8-20-2012

Using computer-assisted graphic organizers in algebra instruction to support high school students with learning disabilities

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USING COMPUTER-ASSISTED GRAPHIC ORGANIZERS IN ALGEBRA INSTRUCTION TO SUPPORT HIGH SCHOOL STUDENTS WITH LEARNING DISABILITIES

by
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A Thesis

Submitted to the
Department of Special Educational Services/Instruction
College of Education
In partial fulfillment of the requirement
For the degree of
Master of Arts
at
Rowan University
May 9, 2012

Thesis Chair: Dr. Joy Xin

Dedication

I would like to dedicate this manuscript to my husband, David, and son, Andrew, for their constant support and patience during this process. My mother, Helen, my sisters, Patricia, and Alice encouraged me to keep going and never give up, and were always interested in my progress. My mother-in-law, Carole, sister-in-law, Denise, my coworkers, especially Jacqueline, Cheryl and the excellent CST members especially Linda, and Rhoda, - who cheered me on. My classmate, Kathy S., who became a dear friend through this whole process, kept me sane and focused. I really appreciated everyone's special support! Lastly, my dog, Smokey, was always by my side as I typed.

Acknowledgments

I would like to express my appreciation to Professor Joy Xin for her guidance and assistance throughout this research and during my entire graduate experience at Rowan U. Also, I appreciate all of my wonderful and encouraging professors that I have had during my graduate experience at Rowan U.

Abstract

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IN ALGEBRA INSTRUCTION TO SUPPORT
HIGH SCHOOL STUDENTS WITH LEARNING DISABILITIES
2011/12
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The purpose of this study was: 1) to examine the effect of the use of graphic organizers in high school algebra instruction; 2) to compare the difference of student performance when hand-written and computer-assisted graphic organizers were used, and 3) to evaluate student attitude towards learning algebra when hand-written and computer-assisted graphic organizers were used. A total of eight high school students with LD in two classes, with four in each class, participated in this study. A single subject design with AB and ABC phases was used in this study for 10 weeks, during which eight Algebraic math skills were taught and assessed. Students were evaluated prior to intervention using a pretest, then a posttest after implementation of a graphic organizer. Student test scores were improved after using both types of graphic organizers. Implications for teaching secondary students with LD basic Algebra math skills are discussed. Continued research on effective strategies in the field of math instruction for secondary students with LD is needed.

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Chapter 1

Introduction

Phrases often heard from students as they enter my resource classes at the beginning of each school year, are usually negative: "I hate math", "I'm not good at math", and "Math isn't my thing". This year, I am currently teaching a total of twenty-two high school freshmen students in three separate Introduction to Algebra Resource Room classes with seven, eight, and seven special education students respectively. The majority of my students are classified as "Specific Learning Disability". So my overall impression with most of the high school students who have learning disabilities is that "they hate math". I came to this conclusion after meeting my students on their first day of class, when the majority of students greeted me with one of the three negative phrases mentioned above. Somehow, in their school experiences, the students had developed a negative attitude towards learning mathematics. Unfortunately, a negative attitude towards a specific subject can lead to lack of motivation with learning and academic failure in that subject. Their frustration can present itself in various forms in the high school mathematics class: passive and aggressive behavior, e.g. "shutting down"; refusal to work; avoidance – doing other subject classwork; constant requests to leave the classroom; behavioral problems - creating class disruptions to escape from the assigned work or to avoid humiliation; fear of failure or embarrassment.

Competence in Algebra is linked to the ability to earn a high school diploma by passing high stakes testing required by the state. Therefore, Algebra is an important subject because it is reflected in graduation requirements across the country. In 2009, 22 states required students to complete Algebra I, whereas one state required students to complete Algebra II prior to graduation from high school. By 2015, the number of states requiring Algebra I and Algebra II for graduation is projected to increase to 29 and 12, respectively (American Diploma Project Network, 2009). In New Jersey, passing the High School Proficiency Assessment is a requirement to graduate from high school. Algebra is the major content in the statewide test to evaluate high school students' mathematic skills for their graduation. Currently, the state of New Jersey has implemented another type of mandatory math test, the End of Course Algebra I & II Tests, which are given during the month of May; thus, again Algebra is considered as an assessment tool to evaluate student mathematic skills. In addition, Algebra is considered a gateway to expanded opportunities for students of all races and cultures, facilitating achievement in advanced mathematics courses, entrance into college, and economic equity in the workforce (Fennell, 2008). For many students with learning disabilities, developing proficiency in Algebra represents a challenging, but necessary goal.

The mathematic difficulties of students with learning disabilities (LD) often begin in elementary school and persist through middle school and high school (Cawley & Miller, 1989; Miller & Mercer, 1997). Through the use of the Woodcock-Johnson Psycho-Educational Assessment Battery, Cawley and Miller (1989) found that children with learning disabilities were far below grade-level expectancy in mathematics. Third graders with LD performed at a first-grade level on computation and application tasks, whereas, sixth graders with LD performed at a third-grade level on basic addition. Findings showed that older children with LD had a wider grade equivalent gap; achievement levels at age 17 peaked at grade equivalent standards of 5.8 for computation and 5.2 for applied problems. These deficits impact the performance of students with LD in basic mathematics courses and persist into more advanced courses such as Algebra and Trigonometry. Students with LD struggle with understanding and applying the math concepts and skills learned. They have difficulties in acquiring and retaining knowledge (Miller & Mercer, 1997). Problem solving and open-ended problems are difficult for these students in identifying relevant information within a problem. The National Longitudinal Transition Study-2 (Wagner, Newman, Cameto, & Levine, 2006) found that more than half of high school students with LD demonstrated mathematics computation and problem-solving levels below the 25th percentile on an individually administered achievement test. There are many problem solving skills involved in learning Algebra, especially abstract thinking and reasoning. Students find mathematical problem solving, particularly word problems, challenging for a variety of reasons as discussed by Babbitt and Miller in their review of literature (1996). These challenges included misreading the problem, having difficulty detecting relevant versus irrelevant information, misidentifying the appropriate mathematical operation, making calculation errors, missing steps needed to carry out the problem, and having trouble organizing the information in the problem (Babbit & Miller, 1996). Further, these students have challenges in identifying, monitoring, and coordinating the sequence of steps required to solve multistep problems (Gagnon & Maccini, 2001, 2007).

Visual aides have been considered as tools to assist students in understanding abstract reasoning. Graphic organizers are one of such visual aides. Common graphic organizers used in mathematics include hierarchical diagrams, sequence charts, and compare and contrast charts (Baxendrall, 2003). It is found that graphic organizers could assist students with organizing and analyzing relevant information within a problem. If graphic organizers are used consistently, coherently, and creatively, they become useful tools to assist students in organizing and retaining information. Graphic organizers can also be used on a regular basis after learning a new mathematic skill or applying a set of new skills learned. Repeated use of graphic organizers allows students to reinforce and practice the skills to achieve a mastery level. Coherent graphic organizers display information clear and free of irrelevant information and other distractions. A graphic organizer can be partially completed to guide students in the process of adding key terms. This creative approach could involve students to design their own visual aides into instruction and integrated in class activities such as small group activities, learning pairs, cooperative groups, or peer tutoring to support and motivate student learning (Gagnon & Maccini, 2005).

Technology has been used to help students bypass disability-related barriers, allowing them to have access to whatever kind of instruction is being provided. For example, the use of calculators for calculating basic arithmetic within higher-level mathematics (e.g., Algebra) can assist students with memory-processing problems that make rapid fact retrieval difficult. Computer-assisted instruction (CAI) has also been used when students interact with mathematics via a computer and programmed software (Woodward & Rieth, 1997). A common use for this type of technology has been computation practice and immediate feedback. It is critical that technology involves students to actively engage in class activities which make the learning of mathematics meaningful. Technology has been used to enhance math instruction to students with LD. It has potential for improving these students' mathematics outcomes at each tier of instruction within mathematics problem solving and response to instruction (Allsopp, McHatton, & Farmer, 2010). When searching "graphic organizers for mathematics" online, it is found that most of them are targeting elementary mathematics, but few websites are developed for teaching Algebra. For example, the website, "Graphic.org", http://www.graphic.org/, includes electronic graphic organizers which are easy to design and rearrange information by allowing users to cut, clip, copy, paste, and move the information around. Inspiration Software, Inc. (http://www.inspiration.com/inspiration-language-arts-examples) provides computer-assisted graphic organizers to engage students in learning language arts, science and social studies, without Algebra. Thus, computer-assisted graphic organizers for high school mathematics were very limited online, especially for Algebra instruction.

Statement of Problems

The main problem in my three Introduction to Algebra Resource classes is an ongoing negative attitude which many of my special education students exhibit, and, therefore, become resistant with learning and applying math concepts and skills. Some of these students exhibit disruptive behavior as a form of avoidance. When these students participate and become engaged in the classroom activities, they are usually successful. If they can experience success and satisfaction by taking ownership in their learning (empowerment), I believe that it will boost student motivation in learning mathematics.

The background of a student's lack of motivation in learning math may come from many factors, especially academic failure. Now, at the high school level, with high stakes testing, teachers and students have to catch up the math skills. It is important to change students' attitudes towards learning math, and to motivate them in the learning process. This becomes quite burdensome at the secondary level. When surveyed about their perceptions, these students were more likely than their peers (55% vs. 32%) to identify mathematics as their least favorite high school class (Kotering, deBettencourt, & Braziel, 2005). Students with LD need more assistance, and teachers need to modify instruction, incorporating group work, and increasing student interest level to enhance their instruction. If students with LD are to succeed in Algebra, the use of evidence-based practices for assessment and instruction must become standard practices. Educators need effective tools for tracking student learning and determining when instructional changes are needed. They also need proven strategies for providing supplemental instruction in Algebra when students experience difficulty.

The challenge of learning Algebra is obvious to students with LD because they may have deficits in language, attention, memory, or metacognition that affect their acquisition of mathematics skills (Miles & Forcht, 1995). Adolescents with LD have difficulty in word problem solving and generally perform at a fifth-grade level in math. It is found that the average 17-year-old is functioning at a math level expected for the average 10-year-old without a disability (Cawley & Miller, 1989). These students often have reading difficulty that hinders their understanding of word problems. The language in mathematics symbolize and express concepts and reasoning. Understanding the language is important to organize the recall and use of multiple steps required to solve problems, and recall arithmetic facts, while multi-step problems in Algebra are especially difficult for students with LD.

The metacognitive difficulties experienced by students with LD (Gagnon & Maccini, 2001, 2007; Geary, 2004; Miller & Mercer, 1997) lead to challenges in identifying, monitoring, and coordinating the sequence of steps required to solve multi-step problems (Gagnon & Maccini, 2001, 2007; Geary, 2004). Students with LD struggle when attempting to solve a word problem due to the many steps involved. They may have difficulty reading it, analyzing the information, choosing pertinent information to use, prioritizing the numbers to arrange the order and (mathematical) operation within the equation, using a variable for the unknown, prior to attempting to solve the problem. When frustrated, these students may take the numbers in the order appeared in the word problem and just guess which operation(s) would be used, disregarding what is to be solved. Teachers have observed students with LD skipping steps when solving multi-step problems or not recognizing an illogical solution due to lack of reasoning skills. These students also struggle with essential mathematical concepts and skills, and higher-level math, e.g. Algebra and Geometry, which will be even more challenging for these students.

Graphic organizers could be a successful tool in general problem-solving procedures such as: remembering steps, substeps, and organizing the information to solve the problem. It is found that graphic organizers are often used in teaching three core content subjects: Social Studies, English, and Science, while not often applied in Algebra instruction (Ives & Hoy, 2003). Although graphic organizers were applied to upper level secondary mathematics instruction and students who received instruction with the graphic organizers outperformed those without the organizers, using computer-assisted graphic organizers to assist students with LD are very much limited in research (Ives, 2007).

Significance of the Study

Teachers of students with LD need instructional strategies that support Algebra learning. Computer-assisted instruction provides an opportunity for these students to practice using visual aides and images on the screen. Using an appropriately modified graphic organizer to teach higher-level mathematics skills may help students with relatively weak verbal skills and strong nonverbal reasoning skills to be successful in learning mathematics (Ives & Hoy, 2003). It is found that graphic organizers are effective in teaching higher-level mathematics skills however, limited research is found to use graphic organizers in mathematic instruction to high school students with LD. Further, few studies have been conducted in math instruction using computer- assisted graphic organizers to students with LD. This study will examine the effect of computer-assisted graphic organizers in Algebra instruction to high school students with LD. I believe that it will be valuable to add information regarding the effectiveness of using graphic organizers (hand-written and computer-assisted) when teaching Introduction to Algebra (PreAlgebra) to these students.

Statement of Purposes

The purposes of this study are: 1) to examine the effect of the use of graphic organizers in high school Algebra instruction; 2) to compare the difference of student performance when hand-written and computer-assisted graphic organizers are used and 3) to evaluate student attitude towards learning Algebra when hand-written and computer-assisted graphic organizers are provided.

Research questions

The following research questions are used in the study:

1. Will the use of hand-written graphic organizers increase math scores of students with LD when learning math concepts and skills of Introduction to Algebra?
2. Will the use of computer assisted graphic organizers increase math scores of students with LD when learning math concepts and skills of Introduction to Algebra?
3. What are the student attitudes towards learning Algebra when hand-written and computer-assisted graphic organizers are provided?

Chapter 2

Review of the Literature

Learning Algebra has become crucial for all high school students. All school districts require students to pass an Algebra course or high school assessments that include Algebra skills to receive their high school diploma (Gagnon, & Maccini, 2001). Algebra skills are important for students to continue their education and search for occupational opportunities after their high school graduation.

Students with LD struggle in learning Algebra because of their difficulties in acquiring and retaining math skills, lacking cognitive process, content foundation, and concepts. This chapter reviews research on Algebra instruction for students with LD. It focuses on using graphic organizers and technology in Algebra instruction for these students.

Students with LD in Learning Algebra

Students with LD experience difficulty with higher-level math, such as Algebra (Maccini, McNaughton, & Ruhl, 1999). These students face the double challenge of trying to learn sophisticated new mathematical procedures while lacking fluency with basic mathematical terms and operations (Maccini, McNaughton, & Ruhl, 1999). Successful students appear to be fluent in facts and mathematical routines and are able to monitor their performance to ensure that intermediate steps and obtained solutions make sense in terms of the given problem. Students with LD experience difficulties with processes necessary for problem solution, such as selecting appropriate operations and executing numerical calculations. Secondary students with LD experienced severe difficulty in word problem solving, because they lack skills to paraphrase and imagine problem situations and significantly lag behind their non-disabled peers (Montague, Bos, & Doucette, 1991).

According to Impecoven-Lind and Foegen (2010), there are three areas of difficulty in learning Algebra, including cognitive processes, content foundations, and concepts. Cognitive processes include attention, memory, language, and metacognition which can limit one's mathematics proficiency (Miller & Mercer, 1997). Attention is to focus on the key words to identify relevant information and follow the steps of problem solving. Memorization requires the recall of math facts and formulas, and previous skills learned. Students with memorization problems would struggle to remember the procedures needed to apply and complete the steps. Language is an integral part in understanding the meaning of the problem to interpret key information. Miller and Mercer (1997) linked the role of language in mathematics achievement to symbols used to express mathematics concepts. They found that language is important for success in calculation, word problems, organizing the recall and using multiple steps required to solve problems. Students with language deficiencies would struggle to understand and apply vocabulary terms associated with mathematical language (e.g., sum, difference, product, quotient, simplify, etc.).

In addition, metacognition difficulties experienced by students with LD lead to challenges in identifying, monitoring, and coordinating the sequence of steps required to solve multi-step problems (Gagnon & Maccini, 2001, 2007; Geary, 2004; Miller & Mercer, 1997). These students often have difficulty in assessing their own ability to solve problems, evaluating solutions for accuracy, and generalizing the use of strategies from one situation to another (Miller & Mercer, 1997).

Content foundations deal with three essential mathematical areas students should master prior to taking Algebra (National Mathematics Advisory Panel, NMAP, 2008). These include fluency with whole numbers, fraction concepts and operations, and geometry and measurement. Students with LD often struggle to develop proficiency with whole numbers, which is evident in the development of counting skills (Geary, 2004). Fractions, decimals, and proportions are challenging concepts for many students regardless of disability status (Impecoven-Lind & Foegen, 2010). A lack of conceptual knowledge of fractions leads to further difficulties with related concepts such as estimation and proportion (NMAP, 2008).

Algebra concepts deal with three areas in which students experienced the most difficulty and used ineffective strategies. The first area involves students interpreting the meaning of variables in which they either ignore them or guess their value when solving a problem. The second area involves using informal methods (guessing answers) rather than the formal methods (correct setup of equations) needed to solve advanced Algebraic problems. The third area involves the incorrect use of coefficients or negative numbers. It is found that students frequently misapply the distributive property, and misinterpret the meaning of the equals sign. Another problem Secondary Students with LD have is motivation. After years of unsuccessful experience in learning math at the elementary level, In Kotering, deBettencourt, and Braziel' s study (2005), 46 high school students with LD and 410 general education students were surveyed about their perceptions regarding their classes. Results showed that those with LD were more likely than their peers (55% vs. 32%) to identify mathematics as their least favorite high school class. If teachers provide assistance, altering typical teaching styles, incorporating group work, and increasing the interest level of the instruction, these students could improve their math performance.

Strategies in Algebra Instruction to Students with LD

The amount of research on Algebra instructional strategies is extremely limited. In a recent review of mathematics interventions for secondary students with LD, Maccini, Mulcahy, and Wilson (2007) identified two studies which focused on instruction of Algebra, specifically Integer skills, and three studies addressed students' conceptual and procedural knowledge of Algebra skills.

Problem Solving Strategies

The two studies which focused on instruction of Algebra researched the representation and solution of problem-solving skills involving integers. In the first study, Maccini and Hughes (2000) investigated the effects of using an instructional strategy called CSA (concrete, semi concrete, and abstract) within a graduated teaching sequence called STAR (Search, Translate, Answer, Review), as a problem-solving strategy for teaching Algebra to secondary students with LD. Students moved through three levels of instruction, CSA: (a) concrete, which involves using manipulatives to represent mathematics problems; (b) semi-concrete, which involves drawing pictorial representations of the problems; and (c) abstract, which involves writing mathematical symbols to represent and solve problems. The Algebra problem-solving strategy STAR (Maccini, 1998) was utilized within the graduated instructional phase (C-S-A). Instructional procedures used to teach STAR were adapted from the Strategic Math Series (Mercer & Miller, 1991). The STAR strategy is as follows:

1. "Search" the word problem by reading it carefully;

2. “Translate” the words into an equation in picture form, choose the correct operation, and represent the problem in an appropriate format (concrete phase, semi-concrete phase, or abstract phase);
3. “Answer” the problem using rules for addition and subtraction of integers;
4. “Review” the solution by checking their answer.

Maccini and Hughes (2000) examined the effects of a problem-solving strategy on the introductory Algebra performance of secondary students with LD. An instructional strategy within a graduated teaching sequence (CSA) to represent and solve problems with integer numbers was used. Six students from a secondary public school participated in the study. All participants were functioning more than two years below grade level, and were placed in a Resource Room for basic skills math instruction. The students scored below 80% on baseline data on problem solving of integer numbers. During the baseline, the mean percentage accuracy score for problem solution was 58% for addition, 39% for subtraction, 41% for multiplication, and 43% for division of integers.

During each instructional phase (C-S-A), the researcher (a) modeled two to three problems while thinking aloud, (b) provided up to five problems with guided practice while fading assistance, and (c) presented five problems for participants to solve independently. Results showed that all participants improved their percentage accuracy on problem representation from baseline to instructional phases in computation of integer numbers. After instruction at the concrete level, the mean percentage accuracy increased from 33% to 94% for addition, from 27% to 93% for subtraction, from 14% to 93% for multiplication, and from 10% to 97% for division of integers. Participants also maintained high mean percentage accuracy scores during semi-concrete and abstract instruction (range = 90%-100%). Mean percentage accuracy scores for problem solution in addition, subtraction, multiplication, and division of integers improved from baseline well above criterion level following concrete instruction (range = 91%-98%). Participants also maintained high mean percentage accuracy scores during semi-concrete (range=89%-100%) and abstract instruction (range=90%-99%). Participants' mean percentage correct on maintenance measures given up to 10 weeks following the intervention was 75% for problem representation and 91% for problem solution. Results indicated that all participants learned to represent and solve addition word problems involving integer numbers and that five participants learned to solve subtraction, multiplication, and division word problems involving integer numbers. These participants also demonstrated increases in their percentage of strategy-use across instructional phases. Their scores improved following strategy instruction at the C-S-A level. Although participants demonstrated improvements in translating the words into a picture and answering the word problem, they experienced difficulty remembering the fourth step of STAR, "Review the solution." Overall, the results of this research provided evidence that students with LD can be taught to represent and solve for the solution to word problems involving integer numbers and to generalize those skills to more difficult problems and maintain effects over time.

In another study, Maccini and Ruhl (2000) investigated the effects of the strategy on solution of Algebra problems involving subtraction of integers for three adolescents with LD. They were males, 14, 15, and 14 years old, identified as learning disabled. These students experience difficulty in mathematics which typically begin in the elementary grades and continue through secondary school. Successful performance in Algebra requires mastery of (a) basic skills and terminology, (b) problem representation, (c) problem solution, and (d) self-monitoring strategies (Hutchinson, 1987; Mayer, 1985). The treatment consisted of the STAR strategy (Maccini, 1998) with (a) concrete, semi-concrete, abstract (CSA) instructional sequence; (b) general problem-solving strategies; and (c) self-monitoring strategies. STAR incorporated the following phases: (a) pretest, (b) concrete application, (c) semi-concrete application, and (d) abstract application. Maccini and Ruhl (2000) noted that the STAR strategy was taught using a process consisting of teacher modeling, guided practice with feedback, and independent practice (similar to Hutchinson's cognitive strategy instruction on Algebra problem solving, 1993). Lesson topics included positive and negative numbers, subtraction of integers, and problem-solving involving subtraction of integers. Each lesson had six elements: (a) advance organizer, (b) model, (c) guided practice, (d) independent practice, (e) posttest, and (f) feedback/rewards. Dependent measures included (a) percent of strategy use; (b) percent correct on problem representation, (c) percent correct on problem solution and answer, (d) generalization, and (e) social validation. Results indicated that adolescent students with LD can learn to successfully represent and solve word problems involving subtraction of integers. These results were consistent with the first study when Maccini and Hughes (2000) conducted it. Continued research is necessary to identify interventions that are successful for secondary students with LD learning Algebra.

The third study, Witzel, Mercer, and Miller (2003) evaluated the effectiveness of the CRA (concrete-representational-abstract) model for students with LD and students who were at risk for failure in secondary mathematics according to a posttest and a three-week follow-up measure. The CRA approach is similar to the CSA (concrete-semi-concrete-abstract) approach and was used successfully by Miller and Mercer (1992, 1993) to teach basic math facts and associated problem-solving strategies to elementary students with LD. Approximately 358 sixth and seventh grade students participated in this study. Of these, 34 students with disabilities or at risk for Algebra difficulty in the treatment group were matched with 34 students in the comparison group according to achievement score, age, pretest score, and class performance. The scores of the students who were taught using CRA were compared to that of matched peers taught using abstract forms of instruction. The same math teacher taught both members of each matched pair, but in different classes. All students were taught in inclusive settings under the instruction of a middle school mathematics teacher. Results indicated that students who learned how to solve Algebra equations through CRA outperformed their peers receiving traditional instruction. The effectiveness of CRA sequence of instruction for Algebra learning among students with math difficulties demonstrated effectiveness of hands-on manipulative objects and pictorial representations for complex mathematics. The students who performed better committed fewer errors with negative numbers and with transformations of equations before solving for variables. It is concluded that teachers need to use concrete and pictorial representations that are appropriate to the age and developmental level of the students. Unfortunately, some secondary teachers may not trust the usefulness or efficiency of manipulative objects for higher-level Algebra, and may view it as an instructional strategy for elementary students.

Further, CRA was examined in Witzel's study (2005) to evaluate Algebra instruction to students with and without LD in inclusive settings. Student achievement in solving linear Algebraic functions across two procedural approaches: a multisensory Algebra model using a concrete-to-representational-to-abstract sequence of instruction (CRA) was compared. Six general education math teachers and 358 students from four middle schools participated in this study. Four teachers individually taught eight mathematics classes for sixth graders, and the other two teachers taught four mathematics classes for seventh-graders. Each teacher taught one class using the CRA method and one class with traditional instruction. The students had minimal prior experience with Algebra, and were introduced to Algebraic thinking through CRA. Each treatment lesson included four steps: (a) introduce the lesson, (b) model the new procedure, (c) guide students through procedures, and (d) begin students working at the independent level. These steps were used for instruction at the concrete, representational, and abstract stages of each concept. Teachers taught the concrete lessons using manipulative objects, the representational lessons using pictures, and abstract lessons using symbols.

The dependent measure, number of correct answers out of 27 possible on an Algebra assessment, was analyzed for both groups before instruction. After 19 lessons covering five math skills, the two groups of students were compared on their performance of multiple-step linear functions with the variable on both sides of the equal sign using an assessment instrument standardized to tenth-grade local students who completed Prealgebra and Algebra with an A or B letter grade. Posttests were provided five weeks later and follow-up measures were obtained three weeks after treatment had ended.

The results showed that out of 231 participating students, those who learned through the CRA model scored significantly higher on the post- and follow-up test. Students who used a CRA sequence outperformed their peers in the comparison condition in which all instruction was provided at the abstract, or symbolic. The results favored the treatment group who learned through multisensory Algebra over the comparison groups. Both the treatment and the comparison group showed improvement from the pretest to posttest and follow-up tests. These findings provide insight into Algebra education for middle-school students in inclusive settings and provide support for CRA instruction and shows promise for inclusive settings where students are highly varied in their math abilities.

Future research regarding Algebra instruction needs to include students with LD who are taught in general education classrooms, similar to Witzel's study (2005). Researchers need to investigate instructional techniques that can be successfully implemented in those settings.

Recently, Strickland and Maccini (2010) summarized the research on additional strategies for teaching Algebra concepts and how teachers can apply those strategies in their teaching. They recommend that as more students with LD participate in general education classrooms with high mathematics standards, there is a critical need to incorporate research-supported practices for all learners to successfully access an age-appropriate mathematics curriculum (Individuals With Disabilities Education Act, 1997; No Child Left Behind, 2002).

Fraction concepts are an area of mathematics that is particularly difficult for students with and without disabilities to understand. Understanding fraction equivalency is particularly important as it is a fundamental concept underlying the study of ratio, proportion, probability, rates, and functions. Another study which utilized the CRA instructional sequence while investigating the effects of teaching middle school students with mathematics disabilities equivalent fraction concepts and procedures was performed by Butler, Miller, Crehan, Babbitt, and Pierce (2003).

In this study, 50 students with learning disabilities enrolled in grades 6, 7, and 8 in two treatment groups, 26 in the CRA group, and 24 in the RA group. Both treatment groups received carefully sequenced instruction over 10 lessons. The only difference between the two treatment groups was that the CRA group used concrete manipulative devices for the first three lessons while the RA group used representational drawings. Two special education teachers participated in the study. Each teacher taught two math sections per day.

The primary dependent measure was a pretest and posttest which consisted of five subtests. Students' attitude toward mathematics instruction was measured using an investigator-constructed 10-item questionnaire using a three-point Likert scale. Materials for both groups included 10 scripted lessons. Teachers used scripted lessons and accompanying learning sheets to progress through each of the following seven components: an advance organizer, a teacher demonstration, guided practice, independent practice, problem-solving practice, feedback routine, and cue cards and notes. Concrete materials included commercially available fraction circles, small white dried beans, and student-made fraction squares of construction paper.

Students in both treatment groups improved significantly in achievement after the 10-lesson intervention. Data indicated that students in both treatment groups improved overall in their understanding of fraction equivalency from pretest to posttest. On all achievement measures, students in the CRA group had overall higher mean scores than did students in the RA group. It is concluded that both the CRA and RA instructional strategies were effectively implemented in middle classroom setting with students who have mathematics disabilities.

Cognitive Strategies

Hutchinson (1993) used cognitive strategy instruction to teach 20 adolescents between the ages of 12 and 15 years old with mathematics LD to solve three types of Algebra word problems, such as relational, proportion, and two-variable (two-equation). All 20 students met several criteria for participation including identification of a specific learning deficit and a discrepancy of more than three years on a standard achievement test in mathematics. Materials for the study included a set of self-questions for representation and solution on prompt cards and structured worksheets. Hutchinson found that solving complex problems in Algebra requires students to successfully complete two phases of activity – (1) represent the problem, by setting up the mathematical structure of one of the three types of problems; and (2) problem solution, by planning how to solve the problem and executing the procedures necessary to do so. Instruction began with teacher modeling and think-alouds, followed by guided practice with teacher support, assistance, and feedback. Two types of dependent measures were used, those collected during the course of instruction with instructed students and those used as pre-post measures to compare instructed and comparison groups. Results of the study revealed positive improvements in problem representation and solution on the problem types for which students had received instruction. Integrating components of strategy instruction, found to be effective for teaching simpler word problems to LD students, with current research on the nature of complex problem solving enabled LD students to master Algebra problem solving even for relational problems. So, the results of the current study suggest that strategy instruction is an effective approach.

Effective strategies are needed to successfully instruct students with LD. A research review of Algebra interventions for secondary students with LD, Maccini, McNaughton, and Ruhl (1999) determined that certain strategies improve students' performance in Algebra. These included the use of (a) general problem-solving strategies in problem representation and problem solution, (b) self-monitoring strategies, (c) the concrete-representation-abstract instructional sequence, and (d) teaching prerequisite skills. They also found that some complementary strategies and approaches for teaching Algebra are: explicit instruction, graduated instructional sequence, technology, and graphic organizers. Participants in the studies were identified as having LD; examined effects of an instructional intervention on performance of students with LD in Pre-Algebra and Algebra; Total of 158 students with LD, 62 females and 96 males; review of six published studies regarding Algebra interventions for students with LD in secondary and postsecondary settings. Teacher involvement differed among the studies. Successful interventions included instruction on domain-specific knowledge, general problem solving, and self regulation strategies. It was determined that continued research needs to be done to identify interventions that can be successfully implemented for students with LD.

The use of evidence-based practices for assessment and instruction must become standard practice. According to Foegen (2008), educators need effective tools for tracking student learning and determining when instructional changes are needed. They also need proven strategies for providing supplemental instruction in Algebra when students experience difficulty. Her article reports research on a group of measures designed to monitor student progress in Algebra and highlights findings specific to students with LD. She also summarizes evidence-based instructional strategies for Algebra.

Maccini and Hughes (2000) concluded that future studies should provide direct comparisons of instructional techniques to determine the most effective approaches to teaching Algebra to students with LD. Also, continued research is necessary to identify interventions that are successful with helping students with LD succeed in higher level mathematics courses. Plus, there is a need for stronger research designs and research reporting within the field of math interventions for secondary school students with LD.

Graphic Organizers in Teaching Algebra to Students with LD

The use of graphic organizers as visual aides is a new instructional strategy to help students arrange information in an orderly manner, which may assist students with LD who have deficits involving the language of mathematics and working memory deficits that may interfere with solving multi-step problems associated with Algebra (Strickland & Maccini, 2010). For example, a graphic organizer for solving quadratic equations is illustrated in Strickland and Maccini’s study (2010). Students are instructed to (a) start with the quadratic equation in the top block, (b) follow the arrows and factor the quadratic to represent two new equations, and (c) solve each equation. Using graphic organizers can be helpful to students with weak language skills to learn Algebra concepts and procedures.

Ives and Hoy (2003) reviewed some approaches to teaching mathematics that emphasized nonverbal skills. Some of the approaches reviewed show that they are often not immediately applicable to some important areas of secondary Algebra, though graphic organizers in various forms have been widely suggested and researched as an intervention approach to improve reading comprehension. Modifying graphic organizers to make them more applicable to teach higher-level mathematics concepts and procedures to help students with relatively weak verbal skills and strong nonverbal reasoning skills to be more successful in mathematics was suggested.

The effect of using graphic organizers was examined by Ives (2007). In the study, Ives worked with secondary students (grades 6 to 12) in a private school for students with LD. He conducted two studies addressing the solution of systems of linear equations. In his first study, he taught two groups of students (14 experimental-10 were male and 4 were female, 16 comparison-11 were male and 5 were female) to solve systems of two linear equations with two variables. The ages of students in the graphic organizer (GO) group ranged from 13 to 19 years. The ages of the comparison (CO) group ranged from 14 to 17 years. Students in both groups used the same instructional materials, received the same amount of instruction, and completed the same practice activities. Only the experimental group used a graphic organizer (a matrix of cells designed to provide non-verbal structure to the problem solution process). The students completed a test of prerequisite skills on the first day of instruction. Once the test was complete, instruction began with a review of the prerequisite skills. Both groups received the same number of hours of instruction, the same number of practice problems, and the same homework assignments. On the last day of instruction, the students completed one version of the content skills test. Ives found the experimental group’s scores on a teacher-developed assessment were statistically significantly higher than the scores of the comparison groups that did not use the graphic organizers.

A second study (Ives, 2007) was conducted using different students and instruction on solving linear systems with three equations with three variables. The purpose of this study was to provide a systematic replication of the first study with a different population and related content. The same graphic organizer was used in both studies. The mathematics content was systems of three linear equations with three variables rather than two linear equations with two variables. This study included a much smaller number of student participants. Experimental and comparison groups each consisted of 10 students. All participants in both groups were male. The ages of the GO group ranged from 16 to 19 years; whereas, the ages of the CO group ranged from 17 to 18 years. As in Study 1, the graphic organizer itself was the critical instructional tool being tested in the study. Scores of the two groups on the problem-solving test were not significantly different, but scores on the conceptual understanding test favored students in the graphic organizer group. Ives noted that the smaller sample size in the second study might have influenced statistical significance. The use of graphic organizers allows further expansion into other Algebraic topics that can be addressed using this instructional strategy, however, educators may consider developing their own graphic organizers to support Algebra learning (Foegen, 2008).

The similar study using graphic organizers in math instruction was examined in Delinda van Garderen’s study (2007). She examined the effectiveness of teaching students with LD to use diagrams to solve mathematical word problems. Three students with LD in Grade 8 participated in the study and received instruction in diagram generation and a strategy to incorporate diagrams as a part of the procedure to solve word problems. During the baseline, students were required to solve word problems by generating diagrams. Student 1 generated one diagram (out of a possible 24), and Student 2 and Student 3 did not generate any diagrams. Following instruction, on the posttest, where the students were to draw a diagram they would use to solve a problem, all the students generated diagrams for 100% of the time. On the word problem tests, where the students were required to solve the problems, Student 2 drew diagrams for 100% of the time for all measurement phases. Student 1 drew diagrams for 100% of the time for all phases except for the two-step measurement phase, where she generated diagrams for 96% of the time. Student 3 drew diagrams for 100% of the time for all measurement phases with the exception of the measurement phase. The results indicated that all students improved in the number of diagrams they used and in their ability to generate diagrams. Their word problem solving skills increased. Overall, the students were very satisfied with the instruction and would continue to use the diagrams and the strategy to solve word problems in other classrooms. It seems that the use of graphic organizers as visual aides would assist students with LD in the learning process to solve mathematical problems.

Computer-Assisted Graphic Organizers in Teaching Algebra

There are limited computer programs for developing graphic organizers, however, the two listed in Maccini and Gagnon's study (2005) are Inspiration developed by Inspiration Software, Inc., www.inspiration.com, and Mind Mapping Software by the Buzan Organization Ltd, www.nova-minBd.com. The Inspiration program helps educators individualize instruction for learners in grades 6 and above. The graphic tools help teachers create a variety of organizational devices, such as concept diagrams, webs, outlines, and maps. Mind Mapping offers a software program to help educators customize lessons, presentation, and handouts. The software can be used to create organization diagrams. Recently, a new software program, GOSolve Word Problems, was created to help students organize math problems and discover their underlying structure. The software's interface allows students to organize the component parts of a math problem and then helps students to identify the relationships between the values and components (Hasselbring, et. al. 2006). However, upon further investigation of these applying programs, none of the websites for graphic organizer software, or "mind mapping", could be applied with appropriate visual aided graphic organizers relating 9th grade Algebra instruction. As a teacher, finding an authorizing program to create my own graphic organizers such as using Microsoft Office applications would be necessary.

Four studies on videodisc instruction were conducted by Bottge and his colleagues (Bottge, 1999; Bottge et al., 2001; Bottge et al., 2002; Bottge et al., 2003). The effects of teaching contextualized problem solving via videodisc instruction were investigated. Bottge et al. (2001) expanded earlier studies to investigate whether students with learning problems using contextualized instruction via videodisc could match the performance of general education students on Prealgebraic concepts. Of the 75 participating students who participated, 16 were identified with LD. One remedial math class and three Prealgebra classes were assigned to treatment (n=34) and comparison (n=41) conditions. Teachers in each condition followed instructional procedures similar to Bottge's (1999) study. All groups made gains from pretest to posttest on problem-solving measures. The results showed promise for the efficacy of videodisc-based contextualized instruction to improve problem solving and maintain the learned skills. This indicated that using technology to integrate into Algebra instruction would support student learning math skills.

Summary

Because high-stakes testing and a focus on standards and accountability for all students is a central theme to current math education policies and agendas, it is critical that future research examine interventions to address middle school and high school curriculum standards (Maccini, Mulcahy, & Wilson, 2007). According to Witzel, Smith, and Brownell (2001), to succeed in learning Algebra and increase high school graduation rates, teachers and researchers need to develop means for teaching secondary students math skills. Continued research on helping students with LD to understand Algebraic concepts and learn skills to solve problems is needed. According to Maccini, Mulcahy, and Wilson (2007), there is a need for strong research on effective strategies in the field of math instruction for secondary students with LD. Research should include valid assessments, as well as thorough descriptions of the intervention in order to apply in the field for further practice. Graphic organizers served as visual aides in Algebra instruction show a new way of instruction to students with LD, while further studies are needed to evaluate their effectiveness on secondary Algebra instruction. Technology has provided an opportunity for teachers to incorporate in their math instruction to motivate student learning and develop hands-on activities to apply math skills in simulations. This current study is proposed to use computer-assisted graphic organizers in secondary Algebra instruction to examine their effectiveness for students with LD.

Chapter 3

Method

Setting

This research took place in two separate resource classrooms in a high school located in a suburban area of southern New Jersey. There are twelve student desks, two teacher desks, a chalkboard in one room, and a whiteboard in the other room. In the high school building, there is a computer lab and library media center which allows students to use computers.

Participants

A total of 8 students, of which 7 are ninth-graders, and one tenth-grader participated in this study. Their average age was 15. All of these students were classified with Specific Learning Disability which means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations. They were diagnosed by the school's child study team following the state's administration code. Each student had an IEP with goals and objectives in learning math. (See Tables 1, and 2 for details.)

Table 1
Participating Student's Information in the 2nd Math Period:

Student	Gender	Ethnicity	Grade	Age	Classification	Math Test 8th grade Mean: 200
1	F	B	9	14.11	SLD	147
2	M	H	9	15.4	SLD	179
3	M	W	9	15.9	SLD	158
4	F	W	9	14.11	SLD	158

Table 2
Participating Student's Information in the 5th Math Period:

Student	Gender	Ethnicity	Grade	Age	Classification	Math Test 8th grade Mean: 200
1	M	B	10	15.4	SLD	165
2	M	B	9	15.7	SLD	128
3	M	A	9	14.6	SLD	153
4	F	B	9	15.11	SLD	167

F: Female, **M:** Male
A: Asian, **B:** Black**, H:** Hispanic**, W:** White
SLD: Specific Learning Disability

Teacher

One teacher taught both Introduction to Algebra classes in the 2nd and 5th periods for 42 minutes each day, 5 days a week for 10 weeks.

Materials

Instructional Materials

The materials included 1) AGS Algebra Textbook by AGS Publishing, 2) teacher-made graphic organizers, and 3) computer programs. The NJ Course Content Standards of Mathematics for 9th grade students was utilized to guide the curriculum. These standards included: Standard 4.2 – communicate mathematically through written, oral, symbolic, and visual forms of expression; and Standard 4.6 – develop number sense and an ability to represent numbers in a variety of forms and use numbers in diverse situations.

Textbook and Curriculum. The textbook was AGS Algebra by AGS Publishing Company (2006). Rather than proceeding with the author's sequence in the textbook, the skills were taught by concept organizations. The Algebraic Concepts incorporated in the lessons are as follows:

1) Properties of Zero
   a) Addition Property of Zero

   b) Additive Inverse Property (opposites)

2) Solving Linear Equations with One Variable
   a) Equations: $x – b = c$

   b) Equations: $x + b = c$

   c) Word Problem Solving Using Linear Equations with One Variable

   d) Equations: $x – (-b) = c$

3) Properties of One
   a) Multiplication Property of 1

   b) Multiplicative Inverses (Reciprocals)

4) Solving Multiplication Equations with One Variable

   a) Creating Multiplication Equations with One Variable, then Problem Solving

Graphic Organizers. A total of 8 graphic organizers were developed by the teacher. These graphic organizers had three types of formats including fill-in-the-blank, hierarchy templates, and sequencing. The type used was dependent on the concept being learned. Each graphic organizer was printed out on a piece of paper to deliver in class as a handout. Students were required to fill out the information onto the printed graphic organizer in class to practice their learned math concepts and skills (See Appendix A for an example).

Computer-Assisted Graphic Organizers. The same format of graphic organizers was developed by the teacher using the Microsoft Word computer software program. All the graphic organizers were consistent with the written format. The only difference was that these were saved as a document on the computer and students had to open the document, then input their answers and save as their own graphic organizer (See Appendix B for a printed example).

Measurement Materials

The materials included: supplemental worksheets and teacher-made tests.

Supplemental Worksheets. All worksheets were selected from the textbook for students to practice. Each worksheet has two or three parts with directions. Each part has computation and word problems. It is worth a maximum score of 100 with 80% for computation, and 20% for word problems. A total of 10 worksheets were used in this study.

Teacher-made Tests. I compiled the test problems from practice exercises in the book which students were assigned as classwork and/or homework, as well as practice problems from their supplemental worksheets. The total maximum score which students could obtain was 100. Each test had 80% for computation problems and 20% for word problems.

Research Design

A multiple baseline single subject design was used in this study. For one group, over the course of 10 weeks, phases A & B were utilized; and for the second group, A, B, & C phases were used. During the baseline (phase A) students were given practice problem solving exercises from the book (Appendix C) and supplemental worksheets (Appendix D) to determine their prior knowledge and their scores were recorded. During phase B, students were taught to use graphic organizers to solve word problems and learn new skills. Supplemental worksheets were provided to the students to evaluate their performance. During phase C, students were taught to use computer-assisted graphic organizers, and their skills were assessed by supplemental worksheets, too.

Instructional Procedures

Students were given a pretest to evaluate their knowledge after learning their new math skill. Appendix E was the pretest used to evaluate their knowledge for the first math skill, “Properties of Zero”. Following completion of their pretest, I assessed how well students understood and applied their new math skill so I could modify subsequent instruction, based upon their pretest results. The first graphic organizer was introduced to students to practice skills at their own pace as a visual guide.

I created my own graphic organizers using Microsoft Word so that students could input their information to enhance student knowledge. After the teacher modeled examples, students were given a graphic organizer as a handout. Appendix A and B were a fill-in (type of format) graphic organizer used for their first math skill, “Properties of Zero”. Then, students were challenged to create their own problems for their classmates to solve. Completion of their pretest, use of their graphic organizer, and creating their own problems were achieved over a two-day period of time. Immediately following this, a posttest was given to each student which counted as a quiz grade (Appendix F).

When instructing students on Solving Linear Equations with One Variable, I modeled a strategy on thinking aloud through the problem-solving process, so that students could see when and how to apply the strategy to get the result. A four-step procedure was utilized when solving the problems:

1. Write the equation
2. Add the opposite to isolate the variable
3. Simplify (Solve)
4. Check the answer by substituting it back into the original equation.

The mnemonic, WASC, was developed to assist students in remembering the procedures when solving linear equations with one variable. When students were given word problems, they were cued to read and find context clues to choose the correct operation, write the numbers and variables in the appropriate position on their graphic organizer, then solve the problem.

When using the computer assisted graphic organizer, students read the word problem, identified and typed in context clues to identify the operation used in the problem. This was the first step in building the equation; then, the student identified which numbers to insert after the operation and after the equal signs. Once the student formed the complete equation, the student added the number's opposite (additive inverse) to isolate the variable ("x"), then simplified (solved) the equation.

Using direct instruction, students learned and practiced a new Algebraic concept for approximately 3 days, and then all students took a pre-test to determine their understanding. Immediately afterward, a graphic organizer was implemented to practice and apply the new concept for approximately 2-3 days. Students took a post-test to determine if the graphic organizer increased their understanding of the concept. (See Table 3 for instructional procedures.)

Table 3
Instructional Procedures

Week	Algebraic Concepts	Methods Used	Student Activity
A	**Properties of Zero**		
1	**Addition Property of Zero**	Direct Instruction; Guided Practice – whole group; Guided Practice independently with feedback;	Complete Exercise A, p. 43, 1-4 (4 problems) Complete Workbook Activity 19 (25 problems)
	Additive Inverse	Pretest;	Complete Exercise B, p. 43,

	Property (opposites)	Instruction using graphic organizer, by modeling, prompting & guided practice; Independent practice with feedback; Posttest.	5- 8 (4 problems) Activity 19 (20 problems) Take Pretest: Alternative Activity 19 (15 problems) Use Fill-in-Blank Graphic Organizer (12 problems) Take Posttest: Teacher-created (14 problems)
B	**Solving Linear Equations with One Variable**		
2	**Equations: x-b=c**	Direct Instruction; Think aloud problem-solving process, using a four-step procedure, WASC: Write the equation Add the inverse (opposite) to isolate the variable Simplify (Solve) Check the answer by substituting it back into the original equation. Guided Practice – whole group; Guided Practice independently with feedback; Pretest; Instruction using graphic organizer, by modeling, prompting & guided practice; Independent practice with feedback; Posttest.	Complete Exercise A, p. 61, 1-14 (14 problems) Complete Workbook Activity 26 (10 problems) Take Pretest: Alternative Activity 25 (10 problems) Use Hierarchy Graphic Organizer Take Posttest: Activity 25 (10 problems)
3	**Equations: x+b=c**	Direct Instruction; Think aloud problem-solving process, using a four-step procedure: Write the equation Add the inverse (opposite) to isolate the variable Simplify (Solve) Check the answer by	Complete Exercise A, p. 63, 1- 20 (20 problems) Complete Workbook Activity 27 (10 problems) Complete Exercise B, P. 63, 21-26 (6 problems) Take Pretest: Activity 26 (15 problems)

		substituting it back into the original equation. Guided Practice – whole group; Guided Practice independently with feedback; Pretest; Instruction using graphic organizer, by modeling, prompting & guided practice; Independent practice with feedback; Posttest.	Use Hierarchy Graphic Organizer Take Posttest: Alternative Activity 26 (10 problems)
4	**Word Problem Solving Using Linear Equations with One Variable**	Same procedures as above. Students were cued to read and find context clues to choose the correct operation, write the numbers and variables in the appropriate position on their graphic organizer, then solve the problem.	Complete Exercise C, p. 61, 21-25 (5 problems) Complete Exercise C, p. 63, 27-30 (4 problems) Solve Teacher-created practice problems (10 problems) Take Pretest: Teacher created (10 problems) Use Sequencing Graphic Organizer Take Posttest: Teacher created (10 problems)
5	**Equations: x-(-b)=c**	Direct Instruction; Think aloud problem-solving process, using a four-step procedure, WASC: Write the equation Add the inverse (opposite) to isolate the variable Simplify (Solve) Check the answer by substituting it back into the original equation. Guided Practice – whole group; Guided Practice-independently with feedback;	Complete Exercise B, p. 61, 15-20 (6 problems) Solve Teacher-created practice activity (10 problems) Take Pretest: Teacher-created (10 problems) Use Hierarchy Graphic Organizer Take Posttest: Teacher-created (10 problems)

		Pretest; Instruction using graphic organizer, by modeling, prompting & guided practice; Independent practice with feedback; Posttest.	
C	**Properties of One**		
6	**Multiplication Property of 1**	Direct Instruction; Guided Practice – whole group; Guided Practice independently with feedback; Pretest; Instruction using graphic organizer, by modeling, prompting & guided practice; Independent practice with feedback; Posttest.	Complete Exercise A, 1-10 (10 problems) Complete Workbook Activity 20 (10 problems)
	Multiplicative Inverses (Reciprocals)		Complete Exercise B & C, 11- 20 (10 problems) Take Pretest: Alternative Activity 20 (15 problems) Use Hierarchy Graphic Organizer Take Posttest: Activity 20 (20 problems)
7	**Solving Multiplication Equations with One Variable**	Introduce lesson using direct instruction; Guided Practice – whole group; Guided Practice independently with feedback; Pretest; Instruction using graphic organizer, by modeling, prompting & guided practice; Independent practice with feedback; Posttest.	Complete Exercises A, 1-26 (26 problems) Complete Workbook Activity 28 (10 problems)
8	**Creating & Solving Multiplication Equations with One Variable**	Same procedures as above. Students were cued to read and find context clues to choose the correct	Complete Exercises B, 27-30 (4 problems) Take Pretest: Alternative Activity 27 (10 problems)

		operation, write the numbers and variables in the appropriate position on their graphic organizer, then solve the problem.	Use Sequencing Graphic Organizer Take Posttest: Activity 27 (10 problems)

Measurement Procedures

Supplemental Worksheets. The sequence of instruction was the following: after introducing the new lesson on Day One, students were assigned exercises from the book related to the lesson. On Day Two & Three, students reviewed their answers. Then dependent upon student understanding, they were assigned practice problems using more exercises from the book and/or the workbook activity worksheets. On Day Four, students were given a pretest utilizing the alternative activity worksheet with a maximum score of 100.

Testing. After evaluating their results, students were given a graphic organizer to practice their new skill for two days (Day Four and Five) using practice problems from the book and/or workbook activity worksheets in the same format but utilizing different numbers. After using the graphic organizer, on Day Six, students took a post-test using an activity worksheet or a teacher-created posttest with a maximum score of 100. Over the duration of the research, eight Algebraic concepts were taught and this procedure was utilized over the course of 10 weeks.

All worksheets took one day each to complete problems. A total of ten worksheets were used in this study. I compiled the test problems from practice exercises in the book which students were assigned as classwork and/or homework, as well as practice problems from their supplemental worksheets. The total maximum score which students could obtain was 100. Each test had 80% for computation and 20% for word problems.

A baseline assessment to determine prior knowledge of each Algebraic concept was included in this study. After the pretest for each of the first four concepts, all students were using hard-copy graphic organizers. Period 2 (4 LD students) continued this procedure for the duration of this study. The second group of students from Period 5 (4 LD students) received a computer-assisted graphic organizer after direct instruction of the last four concepts. The graphic organizer replicated the hard-copy graphic organizer (same as the first group of students utilized).

Data Analysis

Data was organized into two different groups to represent each class that participated within the study. Student performance scores in baseline (Phase A) and intervention (Phase B
and C) were compared.

Data was analyzed using Microsoft Excel to graph the results. Using line graphs, each student's test scores were plotted to determine whether the use of graphic organizers affected their understanding of learning Algebraic concepts. Then, a comparison of line graphs was presented to determine whether hand-written graphic organizers or computer-assisted graphic organizers were effective with increasing understanding and ultimately learning Algebraic Concepts for students with LD.

Chapter 4

Results

Data was organized into two different groups to represent each class that participated within the study. Student performance scores in baseline (Phase A) and intervention (Phase B

and C) were presented.

A single subject design with ABC phases was used in this study. Over the course of 10 weeks, for the first group, phases A & B were utilized; and for the second group, phases A, B, & C were used. During the baseline (phase A) students were given practice problem solving exercises in the book (Appendix A1) and supplemental worksheets (Appendix A2) to determine their pretest scores were recorded. During phase B, students were taught by incorporating the use of graphic organizers created specifically for that Algebraic concept/skill. Supplemental worksheets or teacher-created posttests were given to evaluate their understanding. During phase C, Group 2 students utilized computer-assisted graphic organizers to practice the learned skills. They were assessed by supplemental worksheets or teacher-created posttests with a 0 to 100 point system. Table 4 shows student performance with each Pretest and Posttest for each Algebraic Concept (skill) learned.

Table 4
Student Performance in Tests for Each Skill Area

Algebraic Concept	S1	S2	S3	S4	S5	S6	S7	S8
Properties of Zero								
Pretest 1: Alternative Activity 19	90	80	30	50	70	85	70	50
Posttest 1: Teacher-created	90	100	75	75	80	50	70	100
Solving Linear Equations with One								

Variable								
Equations: x-b=c								
Pretest 2: Alternative Activity 25	90	90	90	60	100	90	50	90
Posttest 2: Activity 25	80	100	100	95	95	100	90	100
Equations: x+b=c								
Pretest 3: Activity 26 (15 problems)	75	65	85	70	75	80	100	90
Posttest 3: Alternative Activity 26	100	100	100	80	95	80	100	90
Word Problem Solving Using Linear Equations with One Variable								
Pretest 4: Teacher created	90	40	50	50	80	80	100	80
Posttest 4: Teacher created	100	70	80	90	100	80	100	100
Equations: x-(-b)=c								
Pretest 5: Teacher-created	70	0	50	75	65	50	60	60
Posttest 5: Teacher-created	80	90	75	95	100	100	90	80
Properties of One								
Pretest 6: Alternative Activity 20	100	100	100	100	85	50	90	70
Posttest 6: Activity 20 Quiz	100	100	100	85	100	95	100	95
Solving Multiplication Equations with One Variable								
Pretest 7: Alternative Activity 27	60	50	60	10	85	90	85	50
Posttest 7: Activity 27	100	70	75	95	90	100	100	100
Solving Equations with Fractions								
Pretest 8: Alternative Activity 28	80	90	50	80	70	90	90	0
Posttest 8: Teacher Created	95	95	85	90	95	95	100	100

Table 5

Student Math Scores for Pretests and Posttests.

Group 1	Pre1	Pre2	Pre3	Pre4	Pre5	Pre6	Pre7	Pre8		Post1	Post2	Post3	Post4	Post5	Post6	Post7	Post8	
Student 1	90	90	75	90	70	100	60	80		90	80	100	100	80	100	100	95	
Student 2	80	90	65	40	0	100	50	90		100	100	100	70	90	100	70	95	
Student 3	30	90	85	50	50	100	60	50		75	100	100	80	75	100	75	85	
Student 4	50	60	70	50	75	100	10	80		75	95	80	90	95	85	95	90	
Average	63	83	74	58	49	100	45	75		85	94	95	85	85	96	85	91	
Group 2	**Pre1**	**Pre2**	**Pre3**	**Pre4**	**Pre5**	**Pre6**	**Pre7**	**Pre8**		**Post1**	**Post2**	**Post3**		**Post4**	**Post5**	**Post6**	**Post7**	**Post8**
Student 5	70	100	75	80	65	85	85	70		80	95	95		100	100	100	90	95
Student 6	85	90	80	80	50	50	90	90		50	100	80		80	100	95	100	95
Student 7	70	50	100	100	60	90	85	90		70	90	100		100	90	100	100	100
Student 8	50	90	90	80	60	70	50	0		100	100	90		100	80	95	100	100
Average	69	83	86	85	59	74	78	63		75	96	91		95	93	98	98	98

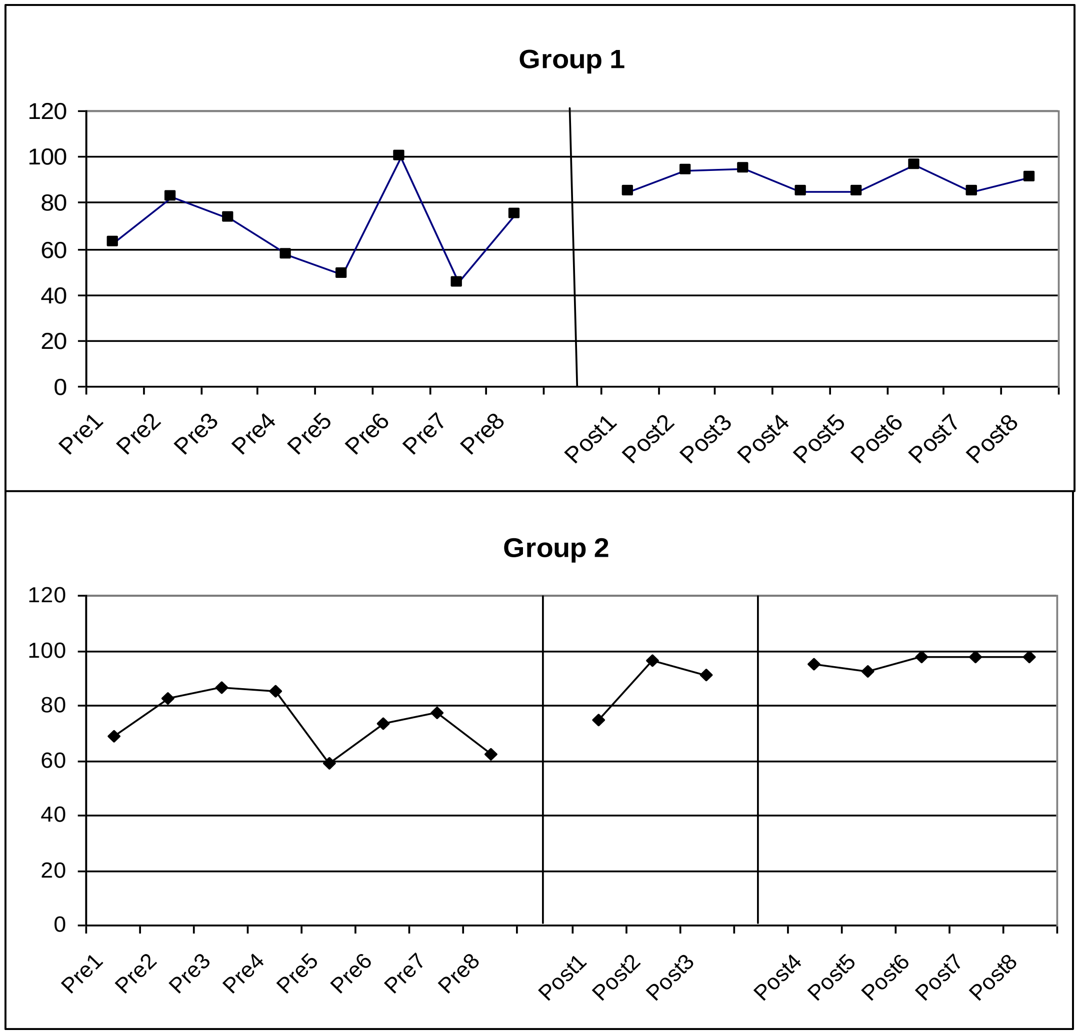

Figure 1. Mean Scores of the students in the two groups

Figure 1 compares average scores of students in each group. During baseline, phase A, the pretest average score for Group 1 was 68 with a range of 45-100; the pretest average score for Group 2 was 75 with a range of 59-86. During phase B, the posttest average score for Group 1 was 90 with a range of 85-96; Group 2 was 87 with a range of 75-96. During phase C., posttest average scores for Group 2 was 96 with a range of 93-98.

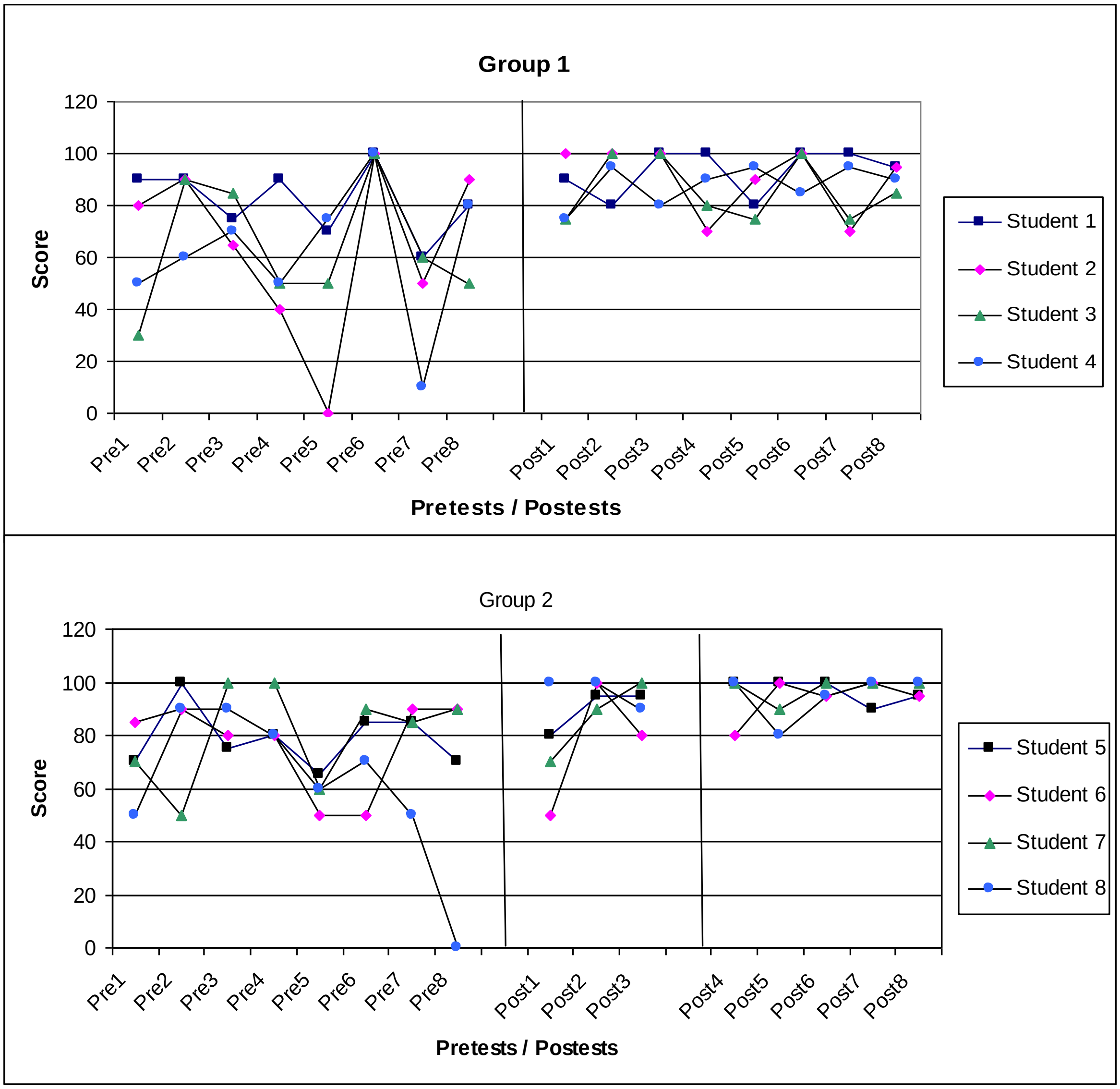

Figure 2. Individual Student performance

Figure 2 compares individual student performance in each group. In Group 1, all students showed improvement after intervention, Phase B. Within this group, Students 2 and 4 demonstrated an increase of 42%, Students 3 and 4, showed an increase of 34%, and 13%, respectively. In Group 2, three out of four showed improvement after intervention, Phase B. Within this group, Students 8, 5, and 7 had an increase of 59%, 14%, and 7% respectively. However, Student 6 stayed the same at 0%. In Group 2, all students showed improvement from Phase A to Phase C. Within this group, Student 8 had an increase of 56%, Students 5, 6, and 7, had an increase of 23%, 22%, and 21%, respectively.

Table 6
Student Average Scores

Students	**Phase A** **Pretest Before Intervention**	**Phase B** **Posttest Hand-written graphic organizer**	**Phase C** **Posttest Computer-assisted graphic organizer**
1	82	93	
2	64	91	
3	64	86	
4	62	88	
5	79	90	97
6	77	77	94
7	81	87	98
8	61	97	95

Table 7
Percentages of increase in Student Performance

Students	**Phase A to B** **Pretest to Posttest after Hand-written graphic organizer**	**Phase A to C** **Pretest to Posttest after Computer-assisted graphic organizer**
1	+13%	
2	+42%	
3	+34%	
4	+42%	
5	+14%	+23%
6	0%	+22%
7	+7%	+21%
8	+59%	+56%

Majority of the students improved their scores using graphic organizers in learning Algebra. All students in Group 1 showed improvement with their average scores from Phase A to B; the range of improvement was a 13% to 42% increase. All students in Group 2 showed improvement with their average scores from Phase A to C; the range of improvement was a 21% to 56% increase. During Phase B in Group 2, only Student 6 did not show improvement from Phase A; however, the same student had a 22% increase from Phase A to C. Student 8 improved by 59% from Phase A to B; however, this same student showed a 56% improvement from Phase A to C. From this result, Student 8 was slightly more successful using the hand-written graphic organizer than the computer-assisted graphic organizer.

Table 9 shows the results from the survey with percentages calculated. Questions eight and nine involved Group 2 (four) students only.

Table 9
Student Survey responses

Survey Results					
Questions	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1. I like math.	2 (25%)	2 (25%)		4 (50%)	
2. I am good at math.	2 (25%)	2 (25%)	2 (25%)	2 (25%)	
3. I understand new math skills immediately.		1 (12.5%)	4 (50%)	1 (12.5%)	2 (25%)
4. After some practice, I am good at math.	1 (12.5%)	4 (50%)	2 (25%)	1 (12.5%)	
5. After much practice, I am good at math.	3 (37.5%)	2 (25%)	3 (37.5%)		
6. Hand-written graphic organizers were easy to use.		3 (37.5%)	2 (25%)	2 (25%)	1 (12.5%)
7. Hand-written graphic organizers helped me understand math		1 (12.5%)	4 (50%)	2 (25%)	1 (12.5%)
8. Computer-assisted graphic organizers were easy to use.		2 (50%)	2 (50%)		

9. Computer-assisted graphic organizers helped me understand math.		2 (50%)	2 (50%)		
10. I liked using graphic organizers.		3 (37.5%)	2 (25%)	2 (25%)	1 (12.5%)
11. All graphic organizers were easy to use.			2 (25%)	4 (50%)	2 (25%)

Chapter 5

Discussion

The purpose of this study was: 1) to examine the effect of the use of graphic organizers in high school algebra instruction; 2) to compare the difference of student performance when hand-written and computer-assisted graphic organizers were used and 3) to evaluate student attitude towards learning algebra when hand-written and computer-assisted graphic organizers were used. The results were obtained by administering pre and posttests for each Algebra skill learned, and a survey was provided to investigate student attitudes towards Algebra learning.

The first research question was regarding student use of hand-written graphic organizers when learning new Algebraic concepts / skills. The results indicated that the majority of students gained in their test scores. Seven of the eight (87.5%) students increased test scores, except one whose scores were unchanged. The findings were consistent with the previous study using graphic organizers by Ives (2007) for secondary students with LD. In his study, it was found that practicing with the graphic organizers the student scores were statistically significantly higher than that of the comparison groups without using graphic organizers. The results are also consistent with Delinda van Garderen's study (2007) using graphic organizers in math instruction. It was found that students with LD using diagrams to solve mathematical word problems improved in the number of diagrams and in their ability to generate diagrams, and their word problem solving skills. It is also indicated that the use of graphic organizers as visual aides would assist those students in the learning process to solve mathematical problems.

The second research question was regarding student use of computer-assisted graphic organizers when learning new Algebraic concepts / skills. The results showed that student math scores increased except one. For example, the scores of Student 6 increased by 22% after using the computer-assisted graphic organizers. He was more attentive using this type of visual aide.

The third research question was related to student attitudes towards learning Algebra using hand-written and/or computer-assisted graphic organizers. Student responses to the survey were varied. The hand-written graphic organizers were accepted by five out of eight students (62.5%); whereas, none of the four students who used the computer-assisted graphic organizers disliked using them. Two of the four students agreed that computer-assisted graphic organizers were easy to use and helped them understand math. Whereas, the other two students neither agreed or disagreed that the computer-assisted graphic organizers were easy to use or helped them understand math. Three out of eight liked using graphic organizers, two neither agreed nor disagreed, and three disliked using them. One student in particular was obstinate regarding the use of hand-written graphic organizers; she was in Group 1, therefore, she did not have the opportunity to use the computer-assisted graphic organizers. This particular student is often reluctant to any changes in her learning.

Limitations

There are some limitations in this study. First, some participants scored high on their pretest prior to the use of the graphic organizer (GO). Thus, the GO was ineffective regarding those particular students (Students 1, 5, 6, and 7), so it was difficult to measure if the GO increased their understanding of that math skill. This was exemplified by each student in Group 1 scoring 100 with Pretest 6 for Group 1 (applying the property of one which involved reciprocals and the multiplication property of one.) Students had disclosed that they had learned and retained this math skill from middle school. Student 4 became more confused after using the GO as evidenced by her Posttest 6 score of 85 (15% decrease). However, this particular student rejects changes whenever a new instructional method is introduced. There were other students that did not like using the GOs as proven by the survey results (Questions 10 and 11). We must keep in mind that special education students may react negatively towards changes.

All participating students were classified as SLD. However, as evidenced by their ability, their classification needs to be re-evaluated; some are OHI (other health impaired), due to their ADHD (attention deficit hyperactivity disorder), but classified in the LD category. Instead of comparing two groups of 4 students, I could increase my sample size to three groups of 6 students with various classifications (SLD, OHI, ED, EBD, CI).

Another limitation is the school environment. There is a huge shortage of computers for the number of students in the building – one computer lab with 20 computers and the library/media center with 15 computers for a student population of approximately 1400. Sometimes, students need to share a computer due to scheduling difficulty for the computer lab or library. Within the computer lab and library, the arrangement of the computers made it difficult to teach students how to use computer-assisted GOs. Much time (3/4 of the class period, 20-30 minutes) was spent assisting students with logging onto the computers, then explaining how to input data into the tables. Hand-written GOs were much easier to incorporate into the math lessons and demonstrate the process. Students understood the application quickly while the computer-assisted GO needs more time for the teacher to explain. Because websites for graphic organizer software, or “mind mapping” could not be applied to Basic Algebra instruction, I created my own graphic organizers using Microsoft Office applications. I chose a table format to make student input user friendly. As indicated by Foegen (2008), the use of graphic organizers allows further expansion into other Algebraic topics that can be addressed using this instructional strategy, however, educators may consider developing their own graphic organizers to support Algebra learning.

Recommendations

All students in my three Resource Room classes (21 students) used the hand-written graphic organizers during the study. If graphic organizers are incorporated into all Algebra lessons, I believe that all students (general and special education) could benefit. For example, the new software program, GOSolve Word Problems, could be incorporated into new math lessons to help students organize math problems. The software’s interface allows students to organize the components of a math problem and then helps students identify the relationships between the values and components (Hasselbring, et. al. 2006). Along with this recommendation, Resource Room classes (remedial math classes) should have at least four computers for students available at all times.

Conclusion

Overall, student scores improved after using both types of graphic organizers in learning Algebra. Table 6 compares student average scores and Table 7 lists the percent of improvement (of student average scores) from baseline (Phase A) to intervention (Phase B and C). Average scores for Group 1 pretests ranged from 45 to 100; whereas their average scores for posttests were 85 to 96. All students in Group 1 showed improvement from baseline to Phase B with a range from 13% to 42%; Students 1, 2, 3, and 4 showed an increase of 13%, 42%, 34%, and 42% respectively. Average scores for Group 2 pretests ranged from 59 to 86; whereas their average scores for posttests were 75 to 96 during Phase B, and 93 to 98 during Phase C. Group 2 students had a range from 0% to 59% improvement from baseline to Phase B; Students 5, 7, and 8 showed an increase of 14%, 7%, and 59% respectively. Student 6 did not show a change from Phase A to B. Group 2 students had a range from 21% to 56% improvement from baseline to Phase C; Students 5, 6, 7, and 8 showed an increase of 23%, 22%, 21%, and 56% respectively.

Also, in Group 2, Student 8 showed an increase of 59% which was slightly better with the use of the hand-written graphic organizer (59%) in Phase B, compared to an increase of 56% with the use of the computer-assisted graphic organizer from Phase A to Phase C.

Because high-stakes testing for all students has become a central theme to current math education policies and agendas, Maccini, Mulcahy, and Wilson (2007), suggest that future research examine interventions that address middle school and high school curriculum standards. According to Witzel, Smith, and Brownell (2001), to succeed in learning Algebra and increase high school graduation rates, teachers and researchers need to develop means for teaching secondary students math skills. Therefore, continued research on effective strategies in the field of math instruction for secondary students with LD to understand Algebraic concepts and learn skills to solve problems is necessary.

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Ch.2, L7 – Properties of Zero

Addition / Subtraction Property of Zero
Adding zero to a number does not change the number.
Subtracting zero from a number does not change the number.

$3 + 0 = 3$	$-1 + 0 = -1$	$x + 0 = x$	$-ab + 0 = -ab$
$3 - 0 = 3$	$-1 - 0 = -1$	$x - 0 = x$	$-ab - 0 = -ab$

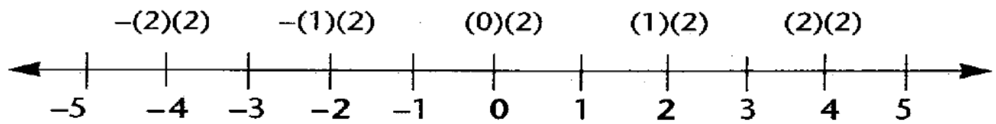
$\boxed{} + 0 = 5$ $\quad -7 + \boxed{} = -7$ $\quad \boxed{} + 0 = xy$

$\boxed{} - 0 = -23$ $\quad xyz - 0 = \boxed{}$ $\quad 4 - \boxed{} = 4$

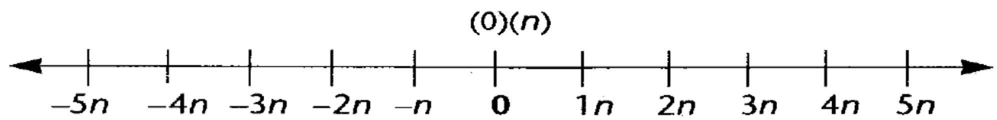
Graphic Organizer to Solve x – (-b) = c

1)	**x**	**-**	**(- b)**	**=**	**c**
R1		**Change – (-b) to** +		=	
R2	**Get x by itself**			=	
R3	**x**			**=**	
2)	**x**	**-**	**(- b)**	**=**	**c**
R1		**Change – (-b) to** +		=	
R2	**Get x by itself**			=	
R3	**x**			**=**	

Counting by 2's



Counting by n's



You can see that $(0)(2) = 0$
$(0)(n) = 0$

Writing About Mathematics

Explain what the opposite of a positive integer is and what the opposite of a negative integer is.

Multiplication Property of Zero
Zero times any number is zero.
$(0)(n) = 0$ where n is any number.
$0(a + b) = 0$ because $0(a + b) = (0)(a) + 0(b) = 0 + 0$.

Exercise A Write each sum.

1) $3 + 0$ **2)** $0 - 7$ **3)** $x^2 + 0$ **4)** $0 - y^3$

Exercise B Copy and fill in the missing number or letter.

5) $-5 + \blacksquare = 0$ **6)** $4 - \blacksquare = 0$ **7)** $a + \blacksquare = 0$ **8)** $-x^2 + \blacksquare = 0$

Exercise C Write each product.

9) $0(5)$ **11)** $(-8)(0)$ **13)** $(a + b)(0)$

10) $(0)(y)$ **12)** $(ax)(0)$

Exercise D Write your answer to each question.

14) How are 23 meters below sea level and 23 meters above sea level related to each other?

15) Explain why 5° Fahrenheit is 10 degrees warmer than −5° Fahrenheit.

[redacted]

See page 395 for sample solutions to problems 1, 5, 9, and 14.

Name ______ Date ______ Period ______ Workbook Activity 19

Chapter 2, Lesson 7

Properties of Zero

EXAMPLE

Additive Property of Zero:	$4 + 0 = 4$	$-2 + 0 = -2$
Additive Inverse Property:	$-3 + 3 = 0$	$5 + (-5) = 0$
Multiplication Property of Zero:	$0(6) = 0$	$-4(0) = 0$

Directions If the two numbers are additive inverses, write *true*. Otherwise, write *false*.

1. -12 12 ______
2. 7 -7 ______
3. -5 0 ______
4. -75 75 ______
5. -8 -8 ______
6. x $-x$ ______

Directions Write each sum.

7. $9 + 0$ ______
8. $0 + 27$ ______
9. $0 - 14$ ______
10. $k + 0$ ______
11. $-16 + 0$ ______
12. $0 + m^2$ ______
13. $0 - 37$ ______
14. $k^5 + 0$ ______
15. $0 - y^2$ ______

Directions Write each product.

16. $0(112)$ ______
17. $(-17)(0)$ ______
18. $0 \cdot q$ ______
19. $(xy)(0)$ ______
20. $(0)(-9)$ ______
21. $(cde)(0)$ ______
22. $(-jk)(0)$ ______
23. $n^7 \cdot 0$ ______
24. $(0)(ab^3)$ ______

Directions Solve the problem.

25. Jenna said to Brett, "I'll give you double the number of marbles you have in your pocket."
Brett replied, "But I don't have *any* marbles in my pocket."
Jenna responded, "So I'll give you double nothing, which is nothing."

How could Jenna say the same thing in a mathematical expression? Underline one.

a. $1 + 2 = 3$ **b.** $0 + 2 = 2$ **c.** $2(0) = 0$

Aopendix D

Name Date Period

Alternative Activity 19
Chapter 2, Lesson 7

Properties of Zero

Directions For each mathematical statement, write one of the following: *true*, *false*, or *neither true nor false.*

1. $a(b + x) = a + b + x$ ______________________
2. $5 \cdot w = w \cdot 5$ ______________________
3. $a + (9 + z) = (a + 9) + z$ ______________________
4. $12n(0) = 12n$ ______________________

Directions Fill in the missing blank to complete each sum or product.

5. ________ $\cdot\ 14 = 0$
6. $122 + 0 =$ ________
7. $-12 +$ ________ $= 0$
8. $r^4 \cdot 0 =$ ________
9. $-p +$ ________ $= 0$
10. $-32 \cdot$ ________ $= 0$
11. ________ $+ (-9) = 0$
12. $-7 + 7 =$ ________
13. ________ $+ 0 = 68$

Directions Answer the questions about the problem.

Suppose you found 3 quarters in a parking lot one day. On another day, you lost 3 quarters out of your pocket. What was the overall result for these two days?

14. Complete the equation to show the answer.

$3 +$ ________ $= 0$

15. Check the property that this story illustrates.

a. ________ Addition property of zero

b. ________ Multiplication property of zero

c. ________ Additive inverse property

Chapter 2, Lesson 7
Properties of Zero

Directions: **Fill in the missing blank to complete each sum or product.**

1. ________ • 14 = 0

2. 122 + 0 = ________

3. –11 + ________ = 0

4. $r4 \bullet 0 =$ ________

5. $–p +$ ________ = 0

6. $(0)(x2) =$ ________

7. 0 + 18 = ________

8. –32 • ________ = 0

9. ________ + (–9) = 0

10. –6 + 6 = ________

11. ________ + 0 = 68

12. (–12)(________) = 0

Directions: **Answer the questions about the problem.**

Suppose you found 3 quarters in a parking lot one day.
On another day, you lost 3 quarters out of your pocket.
What was the overall result for these two days?

13. Complete the equation to show the answer.

3 + ________ = 0

14. Check the property that this story illustrates.

a. ________ Addition property of zero
b. ________ Multiplication property of zero
c. ________ Additive inverse property