorrect the addition operations are performed correctly. In these cases, you should also score the probes for the percentage of problems completed correctly.
How to Categorize Scores

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Level</th>
<th>CDM</th>
<th>IDPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>Frustrational</td>
<td>0-9</td>
<td>8+</td>
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<tr>
<td></td>
<td>Instructional</td>
<td>10-19</td>
<td>3-7</td>
</tr>
<tr>
<td></td>
<td>Mastery</td>
<td>20+</td>
<td>2 or less</td>
</tr>
<tr>
<td>4+</td>
<td>Frustrational</td>
<td>0-19</td>
<td>8+</td>
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<tr>
<td></td>
<td>Instructional</td>
<td>20-39</td>
<td>3-7</td>
</tr>
<tr>
<td></td>
<td>Mastery</td>
<td>40+</td>
<td>2 or less</td>
</tr>
</tbody>
</table>

*Values are from Deno & Mirkin (1977)*
APPENDIX D

TREATMENT INTEGRITY CHECKLIST

1. Administer at least three baseline probes at the student’s grade level.

2. Introduce each step of the intervention to participants explicitly”
   
   Step 1: students were instructed to read the word problem out loud a couple of times to identify the following all the components;
   
   Step 2: students were taught to fill the diagram in the orders;
   
   Step 3: students were taught to decide the operation of choice;
   
   Step 4: students were required to solve the equation and check the answer) explicitly.

3. During the maintenance phase, participants did not receive any extra help.
APPENDIX E

HUMAN SUBJECTS REVIEW COMMITTEE APPROVAL

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board
118 College Drive #5147
Hattiesburg, MS 39406-0001
Tel: 601.266.6820
Fax: 601.266.3509
www.usm.edu/irb

HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE
NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 21, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 10072008
PROJECT TITLE: The Effects of Simplificie Schema-Based Instruction on Students' Mathematics Word-Problem Solving Performance
PROPOSED PROJECT DATES: 08/01/2010 to 08/31/2011
PROJECT TYPE: Dissertation or Thesis
PRINCIPAL INVESTIGATOR: Houbin Fang
COLLEGE/DIVISION: College of Science & Technology
DEPARTMENT: The Center for Science & Math Education
FUNDING AGENCY: N/A
HSPRC COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 09/10/2010 to 09/09/2011

Lawrence A. Hosman, Ph.D.
HSPRC Chair

9.13.2011
Date
REFERENCES


