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**THE EFFECTS OF COGNITIVE STRATEGIES PAIRED WITH HANDS-ON OR
VIRTUAL MANIPULATIVES ON MATH INSTRUCTION FOR STUDENTS
WITH MATHEMATICAL LEARNING DISABILITIES TO LEARN WORD
PROBLEM SOLVING SKILLS**

by

Kimberly C. Plute

A Thesis

Submitted to the
Department of Interdisciplinary and Inclusive Education
College of Education
In partial fulfillment of the requirement
For the degree of
Master of Arts in Learning Disabilities
at
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Thesis Chair: Joy F. Xin, Ph.D.

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Dedications

I would like to dedicate this thesis to my students who allowed me to conduct this study, and whom inspires me every day to be the best educator I can be. Also, I dedicate this thesis to my family and friends who have supported and guided me throughout my time in this program of study.

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Abstract

Kimberly C. Plute

THE EFFECTS OF COGNITIVE STRATEGIES PAIRED WITH HANDS-ON OR
VIRTUAL MANIPULATIVES ON MATH INSTRUCTION FOR STUDENTS WITH
MATHEMATICAL LEARNING DISABILITIES TO LEARN WORD PROBLEM
SOLVING SKILLS

2015-2016

Joy F. Xin, Ph.D.

Master of Arts in Learning Disabilities

The purposes of this study was to evaluate the effects of using cognitive strategies with hands-on manipulatives, and cognitive strategies with virtual manipulatives to enhance problem solving skills of students with Mathematical Learning Disabilities (MLD), as well as their satisfaction with those strategies. Five, 5th graders with MLD participated in the study to learn word problem solving skills in a math class for 80 minutes, 5 days a week for 10 weeks. A single subject research design with ABC phases was used in the study. Results showed each student gained from 3.6 to 5.2 mean points of the weekly quizzes compared to the baseline. A paired cognitive strategy with hands-on manipulatives or computer-based manipulatives may strengthen the math instruction and provide further practices to benefit students with MLD to learn problem solving skills.

Table of Contents

Abstract	v
List of Figures	viii
List of Tables	ix
Chapter 1: Introduction	1
Statement of Problems	1
Significance of Study	6
Statement of Purpose	7
Research Questions	7
Chapter 2: Review of Literature	9
Approaches to Teaching Mathematical Word Problem Solving	9
Metacognitive Approach	10
Manipulative Approach (Hands-on)	15
Technology Approach (Virtual Manipulative)	17
Summary	20
Chapter 3: Method	22
Setting	22
Classroom	23
Participants	23
Students	23
Teacher	25
Materials	25
Instructional Materials	25

Table of Contents (Continued)

Measurement Materials.....	26
Procedure	27
Instructional Procedure	27
Measurement Procedure.....	29
Research Design.....	29
Data Analysis	30
Chapter 4: Results.....	31
Weekly Quiz	31
Survey	34
Chapter 5: Discussion	36
Limitations	38
Implications.....	39
Conclusion and Recommendations.....	40
References.....	41
Appendix A: Handouts	43
Appendix B: Weekly Quiz.....	47
Appendix C: Satisfaction Survey.....	49

List of Figures

Figure	Page
Figure 1. Participant's Quiz Scores Across Phases	33

List of Tables

Table	Page
Table 1. General Information of Participating Students	23
Table 2. Weekly Instructional Procedures	28
Table 3. Means and Standard Deviations of Students Quiz Scores	31
Table 4. Means and Standard Deviations of Student Responses to the Survey	34

Chapter 1

Introduction

Statement of Problems

Mathematics is one of the key subject areas with the most abstract skills taught in elementary school. The technique of using concrete examples when teaching mathematical concepts is a way to enhance learning. Hiebert, Carpenter, Fennema, Fuson, Wearne, Murray, Olivier, and Human (1997) argued that mathematical tools can build a foundation for children to understand concepts, which can then initialize an abstract understanding (as cited in Reimer & Moyer, 2005, p. 6). For example, children learn at a young age what a number is and how it represents a specific amount in a very concrete way by counting various objects. Quickly children understand that numbers represent quantity. As they move along in school they are introduced to different mathematical symbols, such as the plus sign representing addition and the minus sign for subtraction. Again, they learn these in a concrete way by using objects to add to and take away from a specific amount. Even further, students learn very concretely how to add and subtract double digit numbers with math cubes, representing ones, groups of tens, and even hundreds. However, starting at the 4th grade, the mathematical curricular require solving word problems, which contain numbers, words to represent numbers, and operations with non-relevant information included. Students are no longer required to complete a computational problem but yet a mathematical problem within context. The keys to deciphering these problems require not only abstract knowledge of numbers and operations but also reading comprehension skills.

According to Carbonneau, Marley and Selig (2012), more than 50% of students from 4th to 8th grade in the U.S.A., failed to meet the standard of proficiency in mathematics in 2011, which lag behind the other developed countries, such as South Korea, Japan, and Finland. A new initiative called *Educate to Innovate*, proposed by President Obama is to target student achievement within science, technology, engineering, and mathematics with a focus on increasing domain-specific critical reasoning skills (Carbonneau et al., 2012). The expectations of mathematical achievement for students are the most important. This achievement not only includes computational skills, but also problem solving and critical thinking skills.

Students with mathematical learning disabilities (MLD) often struggle across most academic subjects with reading as the most. MLD does not necessary have to include students who are classified as having a specific learning disability, rather it includes students who greatly struggle with mathematical concepts, specifically word problem solving. It should include “children who performed in the lower 25th percentile on norm-referenced word problem solving math tests. The 25th percentile cutoff score on standardized achievement measures has been commonly used to identify children at risk” (e.g., Fletcher et al., 1989 and Siegel & Ryan, 1989) (as cited in Swanson, Moran, Bocian, Lussier, Zheng, 2012, p. 205). When context is added to the mathematical problems, these students present a greater deficit in learning. Some of them are already struggling in computational skills; if the task of reading and deciphering are required, these students will become low achievers and fail eventually.

Typical instructional strategies for word problem solving in mathematics include key words, cognitive strategies, using manipulatives, and technology. For example,

teaching students to use “key word” to look for words such as, added to, more than, less than, quotient of, and product of. However, this strategy doesn’t help the students if they cannot comprehend and decode what they are reading to make sense. Often times the word problems won’t even include those “key words” but worded as scenarios. Although using key words is a commonly taught strategy, research has demonstrated that using key words encourages a superficial understanding of the problem and also may lead students to select the wrong operation, for example “more” may require subtraction (Hudson & Miller, 2006). Thus, the use of key words is a less effective strategy than paraphrasing the important information (Krawec, Huang, Montague, Kressler, Melia de Alba, 2012). Moreover, multi-step word problems are presented and students are no longer being asked to solve word problems with only one step. Therefore, the students have no idea where to even begin with and what is really being asked.

To date, there are limited mathematical instructional strategies targeting the word problem solving. According to Goldsmith and Mark (1999), pedagogical changes stress student engagement through investigations, multiple representations, and discussion, primarily through problem-solving activities. Yet, despite the increased interest given to math problem solving by researchers and practitioners, students in general, but particularly students with MLD, continue to struggle. Difficulties in working memory and processing speed (Fuchs and Fuchs, 2002), identifying the correct operation and performing the computation (Huinker, 1989; Montague & Applegate, 1993a), higher order reasoning (Maccini & Ruhl, 2001), and the comprehension demands inherent in word problems combine to make math problem solving one of the most challenging parts of the curriculum for this group (Lerner, 2000) (as cited in Krawec et al., 2012, p. 80).

Reading is the first component for solving a word problem. Reading comprehension has been found to be highly predictive of solution accuracy (e.g., Cornoldi, Drusi, Tencati, Giofre, & Mirandola, 2012; Kail & Hall, 1999; Swanson, Cooney, & Brock, 1993; Vilenius-Tuohimaa, Aunola, & Nurmi, 2008) and in some cases is a better predictor of solution accuracy than calculation skills; (e.g., Swanson et al., 1993) and misunderstandings occur when students construct a mental model of a problem that conflicts with information, such as the propositions in the problem statement (Swanson et al., 2012). Students are easy to misunderstand what the problems are asking and how operations or steps should be used to solve the problems. Also, many problems tend to include extra information that can be considered irrelevant. Students often confuse this kind of information as part of the problem and the importance related to the problem. Therefore, these students not only need to support with the operational skills but also the reading comprehension to understand the word problem presented.

A strategy that can address the understandings of word problems is to use metacognitive strategies. For example, a strategy title *Solve it!* uses metacognitive strategies to activate students thinking when working through word problems. According to Montague, Warger, and Morgan (2000), *Solve It!* is a researcher-developed intervention to improve the problem-solving performance of students with LD by explicitly teaching the cognitive processes and metacognitive strategies that proficient problem solvers use to solve math word problems (as cited in Krawec et al., 2012, p. 81). *Solve it!* has seven steps, which include: (1) reading the word problem and rereading as necessary, (2) paraphrasing the word problem into the readers own words, (3) visualizing the word problem by drawing a picture, (4) creating a hypothesis on how to solve the

problem, (5) using estimation to solve the problem, (6) solving the problem, and (7) checking their work. This is effective because the success of *Solve It!* instruction is founded on effective cognitive and metacognitive processes and strategies for math problem solving, and it provides students with a research-validated problem-solving routine, which has demonstrated results (Krawec et al., 2012). The findings from Krawec et al. (2012) demonstrated that students receiving *Solve It!* intervention outperformed control students on reported strategy use regardless of ability level, with a medium effect size of 0.52, is in agreement with these previous studies that emphasized solution accuracy. The present finding from Krawec et al. (2012), with its emphasis on strategy use, adds to the understanding of why the intervention may be effective. It teaches students the processes and strategies needed to represent mathematical word problems and how to apply those processes and strategies when solving problems. It is found that *Solve It!* enhances the strategy knowledge of students across ability levels (Krawec et al., 2012). How often metacognitive strategies, such as *Solve it!* are being used by students with MLD may need to be explored.

Furthermore, students struggle to work through word problems because of the abstract nature of the context. The use of manipulatives can be an effective way to assist students in visualizing the word problem. The National Council of Teachers of Mathematics (NCTM, 2000) has recommended that students be provided access to manipulatives in order to develop mathematical understanding. Manipulatives can be used in two ways, hands-on or virtual computer-based. Hands-on manipulatives include any tangible item that assists students in solving mathematical problems. These manipulatives include: base-ten blocks, fraction strips, protractors, calculators, index

cards, post-its, cubes, shapes, coins, and many more. Virtual computer-based manipulatives are the same items but simulated on the computer. Virtual manipulatives can be beneficial because it adds a component of motivation for the students to use the technology. Manipulatives, whether physical or virtual, have allowed students to understand abstract concepts in a more concrete way. However there is still much research to be conducted in regards to manipulatives, whether hands-on or computer-based. To date, studies have shown limitations, such as, limited environment and participating students, and inconclusive findings which result inconclusive findings (e.g., Reimer & Moyer, 2005; Baki, Kosa, & Guven, 2011). Future research to examine possible differences in students' responses to instruction involving manipulatives is needed to determine the effectiveness of hands-on and computer-based manipulatives when solving word problems.

Significance of the Study

President Obama's *Educate to Innovate* (2009) initiative calls teachers to provide instructional strategies for students to foster their critical thinking skills, such as reasoning and problem solving. These skills are vital for students to be successful in learning mathematics at middle and high school.

There are many different instructional strategies in word problem solving, such as using key words, metacognitive strategies, manipulatives, and technology. However, some are abstract and difficult for the students with math learning problems; especially those with learning disabilities, communication impairments, and attention deficits. Using cognitive strategies, such as *Solve it!* to active a student's metacognition have been proven effective ways to enhance reading comprehension. Students who exhibit learning

deficits in mathematics typically lack the background knowledge and fundamental problem solving skills. According to Belenky and Nokes (2009), materials themselves, such as manipulatives, do not improve the students ability to reason deeply and there is still work to be done to figure out all the ways in which materials and student cognition interact across a variety of populations. The present study is designed to examine the impact of combining cognitive strategies, manipulatives, and technology to teach student's problem solving skills in mathematics. The manipulatives will be used in two ways: hands-on activities and using virtual computer-based program with simulated manipulatives. It attempts to investigate the effects of cognitive strategies paired with two different tools, hands-on activities and computer programs for students with MLD.

Statement of Purpose

The purposes of this study are to: a) evaluate the effectiveness of using cognitive strategies with hands-on manipulatives to enhance problem solving skills of students with MLD; b) evaluate the effectiveness of using cognitive strategies with virtual computer-based manipulatives to enhance problem solving skills of students with MLD; c) examine student satisfaction with the use of cognitive strategies, hands-on manipulatives, and computer-based manipulatives to assist in their mathematical problem solving skills.

Research Questions

1. Do students with MLD increase their scores when cognitive strategies paired with hands-on manipulatives are provided to solve word problems?
2. Do students with MLD increase their scores when cognitive strategies paired with computer-based manipulatives are provided to solve word problems?

3. Are the students satisfied with learning word problem solving skills while using cognitive strategies, hands-on manipulatives, and computer-based activities?

Chapter 2

Review of the Literature

According to Krawec, et. al. (2012) math problem solving is an increasingly critical skill in today's mathematics curriculum. Success in math problem solving is highly correlated with overall math achievement (Bryant, Bryant, & Hammill, 2000), and the need to develop proficiency in this domain is relevant to a student's success in school. Solving word problems requires computation, reading, reasoning, and critical thinking skills. The strategy of teaching "key words" was often used; however, research has shown that this often used approach is ineffective because "key words" may lead students to select the wrong operation, e.g., "more" may require subtraction not addition (Hudson & Miller, 2006). Thus, the use of key words is a less effective strategy than paraphrasing the important information (Krawec, et. al., 2012). Other instructional strategies in mathematical problem solving have been researched. This chapter presents a review of research on three different approaches: cognitive strategies, manipulatives, and using technology for teaching problem solving skills, especially for teaching students with MLD.

Approaches to Teaching Mathematical Word Problem Solving

Three major approaches to teaching mathematical problem solving include: cognitive strategies, the use of manipulatives, and technology. The cognitive strategy approach is evaluated through the studies that adopted the *Solve it!*. Manipulatives were researched in two ways including: hands-on, physical use of manipulatives and manipulatives paired with cognitive strategies. Lastly, technology and its role in assisting students with solving word problems is assessed, specifically focusing on computer-

based simulated manipulatives. All of these approaches were reviewed and examined in the context of how these can be used and replicated for students with MLD.

Metacognitive Approach

Students with MLD have difficulties in solving word problems because they become misled by the words. Reading is the first requirement to solve a word problem. For example, reading comprehension has been found to be highly predictive of solution accuracy (e.g., Cornoldi, Drusi, Tencati, Giofre, & Mirandola, 2012; Kail & Hall, 1999; Swanson, Cooney, & Brock, 1993; Vilenius-Tuohimaa, Aunola, & Nurmi, 2008) and in some cases is a better predictor of solution accuracy than calculation skills, (e.g., Swanson, et. al., 1993), and misunderstandings occur when students construct a mental model of a problem that conflicts with information, such as the propositions in the problem statement (Swanson, et. al., 2012). Therefore, the first step for students with MLD to solve word problems is to accurately decipher the word problem at hand and determine what operations are being asked. The ability to successfully do this requires metacognitive awareness. Students need to talk through their word problems and ask themselves what is relevant, what isn't relevant, what should determine, and what operation must be performed. Instructing students to use cognitive strategies when reading through word problems can assist them in that process (e.g., Krawec, et. al., 2012; Montague, Krawec, Enders, & Dietz, 2014).

Krawec and colleagues' study (2012) examined the effects of the cognitive strategy, *Solve it!*, on math problem solving for middle school students with learning disabilities. *Solve it!* is a researched based intervention to improve problem-solving skills.

It explicitly teaches the cognitive processes and metacognitive strategies that proficient problem solvers use (Krawec, et. al., 2012).

Participants included 53, 7th graders in an experimental group and 29 in a control group; moreover, 35, 8th graders in an experimental group and 44, 8th graders in a control group. Both the control and experimental groups contained students classified with a learning disability (LD) and average achieving students (AA) randomly assigned into these groups. Procedures for the experimental group included three days of initial instruction and then once weekly for 30 minutes of intervention instruction for the rest of the year. The intervention instruction was a scripted *Solve it!* lesson that focused on solving word problems in the following sequence: reading and paraphrasing, visualizing the problem, making a hypothesis and estimation, computing the problem, and then checking the answer. The comparison group received no intervention instruction and teachers were advised to teach as they normally do; however, to focus on problem solving during at least one class period weekly for the year. A pre and posttest on math problem-solving was provided to evaluate student's performance as well as a structure interview to record their application of these strategies.

The results indicated that students who received the intervention reported using significantly more strategies than those in the control. However, average achieving students reported using more strategies than those with LD. Overall, the students receiving the intervention improved significantly from their pre to posttests when compared to those in the control. While strategy use was reported, there are some limitations. Such as, this study did not measure the students' actual use of the strategy for problem solving; therefore, there is no idea whether they actually used the strategies.

Knowing the strategies may not mean the application of these strategies. Students with LD typically struggle in implementing cognitive strategies for problem solving and future research is needed to record actual strategy use and problem solving accuracy.

Further, Montague and colleagues' study (2014) investigated the effects of the cognitive strategy *Solve it!* on students of varying abilities, including students with LD, low-achieving and average-achieving students. The participants included 1,059, 7th graders, 644 in the experimental group and 415 in the control. As well as 34 teachers, 16 taught the experimental group and 18 taught the control. Both groups included students with LD, low-achievement, and average-achievement. Students in the experimental group were given three days of intensive instruction on the *Solve it!* strategy and then weekly problem solving practice, while those in the control group received regular instruction with a focus on word problem solving once a week. A pre and posttest on math problem solving and Florida Comprehensive Assessment Test (FCAT) were used to evaluate student's performance.

The results indicated that there was no statically significant difference between the two groups on the FCAT; however, there was a small effect on growth when comparing with years of 2009 and 2010. The experimental group demonstrated small growth rate from 2009 to 2010, and the control group had a monthly growth rate of .716 compared to the experimental group with a monthly growth of 1.323, demonstrating a significantly higher rate. Overall, the intervention effect was stronger for low-achieving students compared to average-achieving students. Students with LD showed a positive growth rate compared to average-achieving students, however it was not statistically

significant. The limitation of this study is the unknown of whether either group engaged in more problem-solving than the other.

Despite the positive results of these two studies, some concerns were raised, such as, the effectiveness of the intervention in regards to curriculum and state standards and the actual implementation of the strategy by the students. First, there is a concern of the relationship between interventions and the curriculum. Montague, et. al., (2014) found no statistically significant difference between the groups on the FCAT. Therefore, teachers and school districts will be less likely to adopt an intervention if it does not show growth on the state assessment scores. Lastly, there is no evidence showing if and how often students are using the metacognitive strategies during their problem solving.

In contrast, Swanson and colleagues' study (2012) demonstrated inconclusive findings. In their study, the use of generative strategies was evaluated to improve word problem solution accuracy in children at risk for MLD. A total of 91, 3rd graders participated; 46 boys and 45 girls from four elementary schools in two southwest U.S. school districts, 69 identified as being at risk for MLD assigned to the experimental group and 22 for the control. The students in the experimental group were randomly assigned to one of three treatment conditions, 18 in each, for example, 1.) Restate, when students were asked to paraphrase the question proposition, focusing only on the question being asked in the word problem; 2.) Relevant, focusing on paraphrasing relevant propositions; to include the question and numbers needed to solve the problem; 3.) Complete, paraphrasing all the propositions in the word problem; while 15 participants were placed in the control.

All the students in the treatment condition received supplemental instruction in word problem solving, but those in the control received supplemental instruction from the classroom teacher. The instruction was conducted for 30 minutes a session, twice a week, for 10 weeks, with a total of 20 lessons. The lessons were scripted from a booklet including 4 phases: warm-up, modeling with one problem, guided practice with one problem, and independent practice with three problems.

Pre and posttests were used to evaluate student performance. The student posttest scores of problem solving accuracy for Restate, Relevant, and Complete conditions were not significantly different from the control. There was an apparent advantage for participants in the control group compared to those identified as at risk. When comparing the treatment conditions posttests, there was a significant advantage for participants in the Relevant and Complete conditions when compared to the at risk for MLD in the control. Moreover, statistical analysis concluded a significant difference in favor of Relevant and Complete conditions when compared with other conditions. According to Swanson, et. al., (2012), the results support the notion that paraphrasing relevant-only and all propositions enhance problem-solving accuracy. In regards to identifying problem solving components, there were significant gains in the posttest to compare to the control group. Also, there was a significant difference in favor of Complete and Relevant conditions compared to other conditions that included students at risk for MLD. However, when comparing the participants in the control group to Relevant and Complete conditions, there were no significant differences on the posttest.

Overall, the results showed that generative treatment conditions focusing on relevant-only propositions or all propositions facilitated solution accuracy when

compared to control conditions with and without participants at risk for MLD. However, this study focused on working memory capacity, and without the working memory capacity there was no significant gain for the complete generative condition. This study lends itself to some limitations, such as participating students, limited environment, and inconclusive findings.

Manipulative Approach (Hands-on)

Manipulatives can be hands-on, tangible items that students use to conceptualize a word problem. They allow students to physically manipulate items to understand abstract concepts in a concrete way. This has been an effective strategy for teaching the skills of solving word problems to children with disabilities, especially for those with MLD (e.g., Aburime, 2007; Tournaki, Seh Bae, & Kerekes, 2008). Tournaki, Seh Bae, and Kerekes's study (2008) investigated whether a manipulative called "rekenrek" was effective in teaching addition and subtraction to students with MLD. The "rekenrek" is based on a five structure, containing two rows of 10 beads, each broken into sets of five by color. This allows students to manipulate addition and subtraction of numbers by using sets of five. A total of 45, 1st graders with learning disabilities in a self-contained classroom were randomly assigned into three different groups with each of 15.

The students in Group 1 and 2 received 15 lessons, 30 minutes daily for 3 weeks in addition to classroom instruction. Group 1 received the lessons with the use of "rekenrek," Group 2 received the same lessons without the "rekenrek," and Group 3 received no such lessons. Curriculum based pre and posttests, each with 20 questions on addition and subtraction from zero to 20 were used to evaluate student's progress.

The results indicated that students in Group 1, receiving instruction with the “rekenrek” manipulative, performed significantly higher than those in Groups 2 and 3, while no significant difference was found between these two groups. Manipulatives serve as facilitators of knowledge for students to develop efficient thinking strategies because learners must create a relationship between action and thought.

In Aburime’s study (2007), the effectiveness of simple improvised geometric manipulatives was evaluated on Nigerian high school students. There was a total of 185 high school participants who were randomly assigned in two groups, 94 in the experimental and 91 in the control. Students in the experimental group received instruction for 10 weeks with Simple Improvised Manipulatives (SIM). SIM is geometric manipulatives made from ordinary cardboard paper. It included 18 different shapes, such as triangles, quadrilaterals, parallelograms, and trapezoids. Students in the control received regular instruction without the SIM. A pre and post Mathematics Achievement Test (MAT) with 68 multiple choice questions was used to evaluate student learning outcomes.

Results indicated that there was a significant difference between the experimental and control with an average increase of scores of 3 to 1, in favor of the experimental group. This supports the notion that simple manipulatives can improve students understanding of math concepts.

Despite the positive results, some concerns were raised in regards to the limitations of these studies. First, both studies focus on specific manipulatives, “rekenrek” and SIM. Considering that the results are specifically related to those types of manipulatives, it cannot be assumed that same positive results would occur for other

types of manipulatives. A wide range of manipulatives, across a variety of mathematical skills need to be examined to conclude a consensus about manipulatives. Also, both of the studies were related to specific grade levels. Tournaki and colleagues study (2008) focused on 1st graders and Aburime's (2007) on high schoolers; therefore, these results cannot be associated with every grade level. Tournaki et al. (2008) focused on students with MLD only, while Aburime (2007) on low achievers. Therefore, students at a variety of grade levels should be assessed to determine the effectiveness of manipulatives.

Technology Approach (Virtual Manipulative)

Virtual manipulatives are replicas of physical manipulatives that are placed on the internet in the form of computer applets with advanced features. Technology has been an effective strategy for supporting students with disabilities, especially for those with MLD (e.g., Reimer & Moyer, 2005; Shamir & Baruch, 2012). In Reimer and Moyer's study (2005), 19, 3rd graders participated to learn fractions using virtual manipulatives. In an inclusive classroom including students with special needs. The study lasted for two weeks. During the first week students were given pretests on conceptual and procedural knowledge for learning fractions, and then introduced to virtual manipulatives. During the second week, students were taught the unit on fractions, during which the students spent one hour each day for four days in the computer lab using virtual manipulatives. The teacher started each lesson by reviewing and modeling how to use the virtual manipulatives and assigned students for independent practice with the computer.

Teacher-made pre and posttests on conceptual knowledge and procedural computational skills were used, as well as a survey and interview to obtain their opinions. The results indicated that students scored significantly higher on posttest related to

conceptual knowledge than the pretest; however there was no significant difference between student's pre and post scores on procedural computational skills. Moreover, the student survey revealed that their experience with the virtual manipulatives was positive, with 59% of positive responses. The interview results showed that students felt successful during their experience. They reported that the virtual manipulatives helped them learn and easy to use with quick, specific feedback, and fun. Virtual manipulatives can be an effective way to conceptualize abstract mathematical skills with enjoyable experience for students.

Another study by Shamir and Baruch (2012) examined the effects of using educational e-books to support vocabulary development and early math instruction for children at risk for learning disabilities. E-books are computer-based activities that can actively engage learners using a variety of online representations, such as text, oral narrations, animations, and illustrations, to motivate students with an interactive way of a multi-sensory learning experience.

A total of 52 preschoolers entering kindergarten, who were determined to be developmentally delayed and at risk for learning disabilities were included in this study. The participants were randomly divided into the experimental and control groups, with 26 in each. A pretest for vocabulary and emergent math were given before instruction, and then children in the experimental group were provided six independent sessions with the e-book. This included 20 minutes for each of the three modes (read story only, dictionary, and read and lay with numbers). Lastly, a posttest was given to both groups on the same vocabulary and emergent math skills.

The results showed significant differences between the two groups on posttest scores, in favor of the experimental and a significant improvement was found from pre to posttests for three of the four ordinal number subtests for both the experimental and control groups. In regards to vocabulary, the experimental significantly gained compared to the control. Overall, the results suggest that kindergarteners at risk for learning disabilities are able to improve their early math skills after engaging in educational e-book activities. The study supports the notion that technology can be a useful tool in improving the skills of students who lag behind the rest of their peers.

Despite the positive results, some concerns were raised, such as the limited number of participants in each study and their duration. Both studies included only one to two classes of participants for a couple of weeks. It is difficult to generalize the results of these studies in relation to other students because there was not enough time to determine how the interventions would improve student performance over a longer period of time. Would the intervention still be effective after a few months? Would it be effective if the number of participants was increased? Overall, the use of technology needs to be evaluated over a long period of time in various skill areas.

In contrast, Nguyen, Hsieh, and Allen's study (2006) determined that using computer technology had no difference on students learning attitudes toward mathematics. The study examined 74, 7th graders' learning attitudes towards mathematics. One teacher's four math classes from southern Texas participated in this study with 33 randomly assigned students in traditional assessment and practice (TP), while 41 in web-based assessment and practice (WP). A pre and post survey on their attitudes towards mathematics was provided, followed by a 10 minute interview to

elaborate on their responses to the survey questions. Students in the WP group worked in their computer lab with online practice tasks, while the TP group worked in the classroom with their teacher. Both groups practiced four different sets of homework with practice tasks focusing on fractions and decimals. The WP group had randomized items, automatic grading and feedback, while the TP group had the same questions and activities, but on paper. The students were provided two paper versions and encouraged to try both. The teacher hand graded the worksheets that were returned to the students.

The results showed that there was no statistical significant difference between the two groups in students' post attitude toward mathematics learning. However, the TP groups' attitude remained the same, while the WP student's attitudes showed some improvement. Furthermore, in the interview, the WP students reported that they enjoyed working on the computer and wanted to have more computer math practice. Specifically, the students preferred the immediate feedback and instant scoring the computer provided. It provided the students the opportunity to recognize their mistakes early on and fix them; while, adjusting their understanding is important in the learning process and immediate feedback and scoring allowed them to recognize their mistakes. Limitations for this study include the limited number of participants; geographic location, limited grade level, duration of study, and the study only examine the effect on learning attitudes, not solution accuracy. More studies are needed to evaluate virtual manipulatives in learning math problem solving, especially for those with MLD.

Summary

Overall, the review of the literature brings to light effective ways to assist students in mathematical problem solving. However, all the studies reviewed, examined strategies

in isolation; for example, examining only manipulatives, only technology, or only cognitive strategies. To further enhance student's word problem solving skills, specifically students with MLD, these strategies should be combined and implemented. Cognitive strategies should be a part of a student's everyday thinking and problem solving. Manipulatives or technology should then be paired with the use of cognitive strategies to optimize student's opportunity for understanding the process and practice in a meaningful way. This current study attempts to evaluate the effectiveness of the use of pairing cognitive strategies with manipulatives and technology to improve mathematical problem solving skills for students with MLD.

Chapter 3

Method

Setting

The study was conducted at a middle school located in New Jersey. The state Department of Education (2000) listed the District Factor Group (DFG) for the borough as “B,” based on the 2000 Decennial Census Data. The DFG represents an approximate measure of a community’s socioeconomic status (SES) and is ranked from “A” to “J.” Districts having the later classification have the highest SES. Thus, the borough is classified as a Title 1 school district, serving a low SES population. The district is separated into two elementary schools, one houses students from a working class, and the other is considered more of an urban area with majority of students living in apartment complexes. The borough has more apartment complexes than any of the surrounding areas. The middle school is a mix of both of the elementary schools in a suburban area with an urban environment.

The school was built in 1939 serving a large portion of the county, however, in 2001; it became the middle school for the borough. The school houses about 720 students from fifth to eighth grade. The district is very transient, therefore, student enrollment can change on a daily basis and the majority is African American and Hispanic. Students with disabilities are placed in inclusion classrooms, resource, and self-contained settings according to the decisions made by the child study team based on individual student’s needs.

Classroom

The study was conducted in a 5th grade inclusion classroom where students were learning mathematics. There were 26 students in the classroom, 21 were general education and 5 with MLD. Two teachers, one general education who was the content specialist and the other, special education teacher was the learning specialist. The instruction followed a co-teaching model, where both the general and special education teachers delivered instruction. All of the students participated in the study activities but only special education students were evaluated for recording data.

Participants

Students. A total of five, fifth grade students participated in the study. Table 1 presents their general information.

Table 1

General Information of Participating Students

Student	Age	Gender	Ethnicity	Classification	*PARCC Scores (2015)	**Reading Level
1	11	F	African American	Specific Learning Disability	N/A	O
2	11	M	Caucasian	Specific Learning Disability	N/A	I
3	10	M	African American	Communication Impaired	Level 3	O
4	11	M	Hispanic	Communication Impaired	Level 1	O
5	10	M	African American	Other Health Impairment	Level 1	J

*Note: Partnership for Assessment of Readiness for College and Careers (PARCC). Level 1 = Not meeting expectations, Level 2 = Partially meeting expectations, Level 3 = Approaching expectations, Level 4 = Meeting expectations, and Level 5 = Exceeding expectations.

**Note: Reading level was assessed using *Fountas and Pinnell* informal reading inventory. Letter I = end of first grade to beginning of second grade, Letter J = second grade, and Letter O = third grade.

Student 1 just recently entered the inclusive math class, prior to this class she had been placed in a resource setting. Her strengths include: fluency in multiplication with basic computation skills, and following mathematical procedures or steps. She has difficulty identifying the operation in word problems, visual/spatial math concepts, and solving complex multi-step problems.

Student 2 was in three different schools in the past two years. He was able to use different ways to solve problems, for example if he did not know the multiplication he would try repeated addition to get the answer. He had difficulty in reading and comprehending word problems because his reading level was significantly below grade level, specifically he was struggling in recognizing and decoding sight words. He often got confused when finding relevant information to solve the problem.

Student 3 had strong fluency in multiplication, and followed formulas to solve multi-step problems, with a good visual/spatial recognition. However, he greatly struggled with word problems, often being confused of what is being asked. He had good decoding skills and appropriate reading comprehension; however, he did not understand the mathematical process in solving word problems.

Student 4's math performance was below grade level. He often relied on a multiplication chart for problem solving. Also, he often got confused when calculating two or more digit computation. He could apply the correct formula or process but often made the final answer wrong because his problems in solving multi-digit multiplication, addition, and subtraction. Lastly, his reading comprehension was below grade level and he was struggling with comprehending the word problems.

Student 5 was placed in an inclusive classroom this year. Previously he had been placed in self-contained classes for mathematics. His strengths included his ability to apply simple formulas and follow teacher prompts. However, he greatly struggled with mathematical fluency in basic computation. He had problems in multiplication of one digit numbers, and addition and subtraction of two digits. He had decoding skills; however, he greatly struggled with text comprehension because of his low IQ, he was significantly below grade level in mathematics and reading.

Teacher. One teacher in the classroom participated in this study and delivered all the instruction involving the manipulatives and the cognitive strategy for the entire class. The teacher had four years of experience in teaching students with MLD in both inclusion and resource settings. A co-teacher, the content specialist, also in the classroom, supported the instruction.

Materials

Instructional materials. The instructional materials include the *Go Math!* Textbook, teacher made handouts, manipulatives and technology.

Textbook (*Go Math!*). This program is a K-8 math curriculum following the state standards. It has a student work book and digital resources, which include hands-on and simulated manipulatives.

Handouts. These handouts were developed by the teachers as supplemental materials for class practice, as well as reference sheets, such as a multiplication chart, number grid, number lines, and examples of step by step processes (See Appendix A).

Manipulatives. Manipulatives either come from the *GO Math!* program or from the classroom. The *GO Math!* manipulatives include fraction tiles, pattern blocks, and

fraction circles. The classroom manipulatives include number lines, student made fraction circles and squares, and various shapes.

Technology. A smart board and an Elmo projector were used by the teacher, and Chrome Books were provided to the students to either participate in the simulated manipulatives on *GO Math!* or other websites like www.ixl.com, www.aaamath.com, or www.frontrow.com. The simulated manipulatives included fraction circles, fraction tiles, pattern blocks, and number lines.

Measurement materials. The measurement materials include weekly quizzes and a student satisfaction survey.

Weekly quiz. The weekly quiz consisted of five word problems, of which 2-3 were multiple choices and 2-3 were questions that related to the skills learned during the week; including conceptual and word problems. Each quiz was worth 25 points with 5 for each problem. Of the 5 points, 1 was given for the correct answer, the other 4 for presenting correct process to solve the problem, for example, using the correct formula, applying the correct steps, and completing the correct computation (See Appendix B for an example).

Satisfaction survey. The survey is a questionnaire of 6 questions in a likert scale with an additional one open-ended question. The 6 questions were scored on a four point scale with 4 being strongly agree, 3 being agree, 2 being disagree, and 1 being strongly disagree. The questions were based on the students' satisfaction with the cognitive strategies, the hands-on manipulatives, and the technology (simulated manipulatives) as well as the methods students found more interesting and motivating to their learning (See Appendix C for an example).

Procedure

Instructional procedure. The math instruction was delivered in 10 weeks. The first five weeks focused on the use of cognitive strategies paired with hands-on manipulatives. The rest of the five weeks were spent to use technology together with cognitive strategies, such as Chrome Books and simulated manipulatives adopted from the *GO Math!* program or from online websites (e.g. www.ixl.com; www.aaamath.com; www.frontrow.com). Each math class lasted for 80 minutes, 5 days a week, for 10 weeks. Table 2 presents the weekly instructional procedures.

Table 2

Weekly Instructional Procedures

Days	Daily Instructional Procedures
1	<ul style="list-style-type: none"> • Problem of Day – one to four problems reviewing the previous day’s skills. • Review of previous night’s homework (selected problems). • Introduce cognitive strategy and the steps used in the strategy. • Whole class review of factors and finding factors by using a factor rainbow or factor “T”. • Independent Practice of finding factors.
2	<ul style="list-style-type: none"> • Problem of Day – one to four problems reviewing the previous day’s skills. • Review of previous night’s homework (selected problems). • Review of how to use the cognitive strategy (teacher model). • Whole class review of finding the Greatest Common Factor (GCF) by using factor “T” strategy. • Independent practice of finding the GCF.
3	<ul style="list-style-type: none"> • Problem of Day – one to four problems reviewing the previous day’s skills. • Review of previous night’s homework (selected problems). • Review of cognitive strategy • Student practice of cognitive strategy with word problems. • Introduce adding fractions with common denominators. • Whole class review of adding fractions with common denominators.
4	<ul style="list-style-type: none"> • Problem of Day – one to four problems reviewing the previous day’s skills. • Review of previous night’s homework (selected problems). • Student practice of cognitive strategy from word problems dealing with adding fractions with common denominators.
5	<ul style="list-style-type: none"> • Problem of Day – one to four problems reviewing the previous day’s skills. • Review of previous night’s homework (selected problems). • Weekly Quiz

*Note: The following weeks follow the same procedures except for the content changes, for example, Week 2: subtraction of fractions with common denominators and addition of fractions with unlike denominators, Week 3 and 4: addition and subtraction of fractions with unlike denominators, Week 5 and 6: addition and subtraction of mixed numbers, Week 7 and 8: multiplication of fractions and mixed numbers, and Week 9 and 10: division of fractions and mixed numbers.

Measurement procedure. Measurement procedures included a weekly quiz and a satisfaction survey.

Weekly quizzes. A weekly quiz consisting of five word problems was given on Friday each week for 10 weeks. The students were allowed to use a cognitive strategy reference sheet and hands-on manipulatives throughout the week. Questions were read aloud for students as needed, and verbal prompts were provided if needed. Students were given as much time as needed within one class period to complete.

Satisfaction survey. The survey was given to students at the end of the 10 weeks. The directions and questions were read aloud to students, and students were required to mark their responses on the survey until completed.

Research Design

A single subject research design with ABC phases was used in the study. During the baseline (Phase A), students were tested each week during their math class for five weeks. This weekly quiz was read aloud to the students for completion. Their quiz scores were recorded as the baseline data.

During the intervention (Phase B), the students were provided instruction on how to use a multi-step cognitive strategy to break apart and comprehend mathematical word problems. Simultaneously, the students were guided to apply hands-on manipulatives to enhance their understanding of the problem solving process. This activity allowed them to understand abstract concepts with concrete objects and symbols. The scores of weekly quizzes were continually provided and student scores were recorded.

During the second intervention (Phase C), the students continued using the cognitive strategy to enhance their understanding of the word problems. However, the

hands-on manipulatives were replaced by the use of technology, such as various websites and the *Go Math!* program as simulated manipulatives to enhance their understanding.

The weekly quizzes and recording of student scores were continued.

Data Analysis

The means and standard deviations of student quiz scores were calculated across phases, and presented in a table to compare their performance. A visual graph presented their ongoing math performance in each phase to compare the difference. The survey responses were calculated by percentages. The responses to the open ended question were summarized and presented narratively.

Chapter 4

Results

The students were given weekly quizzes for five weeks prior to the intervention as baseline data (Phase A). A cognitive strategy paired with hands-on manipulatives was implemented for five weeks as Phase B, and then paired with computer-based manipulatives (Phase C) was implemented for the additional five weeks. Student performance was evaluated by weekly quizzes.

Weekly Quiz

Each student was given a weekly quiz during Phase A, the baseline, when no interventions were provided. The weekly quiz continued during Phase B when a cognitive strategy paired with hands-on manipulatives was implemented. Subsequently, the weekly quiz continued during Phase C when a cognitive strategy paired with computer-based manipulatives was provided. Table 3 presents the means and standard deviations of student quiz scores.

Table 3

Means and Standard Deviations of Students Quiz Scores

Participants	Phase A		Phase B		Phase C	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Student 1	16.4	1.1	21.2	1.3	21.4	1.7
Student 2	18	1	22.2	0.8	22.2	0.8
Student 3	18.8	1.3	23	0.7	23.2	0.4
Student 4	16.2	1.3	19.8	0.8	20.4	0.9
Student 5	13.2	1.3	18	0.7	18.4	0.9

Student 1's weekly quiz scores are as follows: (A: 16, 15, 16, 17, 18) (B: 22, 23, 21, 20, 20) (C: 21, 19, 23, 23, 21). During Phase B, student 1's average score was 21.2, which is an increase of 4.8 points from the baseline's mean of 16.4. During Phase C, the average score was 21.4, which is 5 points increased from the baseline data.

Student 2's weekly quiz scores are as follows: (A: 17, 19, 18, 19, 17) (B: 22, 23, 22, 23, 21) (C: 23, 21, 22, 23, 22). During Phase B and Phase C, student 2's average score was 22.2, which is an increase of 4.2 points from the baseline's mean of 18.

Student 3's weekly quiz scores are as follows: (A: 18, 18, 19, 21, 18) (B: 22, 23, 23, 24, 23) (C: 23, 23, 23, 24, 23). During Phase B, student 3's average score was 23, which is an increase of 4.2 points from the baseline's mean of 18.8. During Phase C, the average score was 23.2, which is 4.4 points increased from the baseline data.

Student 4's weekly quiz scores are as follows: (A: 15, 15, 16, 17, 18) (B: 20, 20, 21, 19, 19) (C: 21, 19, 20, 21, 21). During Phase B, student 4's average score was 19.8, which is an increase of 3.6 points from the baseline's mean of 16.2. During Phase C, the average score was 20.4, which is 4.2 points increased from the baseline data.

Student 5's weekly quiz scores are as follows: (A: 12, 13, 12, 15, 14) (B: 18, 18, 19, 18, 17) (C: 19, 17, 19, 19, 18). During Phase B, student 5's average score was 18, which is an increase of 4.8 points from the baseline's mean of 13.2. During Phase C, the average score was 18.4, which is 5.2 points increased from the baseline data.

Figure 1 presents individual student's quiz scores across phases.

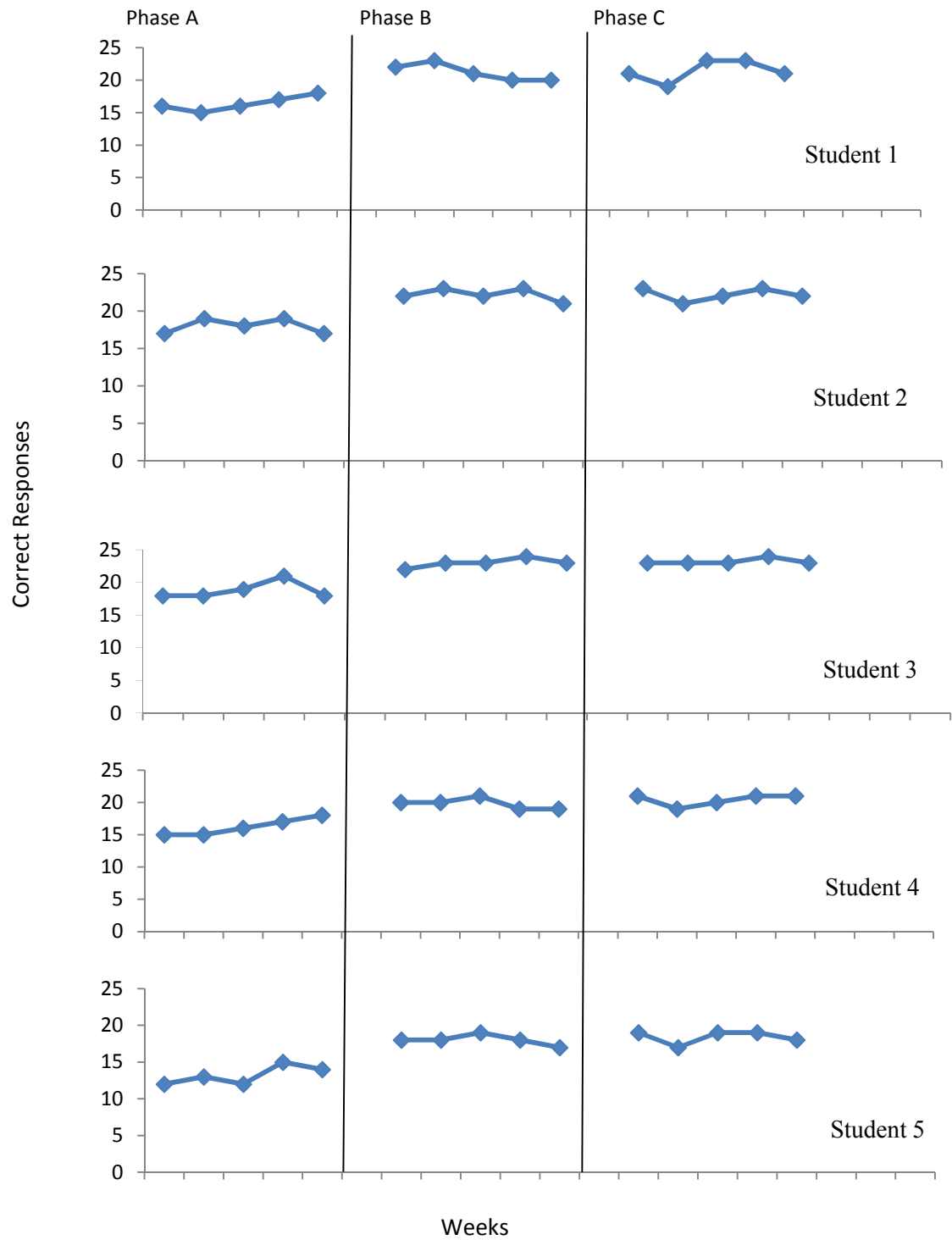


Figure 1. Participant's Quiz Scores Across Phases

Survey

Each student was given a survey to investigate their opinions about the interventions implemented. Each student was required to respond to 6 questions in a likert scale format. The questions were scored on a four point scale with 4 being strongly agree, 3 being agree, 2 being disagree, and 1 being strongly disagree. Table 4 represents the mean and standard deviation from the survey.

Table 4

Means and Standard Deviations of Student Responses to the Survey

Question	Mean	Standard Deviation
Cognitive Strategy Effectiveness	2.6	1.1
Hands-on Manipulative Effectiveness	3.4	0.9
Computer-Based Manipulative Effectiveness	3.8	0.4
Use of Cognitive Strategy	2.6	1.1
Use of Hands-on Manipulatives	3.4	0.9
Use of Computer-Based Manipulatives	4.0	0

The question with the highest mean (4) was the question that asked the students if they would like to use the computer-based strategy again. Comparatively, when students were asked if they would like to use the hands-on manipulatives again, the mean score

was 3.4. That is only a 0.6 difference between the mean scores for using computer-based manipulatives again compared to using hands-on manipulatives again. The mean score of 2.6 for using cognitive strategies again was the lowest. The effectiveness of computer-based manipulatives also scored the highest mean of 3.8. The effectiveness of hands-on manipulatives scored a mean of 3.4; which is only a 0.4 difference from computer-based manipulatives. Lastly, the mean score of 2.6 for effectiveness on cognitive strategies was again the lowest.

In addition, all students were asked to provide narrative comments. The question was related to their preferred strategies (i.e. cognitive strategy, hands-on manipulatives, and/or computer-based manipulatives). Four out of five students (80%) stated that they preferred to use the computer-based manipulatives again. One student indicated, “I like using the computer. It is fun and helpful.” Four out of five (80%) reported they preferred to use the hands-on manipulatives as well. As one student stated, “I like drawing pictures and having something I can see;” and another student said that he would also prefer to use the cognitive strategies. “It helps me think,” was his comment, while no other students mentioned.

Chapter 5

Discussion

The purposes of this study are to: a) evaluate the effectiveness of using cognitive strategies with hands-on manipulatives to enhance problem solving skills of students with MLD; b) evaluate the effectiveness of using cognitive strategies with virtual computer-based manipulatives to enhance problem solving skills of students with MLD; c) examine student satisfaction with the use of cognitive strategies, hands-on manipulatives, and computer-based manipulatives to assist in their mathematical problem solving skills.

The first research question asked if students with MLD increased their scores when cognitive strategies paired with hands-on manipulatives were provided to solve word problems. The results show an increase in the mean score for every student when the cognitive strategies with hands-on manipulatives were provided. The increase ranged from 3.6 to 4.8 points from the baseline to in the intervention. Because of a cognitive strategy paired with hands-on manipulatives, the finding may not be same as only one cognitive strategy was provided, such as *Solve it!*, presented in Krawec and colleagues' study (2012) . In their study, the effects of the cognitive strategy, *Solve it!*, for middle school students with learning disabilities were examined, and a significant increase in student scores from pre to posttests were found when learning the strategy to solve math problems. In the current study, because of paired strategies, the findings may be strengthened.

The results are consistent with findings of Tournaki, Seh Bae, and Kerekes's study (2008) when hands-on manipulatives, such as "rekenrek" were implemented. Their study showed a significant difference between experimental and control groups, in favor of the experimental, based on one individual manipulative. This present study focused on

a variety of hands-on manipulatives, such as fraction strips and counters to support students in learning math and to improve their word problem solving skills. The pairing of cognitive strategies and hands-on manipulatives may be powerful to strengthen the intervention to benefit students.

The second research question asked if students with MLD increased their scores when cognitive strategies paired with computer-based manipulatives were provided to solve word problems. The findings indicated an increase in the mean score for every student, with a range from 4.2 to 5.2 compared to the baseline. Again, because of a paired cognitive strategy with computer-based manipulatives, the results are consistent with prior findings on using cognitive strategies. Krawec and colleagues' study (2012) found a significant increase in scores from pre to post tests for students receiving the intervention. Furthermore, Montague and colleagues' study (2014) found that students receiving the intervention had a significantly higher monthly growth rate. The present study focused on the pairing of cognitive strategies and computer-based manipulatives, which strengthened the intervention to benefit students.

The results may expand the findings of Reimer and Moyer's study (2005). In their study, the effectiveness of learning fractions using virtual manipulatives for 3rd graders with special needs was examined. The results indicated that students scored significantly higher on the posttest related to conceptual knowledge compared to the pretest, while this present study was focused on a variety of computer-based manipulatives, such as virtual fraction strips, virtual counters, and competitive fraction games. The pairing of the two interventions, cognitive strategies and computer-based manipulatives seems powerful to strengthen the findings.

The last research question sought to determine if the students were satisfied with learning word problem solving skills using cognitive strategies, hands-on manipulatives, and computer-based activities. Results from the current study demonstrated that the computer-based activities were the most motivating to students. The mean score for the use of computer-based activities was a perfect score of 4 compared to hands-on manipulatives with a mean score of 3.4 and cognitive strategies with a mean score of 2.6. The question about the effectiveness of computer-based activities were also favored with a mean score of 3.8, while the other mean scores were 3.4 for hands-on manipulatives and 2.6 for cognitive strategies.

Furthermore, student narrative comments on the survey are consistent with the findings of Nguyen, Hsieh, and Allen's study (2006) to demonstrate that using computer technology had no difference on students learning attitudes toward mathematics. In their study, results showed that there was no statistical significant difference between the experimental and control groups in students' attitude toward mathematics learning, but students stated that they enjoyed working on the computer and wanted to have more computer-based practice. Participating students in the current study stated that they liked using the computer because it was fun and helpful, with 80% of their responses to support the statement about their preference to use computer-based activities in the future again.

Limitations

The current study was conducted with a small sample size of 5 students in a short time period of 10 weeks. It is difficult to generalize the findings to other student populations and schools. Also, two strategies were paired together simultaneously and implemented in the intervention. For example, the first five weeks paired cognitive

strategies with hands-on manipulatives, while the consecutive five weeks paired cognitive strategies with computer-based manipulatives. Although both pairings showed student's scores increase, it is difficult to determine if this increase was due to the cognitive strategies, hands-on manipulatives or computer-based manipulatives specifically. Comparatively, the cognitive strategies paired with computer-based manipulatives had a slightly higher increase in mean scores than the other. However, that paired intervention was given during weeks 6-10; therefore, there is no way to verify if this higher increase was due to the students' previous practice and exposure to the cognitive strategy.

Implications

The participants in this study practiced three different mathematical word problem solving strategies in an inclusive classroom. The cognitive strategy was paired with a conceptual intervention. Teachers who are making efforts to improve the word problem solving skills and conceptual knowledge in their classroom should consider a cognitive strategy with a conceptual knowledge building in their instruction, such as manipulatives. First, the school may adopt a cognitive strategy, such as *Solve It!* to increase students' reading comprehension across curricula. Secondly, they may consistently present math materials on a conceptual level with the manipulatives. Whether it is hands-on or computer-based manipulatives, students need to practice with physical manipulatives and visualize the concepts they are learning. A computer-based activity seems to be more enjoyable and highly motivated to students. Teachers need professional development on the use of cognitive strategies and manipulatives, especially involving technology, such as computer-based manipulatives. Manipulatives seem effective for some students but

difficult for others. For example, students who already understand the problems at the abstract level may not work at the concrete level to avoid confusion or frustration.

Teachers should understand their student learning level before starting their instruction, this way, they can make an accurate decision on when and how the concrete or abstract examples should be provided to support students based on their individual needs.

Conclusion and Recommendations

Students with MLD are facing challenges in solving mathematical word problems. They exhibit problems such as: understanding the problem, selecting appropriate operations, and following the procedures to apply the specific skills. Various strategies have been applied to assist these students; however, some have not been effective. The present study was seeking to pair a cognitive strategy with hands-on manipulatives and then with computer-based manipulatives to determine if the pairing of either of those strategies was effective for students with MLD in learning word problem solving. The findings show that both pairings had a positive effect on improving their word problem solving skills.

Further studies are needed to validate the finding with more participants in a variety of student populations, and to examine if cognitive strategies, hands-on manipulatives, and computer-based manipulatives are effective individually for students with MLD. Despite some limitations of this present study, it is pleased to see student motivation and improved test scores in learning word problem solving. It is my hope to involve more teachers using virtual manipulatives in their math instruction to motivate student learning, especially those with learning disabilities.

References

- Baki, A., Kosa, T., & Guven, B. (2011). A comparative study of the effects of using dynamic geometry software and physical manipulatives on the spatial visualisation skills of pre-service mathematics teachers. *British Journal Of Educational Technology*, 42(2), 291-310. doi:10.1111/j.1467-8535.2009.01012.x
- Belenky, D. M., & Nokes, T. J. (2009). Examining the Role of Manipulatives and Metacognition on Engagement, Learning, and Transfer. *Journal Of Problem Solving*, 2(2), 102-129.
- Carbonneau, K. J., Marley, S. C., & Selig, J. P. (2013). A Meta-Analysis of the Efficacy of Teaching Mathematics With Concrete Manipulatives. *Journal Of Educational Psychology*, 105(2), 380-400. doi:10.1037/a0031084
- Ganesh, T. G., & Middleton, J. A. (2006). Challenges in Linguistically and Culturally Diverse Elementary Settings with Math Instruction using Learning Technologies. *Urban Review*, 38(2), 101-143. doi:10.1007/s11256-006-0025-7
- Krawec, J., Huang, J., Montague, M., Kressler, B., & de Alba, A. M. (2013). The Effects of Cognitive Strategy Instruction on Knowledge of Math Problem-Solving Processes of Middle School Students With Learning Disabilities. *Learning Disability Quarterly*, 36(2), 80-92. doi:10.1177/0731948712463368
- Montague, M., Krawec, J., Enders, C., & Dietz, S. (2014). The Effects of Cognitive Strategy Instruction on Math Problem Solving of Middle-School Students of Varying Ability. *Journal Of Educational Psychology*, 106(2), 469-481. doi:10.1037/a0035176
- Puchner, L., Taylor, A., O'Donnell, B., & Fick, K. (2008). Teacher Learning and Mathematics Manipulatives: A Collective Case Study About Teacher Use of Manipulatives in Elementary and Middle School Mathematics Lessons. *School Science & Mathematics*, 108(7), 313-325.
- Reimer, K., & Moyer, P. S. (2005). Third-Graders Learn about Fractions Using Virtual Manipulatives: A Classroom Study. *Journal Of Computers In Mathematics And Science Teaching*, 24(1), 5-25.

- Shamir, A., & Baruch, D. (2012). Educational e-books: a support for vocabulary and early math for children at risk for learning disabilities. *Educational Media International*, 49(1), 33-47. doi:10.1080/09523987.2012.662623
- Swanson, H. L., Moran, A. S., Bocian, K., Lussier, C., & Zheng, X. (2013). Generative Strategies, Working Memory, and Word Problem Solving Accuracy in Children at Risk for Math Disabilities. *Learning Disability Quarterly*, 36(4), 203-214. doi:10.1177/0731948712464034
- Tournaki, N., Young Seh, B., & Kerekes, J. (2008). Rekenrek: A Manipulative Used to Teach Addition and Subtraction to Students with Learning Disabilities. *Learning Disabilities -- A Contemporary Journal*, 6(2), 41-59.

Appendix A

Handouts

Handout 1: Step-by-Step Reference Sheet

Borrowing (Miss Gunn's Way)

****Step 1:** Find the LCM of the two denominators:

$$3\frac{3}{8} - 1\frac{4}{6}$$

8: 8, 16, 24

LCM = 24

6: 6, 12, 18, 24

****Step 2:** Make NEW fractions using the LCM as the new denominator:

$$3\frac{3}{8} \times \frac{3}{3} = 3\frac{9}{24}$$

$$\text{New problem} = 3\frac{9}{24} - 1\frac{16}{24}$$

$$1\frac{4}{6} \times \frac{4}{4} = 1\frac{16}{24}$$

****Step 3:** Borrow 1 from the whole number. Turn the 1 into a fraction using the denominator. Add the two fractions together. *Don't forget to move your whole number over. **Do NOT change the bottom mixed number**

$$2\cancel{3}\frac{9}{24} + \frac{24}{24} = 2\frac{33}{24}$$

$$1\frac{16}{24} = 1\frac{16}{24}$$

****Step 4:** Now you can subtract with your new mixed number. Simplify if necessary.

$$2\frac{33}{24} - 1\frac{16}{24} = 1\frac{17}{24}$$

Handout 2: Step-by-Step Reference Sheet

Climb the Tree (Miss Plute's Way)

****Step 1:** Find the LCM of the two denominators:

$$3\frac{3}{8} - 1\frac{4}{6}$$

$$8: 8, 16, 24$$

$$\text{LCM} = 24$$

$$6: 6, 12, 18, 24$$

****Step 2:** Make NEW fractions using the LCM as the new denominator:

$$3\frac{3}{8} \times \frac{3}{3} = 3\frac{9}{24}$$

$$\text{New problem} = 3\frac{9}{24} - 1\frac{16}{24}$$

$$1\frac{4}{6} \times \frac{4}{4} = 1\frac{16}{24}$$

****Step 3:** Turn both mixed numbers to an **improper fraction** by "climbing the tree".

$$3\frac{9}{24} = \frac{81}{24}$$

$$1\frac{16}{24} = \frac{40}{24}$$

****Step 4:** Now you can subtract:

$$\frac{81}{24} - \frac{40}{24} = \frac{41}{24}$$

****Step 5:** Turn the answer into a mixed number and Simplify if necessary:

$$\frac{41}{24}$$

$$\begin{array}{r} 1 \\ 24 \overline{) 41} \\ \underline{-24} \\ 17 \end{array}$$

$$1\frac{17}{24}$$

Handout 3: Number Grid

Name _____

Date _____

Time _____

Number Grid

Game Master **174**



									0
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110

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Handout 4: Multiplication Chart

Times Table - 15x15

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
3	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
4	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
5	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
6	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
7	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
8	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
9	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
10	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
11	11	22	33	44	55	66	77	88	99	110	121	132	143	154	165
12	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180
13	13	26	39	52	65	78	91	104	117	130	143	156	169	182	195
14	14	28	42	56	70	84	98	112	126	140	154	168	182	196	210
15	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225

Appendix B

Weekly Quiz

Name: _____

Quiz Week 3

1) Milon wants to send two packages to Miss Plute for her birthday. One package weighs **$2\frac{3}{4}$ pounds**. The other package weighs **$1\frac{3}{4}$ pounds**. What is the **combined** weight of the packages? (*Make sure to simplify and change improper fractions into mixed numbers!*)

a) $4\frac{2}{4}$ pounds

b) $3\frac{2}{4}$ pounds

c) $4\frac{1}{2}$ pounds

2) Norah needs a quilt at Miss Cecchetti's house. Miss Cecchetti bought purple ribbon and pink ribbon to decorate. The purple ribbon is **$4\frac{7}{8}$ yards** long. The pink ribbon is **$\frac{5}{8}$ yards** long. **How much more** purple ribbon does Miss Cecchetti have?

(*Make sure to simplify and change improper fractions into mixed numbers!*)

a) $4\frac{1}{4}$ yards

b) $3\frac{1}{4}$ yards

c) $4\frac{2}{8}$ yards

3) In the school band $\frac{6}{24}$ of the students play the trumpet. In **simplest form**, what fraction of the band plays the trumpet?

a) $\frac{1}{3}$

b) $\frac{1}{4}$

c) $\frac{2}{8}$

4) Miss Gunn ran $\frac{21}{10}$ miles. Which **mixed number** shows how far Miss Gunn ran?

Remember to “Climb the Tree” and circle your final answer

5) La-Nya uses $\frac{3}{12}$ pounds of blueberries and $\frac{2}{12}$ pounds of strawberries to make jam.

How many pounds of berries does she use **altogether**? **Circle your final answer**



Appendix C

Satisfaction Survey

Name: _____

Directions: Please answer each question by circling the number that corresponds to your response for each statement on a 1-4 scale.

1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Disagree

1) I found **cognitive strategies** effective in assisting my learning. 1 2 3 4

2) I found **hands-on manipulatives** effective in assisting my learning. 1 2 3 4

3) I found **computer-based manipulatives** effective in assisting my learning. 1 2 3 4

4) I would like to use **cognitive strategies** again. 1 2 3 4

5) I would like to use **hands-on manipulatives** again. 1 2 3 4

6) I would like to use **computer-based manipulatives** again. 1 2 3 4

Directions: Please answer the following question in complete sentences.

7) Which strategy (**cognitive strategy, hands-on manipualtives, or computer-based manipulatives**) do you prefer? Explain why.
