Supplemental Algebra Vocabulary Instruction for Secondary Students with Learning Disabilities

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SUPPLEMENTAL ALGEBRA VOCABULARY INSTRUCTION FOR SECONDARY STUDENTS WITH LEARNING DISABILITIES

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Curriculum and Instruction

by
Joanna Burns Stegall
August 2013

Presented to:
Janie Hodge, Ph.D., Committee Chair
Sara M. Mackiewicz, Ph.D.
Antonis Katsiyannis, Ed.D.
Gretchen Matthews, Ph.D.
ABSTRACT

Vocabulary is vital for success in secondary content area curricula and students with learning disabilities often have limited vocabulary knowledge which inhibits their success in content area classes. Therefore, the purpose of this study was to examine the effects of an explicit algebra vocabulary intervention with graphic organizers on vocabulary knowledge and skills in algebra for students with learning disabilities. A single-case repeated acquisition design with pre- and posttest measures was used to determine the effects of the intervention for students with learning disabilities who received special education services. The study included 10 students who received Algebra I instruction in general education and additional support in a resource setting. The researcher-implemented vocabulary intervention occurred in the resource setting on alternating days for 30-40 minutes per session across four weeks. Students learned four new vocabulary words during each session through explicit vocabulary instruction and completion of graphic organizers. Results indicated that students with learning disabilities were able to learn the vocabulary and were able to apply the knowledge of the vocabulary to algebra problems. However, students did not maintain the new learning on maintenance measures, although mean scores for the maintenance measures were higher than mean pretest scores across the intervention. Project participants and the special education teachers familiar with the intervention reported positive perceptions of the effectiveness and feasibility of the vocabulary intervention.
DEDICATION

To my parents, Roy and Marjorie Burns, because you both have always wanted more for me.

and

To my husband, Lee Stegall, who supported me during the tough times in big and small ways.

and

To my daughters, Lindsey Stegall and Andie Stegall, because you were my inspiration to continue when I wanted to stop.
ACKNOWLEDGEMENT

First, I have to thank my wise and wonderful dissertation chair, Dr. Janie Hodge. You guided me throughout my doctoral program with patience, kindness, and understanding. Thank you for all of your time commitment through numerous meetings, readings, and written feedback. Your dedication provided me with access to your invaluable teaching, compassion for students, and research skills that I hope to pass on to others. Beyond your professional wisdom, I always left your office feeling uplifted and encouraged, and that means everything.

A community of educators invested their time and talents to support, teach, and encourage me. Thank you to my other dissertation committee members. To Dr. Sara Mackiewicz, thank you for your expertise in single-case research design. To Dr. Antonis Katsyannis, thank you for calm demeanor, expertise, and straight-forward, but friendly, guidance. To Dr. Gretchen Matthews, thank you for your mathematical content knowledge, and expertise.

To Dr. Pamela Stecker, thank you for all of your time and dedication to my intellectual growth. You immersed me into the rich world of research, provided national research and presentation opportunities, and shared freely your expansive expertise. I am forever grateful.

Additionally, I would like to thank Dr. Vivian Correa because you were the first to believe in my potential as a leader in the field of special education. You have wisdom, energy, and passion for education that I hope to emulate.
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Chapter One

Introduction

Achievement in mathematics has been identified as critical for economic vitality. In fact, the National Science Board (NSB, 2003) concluded that U.S. competitiveness in the international market was directly impacted by the mathematical abilities of its citizens. In fact, international mathematics-intensive jobs in science and engineering outpaced overall job growth by three to one (NSB, 2003) and the U.S. Chamber of Commerce estimated that 90% of the fastest-growing jobs required postsecondary education that included skills in higher level mathematics (Dounay, 2007).

Employers seek mathematically competent workers and are concerned about U.S. students’ lack of mathematical competency. Poor results for U.S. students on international assessments, such as Trends in International Math and Science Study (TIMSS) in 2011 (Provasnik, Kastberg, Ferraro, Lemanski, Roey, & Jenkins, 2012) and the 2009 Programme for International Student Assessment (PISA; Fleishman, Hopstock, Pelczar, & Shelley, 2012) brought attention to mathematics instruction. PISA (Fleishman, et al., 2012) included mathematical problems that measure reasoning skills, broad content knowledge, and applied real-world application, while TIMSS (Provasnik, et al., 2012) measured student proficiency in numbers, algebra, geometry, data, and change. The U.S. was outscored by 11 countries on the TIMSS 2011 eighth grade mathematics test and 17 countries outscoresd U.S.15-year olds in mathematical literacy on PISA in 2009. On PISA, almost one-fourth of all U.S. eighth graders did not understand the meaning of their answers to mathematical problems.
The importance of understanding mathematics has been addressed repeatedly by The National Council of Teachers of Mathematics (NCTM), the flagship organization for mathematics educators. NCTM has called for teaching methods that allow for students to explain their answers to mathematical problems. For example, in 1991 NCTM released teaching proficiencies in a document called *Professional Standards for Teaching Mathematic*. Included in this document were standards for teaching effective communication through worthwhile learning tasks. Teachers were to create opportunities for students to apply mathematics in real-world contexts and explain how this was accomplished. NCTM (2000) released *Principles and Standards for School Mathematics* that defined the *Learning Principle*. This principle included that students must learn mathematics with understanding and this would be achieved by providing opportunities for students to build new knowledge from prior experiences and knowledge. Then in 2007, NCTM released *Mathematics Teaching Today*. This document suggested a balanced approach in teaching to include procedural fluency and conceptual understanding. Conceptual understanding, or the comprehension of mathematics, was included because mathematically proficient student must be able to apply acquired mathematics to new situations. Again in 2011, NCTM released a statement in *Principles and Standards Executive Summary* that recommended educators teach thinking, reasoning, and communication skills because these skills were identified as critical for success in postsecondary mathematics courses and jobs in a global technological society (NCTM, 2011). NCTM has recognized that communication in mathematics can lead to improved understanding for over 20 years, but according to the latest PISA results
(Fleishman, et al., 2012) many students lack the skills necessary to be mathematically proficient.

The National Governors Association Center for Best Practices through the Council of Chief State School Officers (NGACBP CCSSO; 2010) worked with community leaders, parents, educators, and researchers to create a national set of teaching standards, the Common Core State Standards (CCSS). Forty-five states, the District of Columbia, and four U.S. territories have adopted CCSS and most public schools are currently transitioning to the CCSS (NGACBP CCSSO, 2010) from state standards.

The Common Core State Standards in Mathematics (CCSSM; NGACBP CCSSO, 2010) calls for expanded mathematical understanding through increased use of problem-solving tasks and mathematical discourse. For example, Mathematical Standards for Practice, Standard Three states that students should be able to “construct viable arguments and critique the reasoning of others.” Students should be able to use definitions, justify their conclusions, communicate with others, and respond to arguments of others. The desired outcome from the increased focus on discourse is high school graduates who are proficient communicators of conceptual understanding as is required to be competitive for careers at an international level (NGACBP CCSSO, 2010).

Findings from international studies (TIMSS, 2011; Provasnik, et al., 2012) highlighted the need for significant change in mathematics education. And as these studies illustrated, many students enter high school lacking the skills needed to be successful. In fact, the National Center for Educational Statistics (NCES, 2012) reported that 28% of all U.S. eighth grade completers entered high school with below basic
mathematical skills and 25% of these students had disabilities. In other words, over one-fourth of students who enter high school may fail mathematics unless they received intensive instruction in prerequisite skills, and among this group are many of the students with disabilities.

Among the students who are ill-prepared for the rigor of more complex mathematics courses are students with learning disabilities (LD). The National Mathematics Advisory Panel (NMAP, 2008) reported high failure rates in mathematics among students with LD compared to their nondisabled counterparts. The Individuals with Disabilities Education Act (IDEA, 1997) required that students with disabilities receive educational services in the least restrictive environment (LRE). This legislation has resulted in many students with disabilities, which comprises 5-8% of the school population receiving instruction in the general education setting. Furthermore, students with disabilities are expected to reach higher levels of achievement demanded by assessments aligned to CCSSM (NGACBP CCSSO, 2010) that have been created by Smarter Balanced Assessment Consortium (SBAC; 2012) and the Partnership for Assessment of Readiness for College and Careers (PARC; 2011).

Student success in college and career opportunities often depends upon successful completion of algebra coursework. In fact, 29 states currently require passing Algebra 1 for a high school diploma and 12 states will require passing Algebra II by the year 2015 (American Diploma Project Network, 2005). Algebra is considered critical to future success in postsecondary education, but little is understood about how students learn
algebra (NMAP, 2008). Therefore, studies are needed to identify strategies for successfully teaching algebra skills to underperforming students with LD.

Most intervention research in mathematics for students with LD has been conducted during the elementary years in non-algebraic domains (Geary, Hoard, Nugent, & Byrd-Craven, 2007). Algebra intervention research is needed because this branch of mathematics is considered a gatekeeper to future educational and occupational opportunities while many students with LD fail to achieve competency in Algebra I (U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress Mathematics Assessment, 2009). One foundational skill needed for successful algebra performance is recognizing and using basic mathematical terms. Standard Three of Mathematical Practice from CCSSM (NGACBP CCSSO, 2010) requires students to understand and use technical mathematical language. Students with LD frequently have difficulty converting linguistic and numerical information into mathematical equations and algorithms and this necessitates additional supports in general education and resource classrooms to ensure opportunities for students with LD to build these skills (Miller & Mercer, 1997).

**Purpose of the Study**

The purpose of this study was to measure the effects of the Supplemental Algebra Vocabulary Instruction (SAVI) for students with LD. SAVI included explicit vocabulary instruction with graphic organizers. This supplemental instruction was created for students with LD who receive Algebra I instruction in the general education setting and who receive special education services in a resource setting. The intervention was
designed to incorporate important features for teaching vocabulary as recommended by the NRP report (NICHD, 2000). Included components were explicit instruction on key vocabulary terms, active student engagement, and the use of a graphic organizer. The impact of this intervention was examined for students with LD who were at risk for failure in Algebra I.

**Research Questions**

The following questions were addressed:

1. What is the impact of SAVI on knowledge of algebra vocabulary for secondary students with LD?

2. What is the impact of SAVI on algebra skill acquisition for secondary students with LD?

3. What is the relationship between student performance on posttest mastery measurement vocabulary probes for vocabulary knowledge and posttest mastery measurement probes for algebra skills probes?

4. What are students’ perceptions of the SAVI intervention for learning important Algebra vocabulary and skills?
Significance of the Study

Limited vocabulary knowledge is typical for most students with LD as their disability affects capacities to receive, process, store, and respond to information. Carnine and Carnine (2004) reported that students with LD often experience difficulties with comprehending textbooks because they cannot understand the content-specific vocabulary in courses such as science, social studies, and mathematics. Saenz and Fuchs (2001) found that secondary students with LD have more difficulty reading and comprehending mathematics’ expository text than narrative texts. Expository text is made more difficult because it includes challenging vocabulary and students lacked prior knowledge or methods for decoding words to determine the meaning (Saenz & Fuchs, 2001). Secondary students with LD need extra assistance in learning terminology and comprehending expository texts. However, Shanahan and Shanahan (2008) identified a shortage of interventions that teach strategies for understanding readings in content courses at the secondary level.

While there are limited evidence-based strategies to inform special educators working with students at the secondary level, there are successful components of instruction that can be applied to secondary content instruction. Deshler, et al. (2001) published key features in research-based interventions for successfully teaching students with LD that included instruction that is explicit, intensive and systematic. These strategies work best when applied to the current curriculum demands of students and when students are given opportunities to master the strategies so the strategies can be generalized to new learning.
Information regarding effective vocabulary instruction specific to mathematics is sparse. Previous research at the secondary level is limited to one study conducted with middle school students in a general education setting; however, this study did not report the effects for students with LD (Jackson & Phillips, 1983). Many secondary students with LD have Individual Education Plans that allow for additional support from a special educator in a resource setting. Thus effective methods to teach vocabulary in resource settings should be investigated.

According to the National Reading Panel Report (NICHHD, 2000) promising trends in research focused on vocabulary instruction. Research from the NRP Report verified that explicit instruction helps students with LD learn vocabulary. Explicit instruction should be systematic and direct and include instructions that follow a specific step-by-step instructional sequence. Carefully planned instruction eliminates overgeneralizations and confusion among the learners, sufficient practice time, materials used at the appropriate level, elaborate teacher feedback and opportunities for students to apply the instruction to other tasks (Ellis, Deshler, Lenz, Schumaker, & Clark, 1991).

When teaching vocabulary, it can be difficult to know how to efficiently and effectively measure student learning. Dependable measures are required to determine whether teaching practices are effective. NICHHD NRP (2000) found little research that attempted to measure “vocabulary growth and its relation to instruction methods” (p. 14) and Pearson, Hiebert, and Kamil (2012) found vocabulary assessment as extremely underdeveloped and lacking data meaningful to teachers. Teachers need brief and reliable measures that determine how well students have mastered terminology.
There is evidence that students with LD need more support to learn content-specific vocabulary and teachers need better ways to measure vocabulary growth. This need may be even greater now as national standards focus on the comprehension of informational text and increased communication skills that lead to college and career readiness. Specifically, CCSSM (NGACBP CCSSO, 2010) emphasize using technical vocabulary because this practice has been linked to the conceptual understanding for the most successful students in mathematics (Fleischman, Hopstock, Pelczar, & Shelley, 2010).

Wagner, Newman, Cameto, and Phyllis (2005) reported that Algebra I instruction does not meet the needs of the majority of students with LD according to the results from the National Longitudinal Transition Study-2. Thus, research-based interventions addressing the specific academic needs for students with LD in Algebra I are warranted. Specifically, research is needed that identifies effective strategies for teaching the content-specific technical vocabulary. Therefore, this study will examine the effectiveness of a vocabulary intervention in Algebra I that includes the NRP (NICHHD, 2000) suggested strategies of explicit instruction and graphic organizers. These strategies will be implemented through supplementary algebra vocabulary instruction (SAVI) for teaching students with LD in a resource setting.
Chapter Two

Review of the Literature

The purpose of this chapter was to examine the literature regarding research-based interventions in algebra and their impact on academic performance in mathematics for secondary students with LD. This chapter includes a brief discussion of the significance of vocabulary instruction in mathematics and the benefits of using explicit vocabulary instruction for students with LD. The primary focus of this chapter is a systematic review of current literature that reports interventions in algebra for secondary students with LD. This review includes descriptions of seven studies that met the inclusion criteria, a synthesis of findings, and implications for future studies.

Mathematical Vocabulary

Fifteen year-old students in the U.S. consistently scored below the international average on mathematical literacy tasks when compared to their peers in 2012, 2009, 2006, and 2003 on the Program for International Student Assessment (Fleischman, Hopstock, Pelczar, & Shelley, 2012). In fact, the mathematical literacy scores for U.S. students were lower than those from 17 countries, including Korea, Finland, Japan, and Germany (Fleishman et al., 2012). Mathematical literacy includes the ability to identify and understand the role of mathematics in the world and to make judgments and engage with mathematics (Fleishman et al., 2012). Furthermore, 23% of U.S. students were not able to consistently apply basic algorithms in mathematical operations or make “literal interpretations of the results (Fleishman et al., 2012).” These students lack procedural knowledge required for remembering how to work mathematical problems and lack skills
sophisticated enough to interpret their results. The foundational understanding of *how to work problems* includes understanding *why* the specific algorithm was selected, and *what* the answer means. In other words, mathematics, even higher level mathematics like algebra, must make sense to the student.

Low performance of U.S. students prompted the National Governors Association Center for Best Practices and the Council of Chief State School Officers (NGACBP CCSSO, 2010) to establish the CCSS (2010) which included a framework that would prepare students for college and the workforce. Increased mathematical literacy is integral to the CCSS (2010) for all mathematics from kindergarten through twelfth grade. CCSS included fewer standards at each grade level to allow more focus on deep knowledge of specifically defined concepts. Increased mathematical literacy was a paradigm shift for the 45 states who adopted CCSS NGACBP CCSSO, 2010) because prior state assessments primarily focused on procedural knowledge through multiple choice items and did not address mathematical thinking.

A major call from the CCSSM (NGACBP CCSSO, 2010) included opportunities for students to “*practice applying mathematical ways of thinking to real world issues and challenges*” as students learn to think mathematically. Beginning in 2014, student annual assessments on CCSSM (NGACBP CCSSO, 2010) will include student explanations of mathematical understanding in addition to procedural skills. For example, CCSSM (NGACBP CCSSO, 2010) for High School Algebra Mathematical Practices requires a student to explain each step in solving a simple equation and then “construct a viable argument to justify the solution method”. Assessment items were created by Smarter
Balanced Assessment Consortium (SBAC), 2012) and the Partnership for Assessment of Readiness for College and Careers (PARCC), 2011). These items required students to illustrate procedural aspects of problem solving and conceptual understanding. Conceptual understanding includes communicating mathematically with proper use of mathematical vocabulary. Mathematical vocabulary is needed to complete an assessment claim from Smarter Balanced which states that “students can clearly and precisely construct viable arguments to support their own reasoning and to critique the reasoning of others” (SBAC, 2012).

The National Reading Panel (NICHD, 2000) identified deep vocabulary understanding as critical for successful text comprehension. Secondary students’ chief reading assignments are in informational text, such as mathematics, science and history. Specific to mathematics understanding, The National Reading Council (NRC) addressed the role of comprehension (Kilpatrick, Swafford, & Findell, 2001). The NRC recommended that mathematical communication begin in pre-kindergarten and continue throughout higher level mathematics. This recommendation was based on information established through cognitive science that metacognition, an awareness of one’s own thinking, increased student knowledge and understanding. Opportunities for metacognition occur when a student explains how and why a procedural strategy was used. Students with LD often have difficulties with metacognition, and this presents challenges when attempting to select and organize information in mathematics word problems (Miller & Mercer, 1997).
Kilpatrick et al. (2001) identified five interwoven “strands” needed for mathematical proficiency. These five strands are identified as necessary for mathematical success, including (a) conceptual understanding, (b) procedural fluency, (c) strategic competence, (d) adaptive reasoning, and (e) productive disposition. The initial strand, *conceptual understanding* is defined as the “comprehension of mathematical concepts, operations, and relations” (Kilpatrick et al., 2001, p. 116) and is fundamental to general knowledge and understanding (Impecoven-Lind & Foegen, 2010). Conceptual understanding includes connecting new learning to past learning to create new meaning (NCTM, 2000). Research published by the NRP (NICHD, 2000) and NRC (Kilpatrick et al., 2001) supported deep vocabulary knowledge as an integral component of increased mathematical literacy.

Informational texts, or content-area texts, contain unique vocabulary to that area of study. Studies have shown significant relations between secondary student knowledge of vocabulary to performance in course grades, standardized tests, and growth of knowledge in social studies (Espin, Shin, & Busch, 2005). The complexity of vocabulary used in reading informational text increases as the difficulty of mathematics increases. Complex vocabulary presented challenges for many students with LD who have difficulty comprehending mathematical text (Smith, 1994). Deficits in vocabulary coupled with the the unique language of mathematics may add to the reasons that many students with LD are not successful in mathematics (Impecoven-Lind & Foegen, 2010).

Kerslake (1986) identified three areas where students made mistakes in mathematical strategies and they were linked to vocabulary understanding. First, students
had conceptual difficulty with understanding that the word *variable* represented a relation between variables or series of values. Second, students failed to use formal methods for identifying answers in advanced algebraic problems and seemed not to be able to apply skills to new situations. Third, students had weak understanding of common procedures in algebra, such as working with negative numbers, applying the term coefficient correctly to algebraic problems, applying the distributive property, and misinterpreting the meaning of the equals sign. These weaknesses were grounded in important mathematical vocabulary such as *variable, value, coefficient, distributive property,* and *equal.*

To assist with categorizing words, mathematical vocabulary can be divided into four groups based on distinctive characteristics. The categories include technical, subtechnical, symbolic, and general (Monroe & Panchyshyn, 1995). Technical vocabulary may be the most problematic to learn because technical terms represent mathematical concepts that are challenging to define with common words. For example, the definition of *factors* is numbers you multiply to get a product. Even if a student understands what is meant by multiply, a definition of product must also be understood. To understand *factoring* (expressing a number as the product of its factors), the meaning of *factor, product,* and how the suffix –*ing* changes the meaning of the base word needs to be understood. The words used to define technical words may not be known and exposure to a new word without this prior knowledge may cause confusion.

Subtechnical words are another category of mathematical vocabulary and include multiple-meaning words and homophones. Students may be familiar with common
meanings for these words, but unfamiliar with the specialized definitions. Teachers often falsely assume that students understand multiple-meaning words and homophones in the new context because of their familiarity of the words (Cervetti, Hiebert, & Pearson, 2010). Subtechnical words, like technical words, are related to complex ideas, and require multiple opportunities for inquiry and discussion (Cervetti, et al., 2010). For example, *volume* has multiple meanings which can cause confusion for many students. *Volume* refers to the quantity of a three-dimensional shape in mathematics, but a student may relate the word to *volume* meaning to increase the sound of the television. Additional examples of multiple-meaning mathematical words are *angle, base, concrete, constant, degree, domain, edge, figure, interest,* and *rational.* Homophones are words that sound the same, but have different meanings, whether they are spelled the same or not (Adams, Thangata, & King, 2005). One example is *cord* and *chord.* While a *chord* is a straight line drawn between two points on a circle, a *cord* is a string or rope. Additional homophones for mathematical terms are listed in Table 1. Without explicit instruction on the precise definitions for multiple-meaning words and homophones, students may apply an incorrect meaning within the mathematical context.

Table 1

*Examples of Mathematical Words and Corresponding Homophones*

<table>
<thead>
<tr>
<th>Mathematical Word</th>
<th>Homophone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arc</td>
<td>Ark</td>
</tr>
<tr>
<td>Complement</td>
<td>Compliment</td>
</tr>
<tr>
<td>Hour</td>
<td>Our</td>
</tr>
<tr>
<td>Plane</td>
<td>Plain</td>
</tr>
</tbody>
</table>
Symbolic terms are a category of mathematical words that include symbols used in mathematical expressions (e.g., =, < and >) and abbreviations, such as oz. for ounce and in. for inch. Symbols are highly abstract and hard to conceptualize due to their varied meanings, such as the 4 in $84$, $45$, and $3^4$ (Shanahan & Shanahan, 2008). Both symbols and abbreviations require meaningful practice for understanding.

General vocabulary words make up the greatest number of words in a category and these words are also used in other academic subjects. General vocabulary words may be difficult for students because textbooks often fail to describe the words adequately. While these terms appear in other settings, Monroe and Panchyshyn (1995) reported that more than 50% of the general vocabulary terms used in elementary mathematics textbooks are not used frequently in other reading materials. Exposure to words, such as *application*, *figure*, and *matrices*, in other subject areas does preclude guarantee understanding in mathematics.

Vocabulary becomes more difficult as mathematics becomes more complex and a lack of attention given to the development of mathematical language in earlier grades can result in noticeable gaps of vocabulary knowledge during advanced mathematics, such as algebra (NGACBP CCSSO, 2010). McKeown, Beck, Omanson, and Pope (1985), found that students needed 8 to 10 repeated encounters with new words before the words became meaningful. Terms introduced in subsequent grades often require knowledge of
the meanings of words used in earlier grades. For example, in Algebra 1, the meaning for
*vertex of an angle*, defined as the common endpoint of the rays forming the angle,
requires that a student has prior knowledge for *endpoint, rays, and angle*, all words taught
during earlier grades. Learning gaps in prior terminology may result in poor
comprehension and weak vocabulary skills for some students (Lott-Adams, 2003). Even
when a student knows the definition for a word used in algebra, Huntington (1994) found
that students were not able to understand the concepts when used in problem solving.

Mathematical vocabulary development includes repeated involvement with the
words in many contexts and active engagement with the words (National Institute for
Child Health and Human Development, National Institute for Literacy, 2007). For
example, Capraro and Joffrion (2006) investigated middle school students’ ability to
transfer from words to linear equations. Students were asked to select the correct multiple
choice answer for sentences, such as, “*Julie has three times as many trading cards as
Mary. They have 36 trading cards in all.*” Of the 668 students in the study, almost half
were not able to select $x + 3x = 36$ as the correct answer and only 9% of the students had
the necessary prealgebra skills, including vocabulary knowledge, to be successful in
algebra. While vocabulary knowledge is identified as essential for building mathematical
literacy by NCTM (2011) and CCSS (NGACBP CCSSO, 2010), vocabulary intervention
research has been sparse. NICHD NRP (2000) concluded after an extensive review of
the literature that very little research that measures the impact of vocabulary interventions
has been conducted, and most of that was conducted in elementary settings.

**Vocabulary Intervention Research in Secondary Mathematics**
Although research suggests vocabulary intervention is important in content areas including science (Siefert & Espin, 2013), research specific to vocabulary interventions in mathematics is limited. An electronic search of common databases for vocabulary interventions in mathematics yielded a single study (Jackson & Phillips, 1983). The intervention occurred during a prealgebra unit on ratio and proportion. Researchers used a posttest-only control group design with seventh graders as participants. Students in the treatment group (n = 111) received 5-10 minutes of instruction on vocabulary in a unit on ratio and proportion during the beginning of each class period while students in the control group (n = 102) worked on ratio and proportion computation problems during this time. The remainder of the instructional period was the same for both groups.

Students who received the brief vocabulary instruction at the beginning of each instructional session received higher verbal and computational scores than students in the control group on a teacher-created test. Students in the intervention group spent less time working computation problems than students in the control group but were more successful with computation problems. Jackson and Phillips (1983) inferred that the intervention groups’ increased understanding of the vocabulary resulted in higher scores on the ratio and proportion problems. These findings offered initial evidence that teaching mathematical vocabulary may increase the ability of students to comprehend, explain, and make mathematical arguments and provide support for conducting additional investigations into the role of vocabulary in mathematical achievement. However, students with LD were not identified in this study. Thus, the impact of an intervention that explicitly targets vocabulary in mathematics cannot be generalized to students with
LD. There is a paucity of research investigating the role of vocabulary in mathematics, but there is evidence to show the importance of vocabulary for understanding mathematics’ curricula for older students. Further research to identify the effects of vocabulary instruction for students with LD in mathematics is warranted.

Jitendra, Edwards, Sacks, and Jacobson, (2004) examined the literature to identify experimental, quasi-experimental, and single-subject design studies of effective interventions for word knowledge with vocabulary outcomes for students with LD. Nineteen intervention studies were divided into the following categories: (a) keyword or mnemonic strategies, (b) cognitive strategy instruction, (c) direct instruction, (d) constant time delay, (e) activity-based methods, and (f) computer-assisted instruction (CAI). Six studies implemented CAI instruction as the intervention with mixed results. One of the CAI studies, conducted by Johnson, Gersten, and Carnine (1987) investigated two methods for using CAI to teach vocabulary words and definitions. Participants were 25 high school students who were at least three levels below grade level on the reading subtest of the Woodcock-Johnson III. Student pretest results were used to make random assignment to two groups. One group received CAI with large sets of vocabulary words and the other group received CAI with small groups of vocabulary words. The CAI sessions were 20-minutes each day for maximum of 11 sessions. While both groups received instruction on 50 words and definitions through a CAI vocabulary program, instructional methods varied. During each session, the students assigned to the small set of vocabulary words were given ten words and a cumulative review on previously learned words. The group assigned to the large set of vocabulary words received 25
vocabulary words that were broken into two sets per session and these students did not receive a cumulative review but were given practice with a computerized arcade game that students receiving the small set were not provided.

Posttest results indicated that students with LD who received small teaching sets of vocabulary and review reached mastery in less time (7.6 sessions) than students who received large teaching sets of vocabulary and no review (9.1 sessions). Therefore, controlling the amount of words and offering opportunities for review emerged as important components of supporting vocabulary growth for students with LD. The limited vocabulary research suggests that students with LD who are significantly below grade level in reading can learn vocabulary more efficiently when using small sets of vocabulary words and are provided opportunities for review of previously learned words. In the meta-analysis conducted by Jitendra, Edwards, Sacks, and Jacobson (2004) interventions could not be located that conducted vocabulary research in mathematics for students with LD.

**Algebra Interventions for Secondary Students with LD**

Students who struggle in mathematics typically fall behind their peers in elementary school and their problems persist as they continue through school (Miller & Mercer, 1997). After many years of academic failure, students with LD often develop learned helplessness and this may be attributed to students having little to no understanding of what the procedures in mathematics mean (Parmar & Cawley, 1991). For example, a student may practice multiplication facts, but have no conceptual
understanding of what multiplication means and this makes the student depend on the teacher for help in making sense of solving problems.

Due to weak foundational skills during the elementary years, many of the 5-8% of students with LD experience academic failure in secondary mathematics. The implications of weak mathematical skills have far-reaching outcomes because algebra skills are a precondition for expanded career and college opportunities. While there is a need for evidence-based strategies to assist students with LD in algebra, Impecoven-Lind and Foegen (2010) noted that there is a critical shortage of these interventions available. When considering potential interventions, the following overview of algebra skills for high school students is provided by CCSS (NGACBP CCSSO, 2010): (a) seeing structure in expressions, (b) arithmetic with polynomials and rational functions, (c) creating equations, and (d) reasoning with equations and inequalities. Further research into these algebra domains is warranted.

While a shortage of research in algebra exists, information is available to inform the field on specific types of strategy errors made by students in secondary mathematics across algebraic topics (Booth, 1984). Three areas in which students use ineffective strategies are: (a) interpreting variables as letters, (b) operating with letters using intuition, and (c) using notations and conventions. Notation and convention errors includes mistakes with coefficients, negative numbers, distributive property, and meaning of the equals sign.

To examine the research base for algebra interventions for middle and high school students, a synthesis of the available research was important. The purpose of the current
literature review was to identify evidence-based practices for teaching students with LD algebraic skills. A thorough search was conducted to identify relevant research on instructional interventions in algebra shown to be effective for middle and high school students with LD.

Studies included in this review of literature were identified through a series of steps, which included an electronic database search, a hand search of relevant journals, and an ancestral search of studies identified in the database and hand search. A search of Premier Search Complete, Education Research Complete, ERIC, PsychArticles, and PsycInfo was conducted using the following key words separately and in various combinations: secondary students, learning disabilities, algebra, instruction, and intervention. A hand search was conducted of the following journals: Learning Disabilities Quarterly, Learning Disabilities Research and Practice, Remedial and Special Education, The Journal of Special Education, and Journal of Learning Disabilities beginning with the earliest issue from the year 1983 to 2012. Finally, the reference sections of all collected articles were searched to identify other relevant research articles. All studies were coded for the following: (a) subject characteristics, (b) type of intervention, (c) setting, (d) experimental design, (e) dependent measures and, (f) and academic outcomes.

Studies were selected for inclusion in the review if they: (a) were published in a peer-reviewed journal, (b) examined interventions specifically for algebra skills for middle or high school students, (c) included participants with LD and who were low-performing in algebra, (c) included an intervention in algebra that was implemented in
the general education or a resource setting in a public or private school, (d) utilized an experimental, quasi-experimental, or single subject research design, and (e) included dependent measures of academic outcomes in algebra. These criteria were chosen because they address the focus of the current study and the quality of existing research.

Of the original 23 studies, 7 studies met the criteria for inclusion in this review. Four of those studies were found through the electronic search, two were found through the hand search, and one was found through the ancestral search.

Several studies were excluded because they were not conducted in public school settings. One was conducted in a juvenile correctional facility (Maccini, Gagnon, Mulcah, & Leon, 2006), one in a postsecondary setting (Ofiesh, 2007), one in a clinical setting (Mayfield & Glenn, 2008), and one in a children’s home (Calhoon & Fuchs, 2003). One study was excluded because it used case study analysis and did not include comparison groups (Butler, Beckingham, & Lauscher, 2005), and another study was excluded because the intervention was an oral testing accommodation and did not use a mathematics intervention (Elbaum, 2007). Studies in mathematics frequently focused on skills that are prerequisite skills that help students solve word problems located in typical mathematics textbooks and were not algebra problem-types so these were excluded. This included research by Maccini and Hughes (1997); Maccini, Mulcahy, and Wilson (2007); Maccini, and Ruhl (2000); and Montague and Bos (1986). Additional empirical studies included strategies for teaching operations and word problems, but did not include algebraic problem types. Examples of these studies include research conducted by Jitendra, Dipippi, and Perron-Jones (2002); Miller and Mercer (1997); Miller, Mercer,
and Dillon (1992); Montague, Applegate, and Marquard (1993); Scruggs and Mastropieri (1989); Xin, Jitendra, and Deatline-Bachman (2005). Few empirical studies are available that investigated the effectiveness of an algebra intervention for students with LD.

**Relevant Research**

Seven studies reporting the results of experimental or quasi-experimental research met the inclusion criteria. Table 2 provides descriptive information about each study including: (a) participants, (b) intervention, (c) intervention category, (d) setting, (e) experimental design, (f) dependent measure, and (g) results. Descriptions of reviewed studies are presented, followed by a summary of results across overall findings and implications for further research.

While vocabulary knowledge is an essential component of mathematical literacy, there is sparse vocabulary intervention research in mathematics. In 2000, the NICHD NRP concluded that there is very little research across all discipline areas to inform the field about the best methods for teaching vocabulary and measuring vocabulary growth, especially for students in secondary settings.

**Hutchinson (1993).** The purpose of this study was to compare the performances of students receiving strategy instruction (intervention group) to students not receiving strategy instruction (control group) on algebra word problems. Hutchinson conducted a combined multiple-baseline design across participants and a quasi-experimental two-group design across four-months. Participants included 20 adolescents ranging from 12.6-15.8 years old across grades 8, 9, and 10 who attended a small group learning assistance
class in mathematics. These students had been previously identified with specific learning deficits and were at least three grade levels behind in mathematics.

Strategy instruction, making an implied process explicit through direct teaching of component skills, was used to teach algebra problem solving. Included during the intervention were two major phases, problem representation and problem solution. Problem representation referred to converting an algebraic problem from words to an internal representation. Problem solution was solution planning and execution of the plan to determine a solution.

Twelve students were in the intervention group and 8 students were in the control group. The intervention sessions lasted 40 minutes and strategy instruction was provided by the researcher. Students in the control group received “typical” instruction by their resource teacher.

One dependent measure included a researcher-created test given at the end of each session. This measure contained five problems that were the same type taught during the intervention session occurring that day and two problems that were near-transfer and two problems that were far-transfer problems. Additional dependent measures used pre- and posttest and maintenance measure that included a researcher-created criterion test with 15-items representing the types of problem types taught during the intervention. A multiple-choice test with 25 word problems selected from the British Columbia Mathematics Achievement Test (Grade 7/8 Applications), a metacognitive 10-question interview, and a brief classification task were also administered as pre- and posttests.
Based on 80% mastery criterion for three different problem types, results for the intervention group were: (a) six students mastered representation, solution, and answers for all three problem types, (b) four students mastered two problem types, and (c) two students achieved criterion on only the first problem type. Also, in 80 of the 84 cases, near-transfer criterion was reached and in 50 of 84 cases far-transfer criterion was reached on the criterion tests. Maintenance data were collected six weeks after the conclusion of the intervention and showed that performance was maintained except for 25 cases out of 28 cases on the criterion test.

Findings indicated significant differences in learning between the two groups on the test of 25 multiple-choice word problems. The control group scores from pretest to posttest remained mostly unchanged, but students in the intervention group showed gains in general questions and in answering questions requiring conceptual knowledge of mathematical structure in representing algebra problems. The authors reported that students in the control group attempted to solve algebra problems like one would solve simpler arithmetic word problems and failed to use the variables and equations correctly. However, students in the intervention group gained proficiency in the use of fix-up strategies that included rereading the problems, using diagrams, and checking answers to see if they made sense. The use of fix-up strategies demonstrated the development of metacognitive awareness for solving algebra problems among students in the intervention group.

**Maccini and Ruhl (2000).** The purpose of the research was to determine the effects of a problem solving strategy that used *Algebra Lab Gear* and a first-letter
mnemonic, STAR, for representing and finding the solution for algebra word problems that required subtracting integers. Maccini and Ruhl conducted a multiple-probe experimental design across participants study with three eighth grade students with LD who were identified as having a functional deficit in subtraction tasks. Each intervention period was 20-30 minutes and the intervention was conducted for three sessions in a quiet room near the cafeteria.

The STAR strategy included six elements and a mnemonic. The strategy was taught through six elements: (a) advance organizer, (b) model, (c) guided practice, (d) independent practice, (e) posttest, and (f) feedback and rewards. The strategy treatment had four phases: (a) pretest, (b) concrete application, (c) semi-concrete application, and (d) abstract application. Additionally, the mnemonic STAR was taught to the participants as a cue for remembering the steps in solving the problems. The “S” stood for Search the word problem, “T” stood for Translate the words into an equation in picture form, “A” stood for Answer the problem, and “R” stood for Review the solution.

Dependent measures included percentages of correct (a) strategy use, (b) problem representation, (c) and problem solution and answer on researcher-created think aloud protocols. Problem representation was used to measure student accuracy for problem representation across concrete, semi-concrete, and abstract application. Percent correct on problem solution and answer was the total score for accuracy.

Results were assessed through 5-item probes and 80% or better on two or more consecutive scores was mastery criterion. Baseline mean scores compared during intervention phases indicated improvement across all dependent measures for all
students. However, results on generalization measures were below average. Generalization tasks included one near-transfer assessment with 5 items and one far-transfer assessment with 5 items. A Likert-scale format was used to evaluate social validity and results indicated that the STAR strategy was perceived as effective to very effective in helping students learn a strategy for solving subtraction problems with integers. All students increased in their abilities to represent and solve word problems that required the subtraction of integers after the strategy instruction with Algebra Lab Gear and STAR mnemonic. Students with LD successfully learned to represent and solve word problems that required the subtraction of integers.

**Maccini and Hughes (2000).** Maccini and Hughes examined the effects of a graduated instructional strategy on problem-solving with integers for six secondary students with LD through a multiple baseline across participants study. The treatment consisted of an algebra problem-solving strategy with the mnemonic STAR and a graduated instructional phase of concrete, semi-concrete, and abstract application. The STAR strategy included six elements and a mnemonic that followed the same procedures in the Maccini and Ruhl (2000) study.

Dependent measures included researcher-created word problems for addition, subtraction, multiplication, and division of integers that were modified from introductory algebra materials and think–aloud protocols. Students completed near-transfer and far-transfer problems after completing two consecutive instructional measures with 80% accuracy. Near-transfer problems were five problems that were similar to the problems on the instructional measures. Far-transfer items were more complex items than were
used in the instructional set. The think aloud protocols were coded for verbalizations. Students were videotaped and did not receive prompting during verbalizations.

Results were percentages of strategy use, accuracy on problem representation, accuracy on problem solution and accuracy on generalization measures. Five participants learned to solve subtraction, multiplication, and division word problems involving integers and their use of instructional strategies. The sixth participant was frequently absent and was unable to complete all instructional objectives. The results offered initial evidence that students with LD can be taught to solve word problems through the use of concrete manipulatives and pictorial displays.

**Witzel, Mercer, and Miller (2003).** Witzel, Mercer, and Miller examined the effectiveness of an explicit concrete-representational-abstract (CRA) method for teaching complex equations in algebra among 34 matched pairs of students with LD or at risk for difficulties in algebra. The research was conducted in an inclusive classroom and the general education teacher conducted all 19-sessions.

Dependent measure included one 27-item assessment that measured student acquisition and maintenance of knowledge for solving single-variable equations and solving for a single variable in multiple-variable equations. This measure was given three times: (a) as a pretest measure one week prior to implementation of treatment, (b) as a posttest after the last day of treatment, and (c) as a maintenance measure three weeks after treatment ended.

All students received 19-lessons with a five-step sequence of algebra equations that included: (a) reducing expressions, (b) inverse operations, (c) negative and divisor
variables, (d) and transformations across the equal sign. For the intervention group, the CRA model was added to “typical” instruction received by the control group. The steps of the CRA model are: (a) introduction of the lesson, (b) modeling the procedure, (c) guiding students through the new procedure, (d) and students working problems independently.

Both groups showed significant gains in learning algebraic skills. However, students who received the addition of the CRA model outperformed the control group on posttest and follow-up exams. The use of CRA significantly improved student performance when added to “typical” instruction for solving single-variable multiple-step algebra equations.

Witzel (2005). Witzel compared student achievement in solving linear algebraic functions across two procedural approaches: (a) a concrete-to-representation-to-abstract (CRA) sequence of instruction, and (b) a repeated abstract explicit instructional model. This quasi-experimental research with a pre-post-follow-up design with random assignment of clusters was used for 231 students in general education middle school and included 46 students with LD. Six classes that included students with and without disabilities participated. CRA was used to teach a series of algebra skills across 19 lessons and five mathematical skills to the treatment group (n= 108). The comparison group included an explicit format of introducing the lesson, modeling, guided and independent practice, and assessment.

Dependent measures included a researcher-created 27-item test that measured student acquisition and retention of a five-step instructional set for solving algebraic
equations. Students were taught a series of skills that included reducing simple expressions to solving linear functions with unknowns on both sides of the equal sign. A single form of the test was used for pretest, posttest, and follow-up.

Students in both treatment and comparison groups made gains in solving linear functions. However, the treatment group who received the multisensory treatment showed greater acquisition on the posttest although their scores were lower than the comparison group scores on the pretest.

**Ives (2007).** Ives conducted two, two-group comparison quasi-experimental design studies to investigate the effectiveness of using a graphic organizer to teach algebra skills to 30 students with LD and/or attention disorders and then to 20 students with LD. Both studies were conducted for one skill and each research period lasted four days. Teaching transcripts and language coding were used so that the influence of the graphic organizer, not language differences, could be isolated on the outcome measure. In both studies, the control groups received instruction from their classroom teachers and the graphic organizer groups received instruction from the investigator.

The first study included 14 students with LD in the intervention group and 16 students in the control group. For these students, a graphic organizer was added to “typical” instruction for solving systems of linear equations. Dependent measures included a researcher-created pretest on prerequisite skills and a researcher-created pre-posttest on content skills. The content test assessed student ability to conceptually justify procedures for solving systems of equations in two variables and solving four systems of equations before and after the intervention sessions. For the second study, a systematic
replication of the first study was conducted with 12 different students with LD. This intervention included using the same graphic organizer as used in the first study to teach systems of three linear equations with three variables.

The content pretest mean scores were compared to the posttest mean scores to determine changes in the intervention and control groups’ performances after the intervention. In both studies, mean scores for the students who received the graphic organizer indicated a stronger conceptual understanding for solving systems of linear equations than for students who received typical classroom instruction. Improved conceptual understanding occurred when a graphic organizer was added to “typical” instruction for solving linear equations for high school students with LD.

Scheuermann, Deshler, and Schumaker (2007). The purpose of the study was to measure the effects of an instructional routine for solving one-variable equations. A multiple-baseline across participants study was conducted with four groups of three to six students as participants in each group. Classes were students in grades six through eight diagnosed with LD and with significant deficit in the solving one-variable equations. The intervention was conducted with a total of 14 middle school students during regular mathematics instructional time in small groups of 3-6 students.

The Explicit Inquiry Routine (EIR) was used to teach students how to solve simple and intermediate one-variable equations during regularly scheduled mathematics classes lasting 55-minutes each. The intent of the intervention was to transition student understanding of basic concepts from concrete to abstract. The three instructional components of EIR are explicit content sequencing, scaffolded inquiry, and systematic
use of illustrations. Once a stable baseline was established, instruction began with students in the first group and probes were administered every seven days. The intervention started with the second group of students after the students in the first group showed a gain of at least 15 percentage points. This pattern continued for students in two additional groups.

Dependent measures included: (a) a word problem test for near-generalization, (b) a concrete manipulation test that measured student ability to concretely illustrate and solve one-variable equations, (c) far-generalization test for measuring student ability to solve advanced one-variable word problems found in their textbooks, and (d) KeyMath Revised: A Diagnostic Inventory of Essential Mathematics (Key-Math-R; Connolly, 1998). KeyMath-R (Connolly, 1998) was used to determine if participation in EIR increased student scores on standardized mathematics’ tests.

Thirteen students across the four groups exceeded the mastery criterion on Word Problem and Concrete Manipulation Tests by the final instructional probe. One student who failed to meet mastery gained more than 50% from baseline to final instructional probe. On KeyMath-R (Connolly, 1998) students had a significant difference from pretest to posttest with a moderate effect size of .54. Students with LD and with significant delays in algebra were able to learn how to solve one-variable equations when provided with explicit content sequencing, scaffolding, and systematic use of illustrations provided through the EIR Model.

**Synthesis of Findings**
The current emphasis on the inclusion of students with LD in the general education setting for Algebra I, increased number of states requiring Algebra I completion for high school graduation, and the recent adoption of the rigorous mathematics standards included in CCSS (NGACBP CCSSO, 2010) highlights the need for effective academic interventions that can ensure success of secondary students with LD in Algebra I. Little is known about effective interventions for students with LD who receive instruction in Algebra I in general education settings. The intervention research conducted in the algebra domain with students with LD has focused on the procedural aspects for problem solving, such as memorizing procedural sequence.

Recent legislation required that students with disabilities participate in the least restrictive environment. This means that the majority of students with LD will take Algebra I in a general education setting and take standards-based assessments. Some students in general education for Algebra I received additional assistance in a resource setting because many students with LD had Individualized Education Programs (IEPs) that included small group instructional time in addition to the general education large group general education classes. The focus of this review was to identify research about interventions for students with LD who receive Algebra I with non-disabled peers in middle and secondary settings, as well as, interventions that could be used in a mathematics resource setting for students with LD. Research is needed that provides evidence that interventions are effective for students with LD taking Algebra I in the general education setting before they are recommended for practice. One area of chronic weakness for students with LD has been the development of problem-solving skills and
the majority of research has been conducted to determine interventions for helping students with LD develop proficient skills in this area. Seven empirical studies that implemented various instructional strategies intended to improve the academic outcomes for students with LD participating in middle and high school algebra skills were identified. The studies included a total of 352 students, with 170 students with LD in middle and high school mathematics classes in grades 6 through 12. Two of the seven studies were conducted in both middle and high schools, four studies took place in middle schools, and one study took place in a high school.

Two of the seven studies included a quasi-experimental design and five studies used an experimental design. The quasi-experimental designs were a posttest only control group (Jackson & Phillips, 1983) and a two-group comparison (Ives, 2007). Experimental design studies included four multiple-probe single subject designs (Hutchinson, 1993; Maccini & Ruhl, 2000; Jitendra, Dipippi, & Perron-Jones, 2002, Scheurermann, Deshler, & Schumaker, 2007), and one study used an experimental matched pair design (Witzel, Mercer, & Miller, 2003). The majority of the outcome measures were researcher-created measures and validity or reliability was not reported. All studies used researcher-created assessments while two studies also included measures on standardized instruments (Hutchinson, 1993; Scheurermann, Deshler, & Schumaker, 2007).

All interventions incorporated explicit strategy instruction on a variety of different algebraic problem types. Explicit instruction consisted of directly taught concepts and rules in a method that was clear, accurate, and unambiguous. Additionally, effective instructional design, effective presentation, and logical instruction that modeled explicit
instruction were provided to the participants. All interventions resulted in gains on outcome measures for students with LD regardless of the problem types (e.g., subtracting integers, systems of linear equations, one variable and two variable equations, subtraction, and word problems). Some studies, however, did not have all students with LD reach criterion on dependent measures and absenteeism was a factor. The majority of students with LD were successful on algebraic skills with interventions when given explicit strategy instruction.

In addition to explicit strategy instruction, six studies combined strategy instruction with one or more additional components that included: (a) a mnemonic (Maccini & Ruhl, 2000), (b) a graphic organizer (Ives, 2007), (c) manipulatives (Maccini & Ruhl, 2000; Witzel, 2005; Witzel, Mercer, & Miller, 2003), (e) illustrations (Scheuermann, Deshler, & Schumaker, 2007), and (e) word problems (Hutchinson, 1993).

Explicit strategy instruction was used to teach a variety of types of mathematical skills that included: (a) converting algebra problems from words to representation and solution (Hutchinson, 1993), (b) subtracting integers (Maccini & Ruhl, 2000), (c) solving systems of linear equations (Ives, 2007), (d) computing one-variable and two variable equations (Scheurmann, Deshler, & Schumaker, 2007), and (e) working word problems (Hutchinson, 1993).

Overall findings demonstrated effectiveness for strategy instruction used in conjunction with a variety of other components for teaching secondary students with LD. Only one study (Hutchinson, 1993) investigated an intervention that did not combine
explicit strategy instruction with an additional component and most of the 20 students with LD in this study were able to meet criterion on dependent measures.

A variety of settings were used in these studies. Witzel (2005) and Witzel, Mercer, and Miller (2003) conducted studies in an inclusive general education setting. Small group resource settings were used during the research conducted by Hutchinson (1993) and Ives (2007). Students received the intervention individually in studies conducted by Maccini and Ruhl (2000), Maccini and Hughes (2000), and Scheuremann, Deshler, and Schumaker (2007).

Implementation of the intervention also varied across studies. The investigator conducted the intervention in a general education setting (Jackson & Phillips, 1983), and teachers conducted the interventions in two inclusive settings (Witzel, 2005; Witzel, Mercer, & Miller 2003). The multiple-baseline across participant studies included instruction by: (a) the investigators (Maccini & Ruhl, 2000), (b) a learning support teacher (Jitendra, Dipi, & Perron-Jones, 2002), and (c) a resource teacher (Scheuremann, Deshler, & Schumaker, 2007). A combination of small group instruction and individual instruction in a resource setting was conducted by Ives (2007).

While limited by number of research-based interventions and varied approaches to teaching algebraic skills to students with LD, the studies seem to support the beneficial nature of including explicit strategy instruction for middle and high school students with LD. Interventions designed specifically for assisting students with LD in Algebra I were not identified in the research synthesis. Additional research is needed to identify effective interventions for students with LD who are taking Algebra I in high school because
Algebra I continues to be a course in which students with LD struggle to complete successfully and this course is a needed for high school graduation.

**Summary and Conclusions**

This review confirms that the research is limited and highlights the need for additional investigations of instructional interventions for students with LD in Algebra I. Only seven studies met the inclusion criteria for this review. Included were studies published in peer-reviewed journals because publication in referred journals is important when considering research-based practices. The conclusions and implications from this literature review should be interpreted with caution because of differences in intervention programs and methods of implementation, participants, settings, locations, and outcome measures.

Effective interventions for students with LD who are taking Algebra I are imperative for: (a) success in higher-level mathematics courses, (b) high school graduation, (c) problem-solving abilities, (d) participation in the general education setting, and (e) preparation for the workplace and college. There is limited research to contribute to the field of special education about methods for teaching algebra to high school students with LD. However, the studies reviewed have shown that students with LD can learn mathematical skills when provided strategies implemented through explicit instruction in a variety of settings and with varied problem types. Current research does not include interventions for students with LD to assist with skills specific to high school Algebra I. Research on the effectiveness of vocabulary instruction in algebra for high school students with LD is warranted as the use of language is needed in algebra for the
reading demands of word problems and is a requisite for remembering steps in algorithms (Englert, Culatta, & Horn, 1987). More research needs to be conducted to determine successful strategies for students with LD in Algebra I to ensure that students with LD can participate and prosper in the general education setting.
<table>
<thead>
<tr>
<th>Citation</th>
<th>Subjects</th>
<th>Intervention</th>
<th>Setting</th>
<th>Design</th>
<th>Dependent Measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hutchinson, 1993</td>
<td>20 students with LD</td>
<td>Strategy instruction for problem solving</td>
<td>8\textsuperscript{th} - 10\textsuperscript{th} grade resource</td>
<td>Repeated multiple case and two group design</td>
<td>Researcher-created multiple-choice, and classification task, and interviews, \textit{British Columbia Mathematics Achievement Test}</td>
<td>Students met criterion on most dependent measures and all posttest mean scores showed significant gains for intervention group when compared</td>
</tr>
<tr>
<td>Maccini &amp; Ruhl, 2000</td>
<td>3 students with LD performing below grade level in math</td>
<td>Strategy and mnemonic instruction for subtracting integers</td>
<td>8\textsuperscript{th} grade middle school resource</td>
<td>Multiple-probe across participants</td>
<td>Researcher-created measured on strategy use, problem representation and problem solution</td>
<td>All students increased in solving word problems with subtraction after intervention</td>
</tr>
<tr>
<td>Maccini &amp; Hughes, 2000</td>
<td>6 students with LD below grade level</td>
<td>Strategy instruction for solving word problems</td>
<td>9\textsuperscript{th} grade resource</td>
<td>Multiple-probe across participants</td>
<td>Researcher-created, measured strategy use for near and far transfer problems and effects of</td>
<td>5 students were able to solve word problems with manipulative and pictorial displays</td>
</tr>
</tbody>
</table>
(Table 2 Continued)

<table>
<thead>
<tr>
<th>Citation</th>
<th>Subjects</th>
<th>Intervention</th>
<th>Setting</th>
<th>Design</th>
<th>Dependent Measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Witzel, Mercer, &amp; Miller, 2003</td>
<td>64 students with LD or at-risk for failure in algebra</td>
<td>Strategy instruction for solving equations</td>
<td>6&lt;sup&gt;th&lt;/sup&gt;-7&lt;sup&gt;th&lt;/sup&gt; grade students inclusive setting</td>
<td>Matched-pairs</td>
<td>Researcher-created assessment for pre/posttest and maintenance</td>
<td>Treatment group significantly outperformed control group</td>
</tr>
<tr>
<td>Witzel, 2005</td>
<td>231 students, 49 with LD</td>
<td>Strategy instruction in pre-algebra equations</td>
<td>6&lt;sup&gt;th&lt;/sup&gt;-8&lt;sup&gt;th&lt;/sup&gt; grade in 6 inclusion classes</td>
<td>Quasi-experimental with random assignment in clusters</td>
<td>Researcher-created assessment for pre/posttest and maintenance</td>
<td>All groups made gains and treatment group made greater increases, students with LD maintained skills</td>
</tr>
<tr>
<td>Ives, 2007</td>
<td>30 students with LD; 14 treatment, 16 control</td>
<td>Strategy instruction on linear equations</td>
<td>13-19 years in resource</td>
<td>2 quasi-experimental 2-group comparison</td>
<td>Researcher-created measure for pre/posttest</td>
<td>Treatment group made more gains than control group</td>
</tr>
<tr>
<td>Citation</td>
<td>Subjects</td>
<td>Intervention</td>
<td>Setting</td>
<td>Design</td>
<td>Dependent Measures</td>
<td>Results</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------</td>
<td>------------------------------------------</td>
<td>--------------------------</td>
<td>-------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Scheuremann, Deshler, &amp; Schumaker, 2007</td>
<td>14 students with LD</td>
<td>Strategy instruction for solving one-variable equations</td>
<td>Resource in middle school</td>
<td>Multiple-probe across participants</td>
<td>Researcher-created word problem and manipulation and far generalization test; <em>Key Math- Revised Test</em></td>
<td>Student scores increased and were maintained for 11 weeks</td>
</tr>
</tbody>
</table>
Chapter Three

Method

The purpose of this study was to investigate the effectiveness of Supplemental Algebra Vocabulary Instruction (SAVI) for secondary students with LD receiving Algebra I instruction in a general education setting and additional support through special education services. Specifically, this study addressed the following questions:

1. What is the impact of SAVI on knowledge of algebra vocabulary for secondary students with LD?

2. What is the impact of SAVI on algebra skill acquisition for secondary students with LD?

3. What is the relationship between student performance on posttest mastery measurement vocabulary probes in algebra and posttest mastery measurement algebra skills probes?

4. What are students’ perceptions of the SAVI intervention for learning important algebra vocabulary and skills?

Participants

Before beginning the research, permissions were received from the district and school administrators. A summary of the research (see Appendix A) was given to the administrators to explain the purpose of this study and letters granting permission were secured. Then, the special educators were given information about the research and they also granted permission through written form.

Prospective participants considered for inclusion in the study were students identified with LD, enrolled in Algebra I in the general education setting, and enrolled in
a resource class for additional instruction and support. Fifteen students with LD in two separate ninth grade resource classes were selected as potential participants and all of these students returned signed permission slips. Five of the initial 15 students were unable to complete at least five of the six sessions and their data were not included in the analysis. All data for 10 remaining participants, who completed five or six sessions, is included in this report. The student demographic data (see Appendix B) was collected and summarized in Table 3.

All participants were ninth graders and ranged in age from 15 years 4 months, to 17 years 4 months. Participants were identified with LD according to district and state guidelines. The LD status for participants included six students with reading disabilities and four students with reading and mathematics disabilities. Participants were enrolled in general education Algebra I classes and received special education services. Two special educators completed demographic forms (see Appendix C). One was the lead teacher for special education services at her school and had a master’s degree in special education. The other teacher was the instructor during resource for the participants and had a Learning Disabilities certification added to her certifications for early childhood and elementary grades. Both had been teaching over 10 years.

The students were enrolled in Algebra I course sections across four different instructors. Algebra I instruction was provided by four teachers designated as A-D. Each of these teachers completed demographic data (see Appendix D). The teachers were new to the profession with an average of two years teaching experience. Two of the teachers received certification through a traditional secondary mathematics bachelor degree
program and two teachers received master’s degrees in teaching through alternative certification programs. According to the demographic information provided by the teachers, two of them had not received training for teaching students with LD through their alternative secondary mathematics certification program. The other two Algebra I teachers had completed one introductory special education course in their traditional undergraduate program for secondary mathematics certification. These teachers also reported that they had not completed any additional coursework or training for teaching students with LD.

For general education instruction in Algebra I, participants 3, 5, 9, 10 had instructor A, participants 1, 4, 8 had instructor B, participants 2 and 6 had instructor C, and participant 7 had instructor D. Participants also received additional support through a resource class that was taught by the same special education instructor as stipulated in their IEP. Resource classes met every other day each week for 90-minute blocks. Resource class was primarily used to provide students additional time during the school day for tests, homework, and project completion. Participants 1-4 were in one resource class referred to as group A and participants 5-10 were in another resource class referred to as group B.
Table 3

Participant Demographic Information

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Age</th>
<th>Ethnicity</th>
<th>Disability</th>
<th>Free/Reduced Lunch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>16</td>
<td>African American</td>
<td>Reading</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>15</td>
<td>African American</td>
<td>Both</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>15</td>
<td>Caucasian</td>
<td>Both</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>15</td>
<td>African American</td>
<td>Both</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>15</td>
<td>Caucasian</td>
<td>Both</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>16</td>
<td>Caucasian</td>
<td>Both</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>15</td>
<td>Caucasian</td>
<td>Reading</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>15</td>
<td>Caucasian</td>
<td>Reading</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>17</td>
<td>African American</td>
<td>Both</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>16</td>
<td>African American</td>
<td>Both</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note. A disability status of both indicates a reading and a mathematics learning disability.

Setting

The study was conducted April to May, 2013, in a school district in a suburban area in a southeastern state. The high school where the study occurred served approximately 1,800 students in 9th through 12th grade. The student population included 62% Caucasian, 31% African-American, 2% Asian/Pacific Islander, and 1% Hispanic (Retrieved from http://nces.ed.gov/ccd/schoolsearch/school). Thirteen percent of the school population were identified with disabilities and of those students, over half (57.9%) scored below basic in mathematics (Retrieved from http://www./ed.sc.gov/data/ayp/2011/school_ayp).

The special education classroom where the intervention occurred was approximately 30 feet by 40 feet. Group A included seven students, of which four
participated in the study and group B included 10 students, of which six participated. During the intervention, all participants sat at individual desks facing the projection screen that was located on a wall at the front and center of the classroom. The researcher served as the instructor for all intervention sessions. The researcher stood behind a cart that held the computer and LCD projector that was located in the back and center of the classroom during all intervention sessions.

The classroom teacher sat at her desk near the front corner of the room. Students who did not participating in the study completed independent work at classroom computers or at desks near the teacher’s desk. The sessions were free of noise and distractions other than general student-teacher interactions.

**Materials and Equipment**

The materials and equipment used to conduct the study included a computer, an LCD projector, an overhead screen, copies of the SAVI graphic organizer, copies of assessments for pretests and posttests, and pencils for each participant. Each participant received four copies of the graphic organizer, one copy of each pretest, and one copy of each posttest during a session.

**Research Design**

A single-case repeated acquisition design was used to examine the impact of the intervention on student performance. The repeated acquisition design provides evidence on repeated demonstrations from pretest to posttest that the treatment is responsible for attainment of the skill (Kennedy, 2005). Repeated learning with new sets of apparently comparable target behaviors from pre- to posttest offers evidence that the treatment, and not competing variables, are responsible for the acquisition (Spencer, et al., 2012). A repeated acquisition design was used in this study specifically because it allowed for
information to be collected on the exact technical vocabulary taught, as well as the productive aspects of using vocabulary knowledge for algebra solving skills.

Dependent variables included mastery measurement probes and a maintenance measure to document student performance. Mastery measurement probes were collected at pretest and posttest conditions for each intervention session. If a change occurred in the points earned from pre- to posttest and this change occurred across sessions and across participants, it can be assumed that there was a functional relationship between the independent variable (SAVI) and the two dependent variables (mastery measurement vocabulary probes and mastery measurement algebra skills probes). The replication of results across 10 participants and across five or six sessions lends support for external validity. It was assumed that participants functioned independently, but were similar enough to respond to the same intervention. Survey data for participants and teachers were collected at the conclusion of the intervention. These measures address the perception and attitudes toward the intervention to document social validity.

**Dependent Variables**

Four dependent variables included a vocabulary mastery measurement vocabulary, an algebra skills mastery measurement probe, a vocabulary maintenance measure, and a student survey. Specific information about each dependent measure follows.

**Vocabulary Mastery Measurement Probe.** Vocabulary Mastery Measurement (VMM) probe was modified from Scott, Vevea, and Flinspach (2010). VMM probe was used to measure depth of word knowledge. An example for the word *variable* is shown in Figure 1.
1. Explain something that has to do with **variable**.

2. Give the definition for **variable**.

3. Write an example of a math problem with **variable**.

4. Explain why that is an example of a math problem with **variable**.

Items on VMM were written in order of the difficulty so that participants were able to show increased depth of understanding about the vocabulary words. The first item allowed for general understanding to be measured and a student received credit for knowing anything about a word. Writing a definition for the word for number 2 required more specific knowledge. For number 3, a student had to apply the word to a mathematical context, and number 4 required an explanation about the mathematical problem within the context of the word. For example, during a pretest a student’s understanding might be limited to knowing that the word **variable** has something to do with solving an equation so the student would receive a score of one point. After the intervention session, however, the same student might provide additional answers to VMM, including an example of a problem with a variable and an explanation of how the example given illustrates a variable. In this way, VMM was structured to measure increased understanding for each of the 24 words taught.

Each VMM assessed knowledge of the four words taught during one SAVI session. Four points were possible for each word and the maximum score on VMM was 16 points. Scores on pre- and posttests were calculated as points correct out of 16 and
these scores were graphed for all probes completed. Graphed VMM were visually
inspected to determine if there were changes from pre- to posttest for each participant.

**Algebra Skills Mastery Measurement Probe.** Algebra Skills Mastery
Measurement (ASMM) probe measured changes in a student’s ability to apply algebra
words to algebra skills. ASMM included two algebra problems for each of the four words
taught during one SAVI session. For example, when the session included teaching
*variable*, ASMM included two items that required solving for a variable, such as items \( 12 - b = 10, b = \) and \( x - 10 = 24, x = \). Problem solving was not taught as part of
the intervention. For example, students were not taught how to solve for \( b \) in \( 12- b = 10 \),
but were taught that \( b \) is a variable and variable means “*a letter used to represent a
value.*” The purpose of ASMM was to determine whether scores increased from pre- to
posttest and whether the increase could be attributed to the application of vocabulary
word meanings learned during the intervention for correctly solving problems.

Each ASMM had eight algebra problems representing two algebra skill problems
for each word taught during one intervention session. Scores were calculated as one point
for each correct answer, giving a total of eight possible points. Scores for ASMM were
graphed and visually inspected for all probes completed to determine if there were
changes from pre- to posttest in participants’ abilities to solve algebra problems.

**Vocabulary Maintenance Measure.** One maintenance measure was
administered one week after the last intervention session to measure participant recall of
previously learned words. This measure, in the same format as VMM, included four
words taught across SAVI sessions. Initially one word from each probe with the highest
participant mean score was selected. Out of these six words, the four words with the highest mean scores were included on the maintenance measure to allow for consistency in measurement and graphing with the VMM probes during the course of the intervention.

**Student survey.** Following the last intervention session, students completed a short survey adapted from the Intervention Rating Profile (IRP; Martens, Witt, Elliott, & Darveaux, 1985). The student survey (see Appendix A) contained 30 items that allowed students to describe their attitudes and perceptions about the intervention in order to evaluate the social validity of the intervention. Participants rated the items on a Likert rating scale. The survey contained items specific to this intervention and took students approximately 10 minutes to complete.

**General Procedures**

The school schedule consisted of alternating days for classes and this schedule determined when groups received the intervention. For example, one group would meet on Monday, Wednesday, and Friday for the first week, then Tuesday and Thursday for the next week. Groups were determined by who met the research inclusion criteria and were in one of the two sections of resource classes. Group A had four students and group B had six students who participated (see Table 4). Two or three sessions for a total of six sessions were held across two weeks with one session completed in week three for these two groups during regularly scheduled class time. A maintenance measure was administered during week four.
Each session lasted 30-40 minutes and the order was pretest, intervention, and posttest. If students were absent or unable to participate in a session, the session continued for those present. Pretests and posttests were passed out to the students by the researcher and included students writing responses to researcher-created assessments on vocabulary and algebra skills. The researcher monitored the students while completing the assessments to ensure that the students worked independently.

Four vocabulary words were taught by the researcher during the intervention for each session. Students were instructed to pay attention, ask questions, and complete the graphic organizers during instruction. Reinforcement was given in the form of verbal praise for the completion of graphic organizers and assessments. The researcher presented the information and allowed the students to ask questions and make comments, but students were not called on to respond during the intervention. In the case of student misbehavior or inattentiveness, the instructor redirected the student.

Table 4

SAVI Implementation Schedule

<table>
<thead>
<tr>
<th></th>
<th>Week</th>
<th>Number of Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group A:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participants</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>1,2,3,4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Group B:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participants</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5,6,7,8,9,10</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
Several steps were conducted to isolate the words to be taught during the intervention. First, the vocabulary that appeared in statewide Algebra I assessments (The California Standards Test in Algebra 1, 2009; New York Regents Exam, 2010) created an initial list. These particular state exams were selected because they are accessible online and have moderate to high technical adequacy as reported by California Department of Education (2009) and New York State Department of Education (2010).

Then, other sources were reviewed to create a more exhaustive list of algebra words, including: (a) Algebra I Scope and sequence for participants’ school district, (b) Mathematics Connections: Algebra 1 textbook (Carter, Cuevas, Day, & Malloy, 2010) used by the participants, (c) Common Core State Standards Mathematics: High School Algebra (retrieved from http://www.corestandards.org/Math ), and (d) Passing the South Carolina HSAP Practice Tests (Pintozzi & Sabbarese, 2008). This created a list of 142 words.

Next, each word in the cumulative list was defined according to the Mathematics Connections Algebra I textbook (Carter, et al., 2010). Some definitions were simplified by the researcher if the definitions contained words that could be replaced by simpler words to make the definitions more understandable for students with weak vocabulary skills.

To help ensure that the words in this intervention were unfamiliar to the participants, a pilot study was conducted with five students with LD and taking Algebra I at the same school during fall of 2013. These students were given a multiple choice test that contained 100 potential words. In addition to selected algebra words from the
cumulative list, additional words found in the definitions of the words in the cumulative list were included. The performance of the students on the assessment during the pilot study indicated that the words selected for the current research were probably unknown by the participants. Twenty-four words were selected that could be taught in six sessions (see Table 5).

The SAVI word list included 17 words identified as Algebra I vocabulary words and seven foundational words. Foundational words are italicized in Table 5. The order of the 24 words was conspicuously arranged to reduce the possibility that a definition would contain a word that a student did not know. For example, value was taught in the first session because the meaning would need to be known in later sessions.

Table 5

<table>
<thead>
<tr>
<th>SAVI Vocabulary Words for Each Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td><strong>Value</strong></td>
</tr>
<tr>
<td><strong>Addend</strong></td>
</tr>
<tr>
<td><strong>Product</strong></td>
</tr>
<tr>
<td><strong>Sum</strong></td>
</tr>
</tbody>
</table>

*Note.* Italicized words were not part of the original Algebra I word list.
**Baseline Condition**

Before each session, students were given pretests for VMM and ASMM to establish baseline. The purpose of baseline was to determine what the students already knew about the words and algebra skills that were included in the intervention for that day. Instructions to participants were presented in the following format:

1. The instructor told students to clear their desks of any/all materials except a pencil.
2. The instructor told the students that each of them would be given untimed pretests on the vocabulary words and algebra skills that were included in the teaching session for that day, and the assessments would be taken one at a time, with the vocabulary test given first. As soon as they finished the vocabulary assessments, they could raise their hands and would receive the algebra skills assessment.
3. As the instructor passed each student the vocabulary pretest, students were instructed to write their names at the top of the paper and to complete these assessments independently.
4. The instructor monitored the students while completing the pretests to be certain their work was independently completed.
5. The instructor collected the vocabulary pretest and immediately handed students the algebra skills pretest.
6. As soon as the last student was finished with the algebra skills pretest, the intervention began.

**Intervention Condition**

The two groups of students were presented the same four words during each of the six sessions. Group A consisted of four students, and group B consisted of six students. These students participated in the research as part of regular instruction in their resource classroom setting for 30-40 minutes per session.

The researcher learned each student by name and took a few minutes before and/or after each session to speak with the students in order to establish rapport. The researcher also collected a list of participants’ favorite snacks that were brought
intermittently as gratitude for participation. During sessions, the researcher gave frequent praise to the students for their hard work and diligence in learning the vocabulary and for trying their best on the assessments.

During the each intervention session, students were taught definitions for four new words. For each word, the students completed a graphic organizer (GO) while watching and listening to a brief explanation that lasted approximately four to five minutes for each word. To ensure fidelity of treatment, scripts were written and followed during each session. An example script read by the researcher for the word equivalent, general PowerPoint (PPT) contents, and general procedures students used to complete each GO are in Table 6. Then, Figure 2 shows an example of GO contents prior to student completion.

Table 6
Procedures for SAVI

<table>
<thead>
<tr>
<th>Slide Number</th>
<th>Contents</th>
<th>Script Example</th>
<th>Procedures for Graphic Organizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Title Slide</td>
<td>Please be sure your name is written on the top of your GO. Also remember that you can ask me questions about the presentation at any time.</td>
<td>Students are prepared for session.</td>
</tr>
<tr>
<td>2</td>
<td>Vocabulary word introduction</td>
<td>The word is “equivalent.”</td>
<td>Students write the word.</td>
</tr>
<tr>
<td>3</td>
<td>Definition</td>
<td>Equivalent means</td>
<td>Students write the</td>
</tr>
</tbody>
</table>
Cognitive Strategy

When you see the word “equivalent”, break the word into the prefix and base words. “Equi” means equal and “valent” means value, so equivalent means “equal value.”

Example 1

The first example is a mathematical sentence with the addends of 100 and 20 which has the value of 120. So 120 is equivalent to the sum of 100 and 20.

Example 2

This is an example for equivalent because 4 to the third power is equivalent to 64. $4 \times 4 \times 4 = 64$, and 64 is equivalent to $4^3$.

Review the word with the and the method for remembering the definition.

When you see equivalent, remember that “equi” means equal and “valent” means value. Equivalent means value.

Discussion

Do you have any questions about anything presented for equivalent?

Students may ask questions and Slides may be reviewed again.
Figure 2

<table>
<thead>
<tr>
<th>Way to remember</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Word</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Example</td>
<td>Example in Algebra</td>
</tr>
</tbody>
</table>

*SAVI Graphic Organizer*

*Note.* Graphic organizer was on an 8.5” x 11” sheet of paper.

At the conclusion of each PPT session the students were provided a brief review period (2-5 minutes). At this time, the students were allowed to look over their GOs and ask the researcher and other students questions related to the words. When students were ready to start the posttest assessments (or at the conclusion of five minutes), students individually handed their set of four GOs to the researcher in exchange for posttest assessment VMM. Once students completed VMM, they handed this measure to the researcher in exchange for ASMM. After students completed ASMM, the session was complete and students would begin working on other assignments.

**Scoring Assessments.** VMM Vocabulary Mastery Measurement Probe measured change in student vocabulary knowledge. The researcher scored student answers as correct or incorrect according to the rubric in Table 7. Students earned one point for each item that was correct for each of the four words, for a possible total of 16 points on each
measure. Percentages of correct responses were also calculated to determine
the difference from pre-to posttest for each participant on vocabulary
knowledge. Table 7

Vocabulary Mastery Measurement Probe Rubric

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1 | Explain something that has to do with_________.  
   | Anything that is related to the word and/or definition that gives related and/or     |
   | partial knowledge.                                                                  |
| 2 | Give the definition for_________.                                                    |
   | An accurate and complete definition should be given. This definition can be in      |
   | the students own words. If points were not given for #1 and the definition is      |
   | incomplete but accurate (partial knowledge), the student can be awarded 1 point    |
   | for #1 here.                                                                        |
| 3 | Write an example of a math problem with_________.                                   |
   | As long as the problem illustrates the word, give credit. The problem does not    |
   | have to be calculated correctly to receive credit.                                 |
| 4 | Explain why that is an example of a math problem with_________.                     |
   | The student may restate the definition within the context of the math problem.     |

ASMM assessed student algebra skills. There were two items that represented
the content for each vocabulary word taught during the intervention, for a total of eight
items across four words. An example of ASMM assessment is located in Table 8.
ASMM pre- and posttests were scored as one point for each correct answer out of a
possible eight points. Percentages of correct responses were calculated to measure
change from pre-to posttest for each participant on algebra skills.
Table 8

SAVI Learning Sheet. ASMM Example

Circle the terms in the following expressions:

1. \(2a + b\)
2. \(4x^3 + 3xz - 5\)

Give an example of a like term for each:

3. \(3a\) _________
4. \(21xy^2\) _________

Provide the reciprocal:

5. \(\frac{1}{5}\) _________

Solve:

6. \(\frac{2}{3}\times\)______ = 1

Use an inverse operation to solve:

7. \(20 + a = 12\) \(a = \) _________
8. \(32x = 8\) \(x = \) _________

Procedural Fidelity

Procedural fidelity was determined by a 50-item fidelity checklist that was completed by a graduate student in curriculum and instruction. There were 12 total intervention sessions and four of these sessions, or 30%, were evaluated for procedural reliability. A graduate student observed the researcher implement the assessments and instructional components of the intervention. The observer checked yes for procedures performed correctly or no for items that were not performed as prescribed on the fidelity checklist for each of the four observations. Procedural fidelity was calculated as the number of procedures completed correctly was divided by the total number of items and then multiplied by 100. Fidelity of implementation for the intervention ranged from 96-100%, with a mean of 98%.

Interscorer reliability. Interscorer reliability (ISR) for VMM scoring was
completed by an assistant professor in reading and literacy who has experience in research, but was not involved in this study. She independently scored 30% of the VMM assessments randomly selected across sessions and across participants using the Interrater Agreement Sheet for VMM (see Appendix H). ISR was calculated as the number of agreements divided by the number of agreements plus disagreements and multiplied by 100. The ISR scores ranged from 95-100% with a mean of 97%.

ISR for ASMM was completed by a second year doctoral student in mathematics curriculum and instruction who has 30 years of experience as a mathematics teacher. She was not involved in this study and she did not know the research questions. First, she verified that the answers on the answer keys created by the researcher were correct. Then, she independently scored 30% of the measures using the Interrater Agreement Sheet for ASMM (see Appendix I). Thirty percent of the ASMM were randomly selected across sessions and across all participants. The percentage of agreements was calculated as the number of agreements divided by the number of agreements plus disagreements and multiplied by 100. All ISR scores were 100%.

**Social Validity**

Students were asked to complete a questionnaire (see Appendix E) to determine their satisfaction and perceptions of the intervention. The means and standard deviations for the survey were calculated. The survey was given to all participants immediately after the last session and took approximately 10 minutes to complete.

Two special education teachers who were familiar with the intervention also completed the teacher survey (see Appendix F) to determine their satisfaction and perceptions of the intervention. One special educator was the teacher observed at least part of all SAVI sessions. The other special education teacher was the department chair
for special education at the school and observed sessions periodically in the resource
classroom during intervention sessions. The surveys were given in a follow-up meeting after the intervention concluded and took approximately 5 minutes to complete.
Chapter Four

Results

The purpose of this study was to evaluate a supplementary algebra vocabulary instruction (SAVI) for secondary students with LD who were enrolled in general education Algebra I classes. Measures employed to evaluate this supplemental vocabulary intervention and its effectiveness included: (a) pre- and posttest mastery measurement probes in algebra vocabulary and algebra skills, (b) a maintenance measure of algebra vocabulary, and (c) a student questionnaire. Results are presented in the following order: (a) pretest and posttest data for vocabulary; (b) pretest and posttest data for algebra skills; and (c) student survey results. Last, teacher responses to a survey for social validity will be given.

Research Question 1

What was the impact of SAVI on knowledge of algebra vocabulary for secondary students with LD?

This question was designed to determine the effects of participation in a supplemental vocabulary intervention on the vocabulary knowledge of 10 ninth students with LD in a resource setting. A researcher-created vocabulary mastery measurement probe, VMM, was administered for this purpose. Reported are: (a) statistical data, (b) results from a visual analysis of the graphs, (c) treatment effect and, (d) effect size.

Statistical Data. Points scored in word knowledge from VMM were determined across all of the sessions for all the words (see Table 9). Word knowledge across all pretest measures for participants was quite low (of a possible 16 points, M= 1.44, SD =
0.63, range = 0-4) indicating that students had very little prior knowledge of the
definitions for the words taught during the intervention. Mean correct on VMM for all
participants at posttest was 9.42 (SD= 4.3 range = 2-16). Almost half (23 out of 56) of the
posttest scores across participants were between 12 and 16 points and the mean increase
was approximately 8 points (7.98). A maintenance vocabulary probe was given to
participants one week after the last session. Points earned on this measure (M=2.5 points,
range = 1-6) were lower than points scored on VMM posttests, yet still higher than the
mean at pretest.

Table 9

Statistical Data for Vocabulary Mastery Measurement Probes at Pre-and Posttest

<table>
<thead>
<tr>
<th>Measures</th>
<th>VMM Pretest</th>
<th>VMM Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>1.44</td>
<td>9.42</td>
</tr>
<tr>
<td>SD</td>
<td>0.63</td>
<td>4.3</td>
</tr>
<tr>
<td>Range</td>
<td>0-4</td>
<td>2-16</td>
</tr>
</tbody>
</table>

Points scored were converted to percentages to allow for additional analysis.
Percentages were calculated by dividing the number of correct items into the total
number of items and multiplying by 100. Pretest scores range from 3-14% with a mean of
9%; and the posttest scores range from 26-91% with a mean of 50%. Of the 10 students,
five students’ mean percentages were above 70% and five students’ mean percentage
scores were less than 50%. Changes made from pre-to posttest were calculated by
subtracting pretest means from posttest means and the range across students was 19-84%.

See Table 10 for individual mean percentages and percentage of change.

Table 10

*Vocabulary Mastery Measurement Pretest and Posttest Mean Percentages*

<table>
<thead>
<tr>
<th>Participant</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent at pretest</td>
<td>14</td>
<td>14</td>
<td>13</td>
<td>7</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Percent at posttest</td>
<td>85</td>
<td>82</td>
<td>88</td>
<td>91</td>
<td>72</td>
<td>42</td>
<td>27</td>
<td>26</td>
<td>45</td>
<td>30</td>
</tr>
<tr>
<td>Percent change</td>
<td>71</td>
<td>68</td>
<td>75</td>
<td>84</td>
<td>62</td>
<td>33</td>
<td>19</td>
<td>23</td>
<td>39</td>
<td>24</td>
</tr>
</tbody>
</table>

**Visual Analysis of the Graphs.** Effects of the intervention were further analyzed by graphing points earned by participants for each session on VMM probe at pre-and posttest (see Figure 3). Separate graphs were created for each participant to allow for individual analysis. A visual inspection of the graphs shows that all participants made gains from pre-to posttest and these gains are attributed to the intervention because of the consistent replication within (five or six sessions) and across participants (n=10) as a result of sequential exposure to a single intervention condition.
Figure 3

VMM Vocabulary Mastery Measurement Points from Pre-to Posttest
(Figure 3 continued)
(Figure 3 continued)

**Participant 9**

**Participant 10**
Note. Maximum score at pretest and posttest was 16 points. Participants 2 and 5 did not complete session 5, participant 3 did not complete session 6, and participant 9 did not complete session 1.

**Treatment Effect and Effect Size.** The treatment effect for VMM was defined as a 4-point increase from pre-to posttest. An increase of four points indicates that a student provided additional information about a word, definition, example, or application of the example at least four more times after the intervention than before the intervention. Treatment effects were replicated across all participants for most of the words (see Table 11). Five of the 10 participant had treatment effects for all completed sessions, while the other five participants had treatment effects for three or more sessions.
Table 11

Treatment Effect for VMM Vocabulary Mastery Measurement Probes

<table>
<thead>
<tr>
<th>Participant</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sessions Completed</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Sessions with treatment effects</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Effect size was calculated using the improvement rate difference (IRD; Parker, Vannest, & Brown, 2009) for summarizing single-case research data. IRD is a form of nonoverlap techniques used to determine the behavior-change index in single-case research (Parker, Vannest, & Davis, 2011). IRD is calculated as the difference between two improvement rates (e.g. pretest and posttest) to document changes in performance between baseline phases and intervention phases. To calculate IRD, the baseline improvement rate is determined by counting the number of data points that tie or exceed those in the intervention phase (Parker, et al., 2009). For the intervention, the improvement rate is the number of data points that exceed all baseline points. In this study, there were 112 total VMM probes that included 56 baseline probes and 56 intervention probes. The proportion of change was 0/56 for baseline phase and 56/56 for intervention phase. This means that all intervention phase scores were greater than all baseline scores (100% intervention - 0% baseline = 100%) and results in an effect size of 1.0. This indicates a strong effect size for the intervention on vocabulary knowledge.
Research Question 2

What was the impact of SAVI on algebra skill acquisition for secondary students with LD?

This question was designed to determine the effects of participation in a supplemental algebra vocabulary intervention (SAVI) on the algebra skills for 10 ninth grade students with LD in a resource setting. A researcher-created algebra skills mastery monitoring probe, ASMM, was administered for this purpose. Reported are: (a) statistical data, (b) graphs of individual students for a visual analysis, (c) treatment effect, and (d) effect size.

Statistical Data. Points earned for algebra skills were determined across all sessions for all of the words according to results on students ASMM. Statistics for pre- and posttests are given in Table 12. Pretest points for participants were low (out of a possible 8 points, M = 2.9, SD = 0.64, range = 1.8-3.6) indicating that students had little knowledge of the skills needed to work the algebra problems. Posttest points increased (out of a possible 8 points, M = 5.16, SD = 0.63, range = 4.6 - 6.44). Additionally, almost half (22 out of 56) of the posttest scores were between 6 and 8 out of a possible 8 points.

Table 12

<table>
<thead>
<tr>
<th>Measures</th>
<th>ASMM Pretest</th>
<th>ASMM Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>2.9</td>
<td>5.6</td>
</tr>
<tr>
<td>SD</td>
<td>0.64</td>
<td>0.63</td>
</tr>
<tr>
<td>Range</td>
<td>1.8 - 3.6</td>
<td>4.6 - 6.44</td>
</tr>
</tbody>
</table>
Points were converted to mean percentages and are shown in Table 13. Pretest scores ranged from 8-48%, with a mean of 36% and posttest scores ranged from 23- 88%, with a mean of 70%. Of the 10 students, all had pretest scores below 55%. Posttest scores varied greatly. The three highest performing students achieved above 75% and gains made by students from pre-to posttest ranged from 15-45%.

Table 13

Algebra Skills Mastery Measurement Pretest and Posttest Mean Percentages

<table>
<thead>
<tr>
<th>Participant</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent at pretest</td>
<td>37</td>
<td>29</td>
<td>35</td>
<td>35</td>
<td>48</td>
<td>33</td>
<td>43</td>
<td>54</td>
<td>35</td>
<td>8</td>
</tr>
<tr>
<td>Percent at posttest</td>
<td>56</td>
<td>56</td>
<td>60</td>
<td>65</td>
<td>69</td>
<td>78</td>
<td>80</td>
<td>88</td>
<td>68</td>
<td>23</td>
</tr>
<tr>
<td>Percent change</td>
<td>19</td>
<td>27</td>
<td>25</td>
<td>30</td>
<td>21</td>
<td>45</td>
<td>37</td>
<td>34</td>
<td>33</td>
<td>15</td>
</tr>
</tbody>
</table>

Visual Analysis of the Graphs. Effects of the intervention on algebra skills were further analyzed by graphing points earned by participants for each ASMM mastery measurement probe at pre-and posttest. A visual analysis of the graphs with data for individual students shows an overall increase in scores from pre- to posttest for all participants (see Figure 4).
Figure 4

Algebra Skills Mastery Measurement Graphs from Pre-to Posttest
(Figure 4 continued)
Note. Maximum score on pretest and posttest was eight points. Participants 2 and 5 did not complete session 5, participant 3 did not complete session 6, and participant 9 did not complete session 1.
Treatment Effect. Treatment effect for ASMM was defined as a 1-point increase from pre-to posttest. A 1-point increase indicates that the student knew how to solve one additional algebra problem after the intervention than before the intervention. Treatment effects were replicated across all participants for most of the algebra mastery measurements. Pre-to posttest scores for participants 6, 7, and 9 increased for all sessions, participants 1, 2, 3, 4, 5, and 8 increased for all sessions except one, and participant 10 increased in four of the six sessions (see Table 14).

Table 14

*Treatment Effect for Algebra Skills Mastery Measurement Probes*

<table>
<thead>
<tr>
<th>Participant</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sessions Completed</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Sessions with treatment effect</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Effect Size. Effect size was calculated using IRD for summarizing the results from baseline phase to intervention phase. An improved data point in baseline is one that ties or exceeds a data point in the treatment phase (Parker et al., 2009). In the intervention phase, 49 out of 56 (87.5%) points exceeded the baseline points and 7 out of 56 (12.5%) baseline points tied or exceeded intervention phase points. The intervention effect size on algebra skills is calculated by subtracting 12.5% (baseline) from 87.5% (intervention) to
get 75%, which is calculated to be a medium effect size of 0.75 for the intervention on algebra skills.

**Research Question 3**

*What was the relationship between student performance on posttest mastery measurement probes for vocabulary knowledge and posttest mastery measurement probes for algebra skills?*

This question was designed to determine whether mean posttest scores on vocabulary knowledge was related to mean posttest scores on algebra skills. A Pearson’s product-moment correlation was used to determine the linear dependence between the increase in the posttest scores on vocabulary knowledge and the posttest scores on algebra skills. A correlation coefficient of 0.408 and was found and this indicates a moderately positive correlation (See Table 15). Therefore, scores on vocabulary knowledge explained approximately 17% ($r^2 = 0.166$) of the variance in scores on algebra skills mastery measurement probes for these students.

Table 15

*Vocabulary and Algebra Skills Posttest Correlation (N= 112)*

<table>
<thead>
<tr>
<th>Variables</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest Vocabulary Skills</td>
<td></td>
</tr>
<tr>
<td>Posttest Algebra Skills</td>
<td>0.408</td>
</tr>
</tbody>
</table>
Research Question Four

What are students’ perceptions of the SAVI intervention for learning important Algebra vocabulary and skills?

Student attitudes and perceptions about the intervention were examined. All students completed the 30-question researcher-designed survey at the conclusion of the study. The survey took approximately 10 minutes to complete and consisted of questions that were answered using a Likert scale of one to six, with one indicating they strongly disagreed and six indicating they strongly agreed with the statement. The mean scores and standard deviations were calculated for each item and are listed on Table 16.

Table 16

Student Survey Means and Standard Deviations

<table>
<thead>
<tr>
<th>Question</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I liked instruction with SAVI, including PowerPoint, graphic organizer, and teacher explanations.</td>
<td>5.0</td>
<td>0.74</td>
</tr>
<tr>
<td>2. SAVI helped me learn definitions.</td>
<td>5.1</td>
<td>0.78</td>
</tr>
<tr>
<td>3. SAVI helped me learn algebra skills.</td>
<td>5.2</td>
<td>0.79</td>
</tr>
<tr>
<td>4. The PowerPoint slides helped me learn definitions.</td>
<td>5.2</td>
<td>0.63</td>
</tr>
<tr>
<td>5. The PowerPoint slides helped me learn algebra skills.</td>
<td>5.0</td>
<td>0.81</td>
</tr>
<tr>
<td>6. Teacher explanations helped me understand the definitions.</td>
<td>4.9</td>
<td>0.99</td>
</tr>
<tr>
<td>7. Teacher explanations helped me understand the algebra skills.</td>
<td>4.7</td>
<td>0.94</td>
</tr>
<tr>
<td>8. The graphic organizer I completed helped me remember important definitions.</td>
<td>4.5</td>
<td>0.97</td>
</tr>
<tr>
<td>9. The graphic organizer helped me remember important algebra skills.</td>
<td>4.7</td>
<td>0.95</td>
</tr>
<tr>
<td>10. Seeing pictures with explanations helped me remember definitions.</td>
<td>4.9</td>
<td>0.91</td>
</tr>
<tr>
<td>11. Writing down the definitions helped me remember the meanings of the words.</td>
<td>4.5</td>
<td>0.88</td>
</tr>
<tr>
<td>12. Writing down a math example helped me remember the meanings of the words.</td>
<td>4.9</td>
<td>0.88</td>
</tr>
<tr>
<td>13. Writing down how to use the words in math helped me</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
to understand the meanings of the words. 4.9 0.88
14. Learning vocabulary for algebra is important to me. 5.1 0.88
15. Learning algebra skills is important to me. 5.3 0.82
16. I liked receiving instruction during Study Skills on SAVI. 5.1 0.74
17. SAVI PowerPoint can help other students learn. 5.2 0.92
18. The graphic organizer could help other students learn. 5.0 0.92
19. Overall, SAVI helped me learn algebra and vocabulary. 5.1 0.82
20. I would watch videos that presented information like SAVI if I had them. 4.8 0.88
21. On my own I would use a graphic organizer like the one used during SAVI to help me learn vocabulary for algebra. 4.9 0.74
22. I would use a graphic organizer like the one used in SAVI to help me learn vocabulary for other classes, like science and history. 4.9 0.99
23. The assessment I completed right before the PowerPoint was easy. 2.6 0.97
24. The assessment I completed right after the PowerPoint was easy. 5.2 0.92
25. My algebra teacher instructs me in vocabulary and definitions during in Algebra I class. 4.0 1.72
26. I would understand algebra better if I knew the meanings of the words. 4.8 1.97
27. I like algebra. 3.9 1.96
28. I like learning definitions. 4.4 0.97
29. I am good at algebra. 4.2 1.69
30. I liked SAVI. 5.1 1.10

Note: n=10
1=strongly disagree, 2=disagree, 3=slightly disagree, 4=slightly agree, 5=agree, 6=strongly agree

Overall findings for student attitudes and perceptions were positive. They agreed that they liked the intervention (M = 5.0) and that the intervention helped them learn both vocabulary definitions (M = 5.1) and algebra skills (M = 5.2). Students agreed (M = 4.8) that the graphic organizer and its components (pictures, writing the definitions, and writing algebra examples) were helpful. They liked getting help with vocabulary and algebra in the resource setting (M = 5.1), agreed (M = 5.2) that the intervention could help other students and agreed (M = 4.9) that they could use the graphic organizer in
other classes and while independently studying. Students did not agree \((M = 2.6)\) that the mastery measurements were easy before the intervention, but agreed \((M = 5.2)\) that the mastery measures were easy after the intervention. Overall, student responses indicate satisfaction with the intervention.

**Social Validity**

Teachers’ attitudes and perceptions about using a supplemental algebra vocabulary intervention in a resource setting for students with LD were also examined. Two teachers completed the 16-question researcher-designed survey after the study concluded. The survey took approximately 5 minutes to complete and consisted of questions that the teachers answered using a Likert scale of one to six, with one as strongly disagree and six as strongly agree.

Both special educators strongly agreed \((M = 6.0)\) that the intervention and its components were helpful for the students with LD and strongly agreed \((M = 6.0)\) that all components of the intervention assisted their students. The teachers also strongly agreed \((M = 6.0)\) that the intervention was a worthwhile use of Study Skills class time and strongly agreed \((M = 6.0)\) that learning vocabulary and algebra skills are important for their students. They agreed that learning vocabulary and algebra skills are important for students with LD \((M = 5.0)\). Overall, the satisfaction of the special educators was high.

**Summary**

The results reported in this chapter describe the nature of a researcher-created and mediated algebra vocabulary intervention in ninth-grade resource class for 10 students with LD. The results illustrate positive effects of a supplemental algebra vocabulary
intervention for increased skills in vocabulary knowledge and algebra skills. Results of repeated acquisition design for vocabulary and algebra skills from pre-to posttests indicated that students benefitted from explicit computer-assisted instruction and graphic organizers. The means, visual analysis of graphs, effect sizes, and treatment effects demonstrated gains for all students across all sessions for vocabulary and for most sessions for algebra skills. In addition, the effect size of 1.0 indicates that all students benefitted from all SAVI sessions in vocabulary knowledge and an effect size of .75 indicated that all students benefitted from every SAVI session on algebra skills.

Based on survey results, students were satisfied with the intervention and its different components. Students like using the graphic organizer and agreed that learning the vocabulary words in algebra was beneficial. The students also agreed that the use of graphic organizers would benefit them in other subject areas. Teacher surveys indicated that they viewed the intervention as beneficial and a worthwhile use of resource class time for students with LD.
Chapter 5

Discussion

The purpose of this early research was to examine the effects of SAVI on algebra vocabulary knowledge and algebra skills performance for ninth grade students with LD. The findings indicated that students were able to improve their vocabulary and algebra skills. Overall, students made greater gains on vocabulary than algebra skills from the intervention, but gains were moderate to high on both measures. It was expected that students would make gains in vocabulary since the intervention was designed to teach vocabulary and was based on strategies that have been shown to be effective when teaching students with LD vocabulary in other settings. However, an interesting outcome was that students also made gains on the algebra skills when provided a vocabulary intervention. Explicit vocabulary instruction with a graphic organizer was successful for increasing the vocabulary knowledge and algebra skills for all participants. Additional research should be conducted to confirm these findings.

IDEA provisions require that students with LD receive services in the least restrictive environment. Thus, students with LD are typically taught content area classes in general education settings alongside nondisabled peers and are included in state and national assessments. Secondary teachers are frequently ill-prepared to teach students with LD in general education settings (Carnegie Council on Advancing Adolescent Literacy, 2010). For example, the Algebra I teachers whose students were participants in this study had very limited or no training for teaching students with LD. As more students with LD receive a majority of their education in general education settings, the field of
education has not kept up with providing adequate training, support, or access to research-based interventions for teaching students with LD. The lack of resources and training made available to teachers has been attributed as a leading factor in low graduation rates for students with LD according to the NAEP from 2009. It is important for general education content area teachers to have research-based methods and interventions to address the needs of students with LD in their classes.

In addition, it is important that special educators have training and tools that allow them to meet their students’ individual needs when the students are served in resource settings. Unfortunately, limited research is available identifying effective algebra interventions for students with LD in the general education and resource settings. Impecoven-Lind and Foegen (2010) identified a critical shortage of evidence-based algebra strategies available to assist students who have LD. A systematic review of literature identified only seven studies conducted since 1983 that investigated algebra interventions for students with LD in secondary settings. The present study adds to this literature base by examining the effects of SAVI on student performance in vocabulary and algebra skills for individuals with LD who were served in a resource setting. Furthermore, this study examined students’ and teachers’ perceptions and attitudes about SAVI. Analysis of the data revealed positive findings related to student learning. In addition, student and teacher ratings of the intervention support the social validity of the intervention.

The remainder of the chapter includes a discussion of the major findings and implications for instruction. Then, the limitations of the study are discussed. Finally,
conclusions and potential directions for future research are addressed. Research findings are described for research questions one, two, three, and four, and then teacher social validity findings are provided.

**Major Findings of the Study**

Research questions one, two, and three measured the effectiveness of the supplemental algebra vocabulary intervention on achievement for two dependent variables (mastery measurement probes in vocabulary and algebra skills) and the correlation of posttest scores from these probes. Independent variable effects were demonstrated through repeated acquisition of these skills across students and across measures. The following outcomes were found for the research questions that guided the investigation.

**Research Question One.** In response to the first research question, “What was the impact of SAVI on knowledge of algebra vocabulary for secondary students with LD?” among the items evaluated were the statistical data, visual inspection analysis, treatment effect, and effect size. All data evaluated revealed a functional relationship between introduction of the intervention and the number of vocabulary assessment items answered correctly.

Only one previous study (Jackson & Phillips, 1983) investigated with a quasi-experimental design teaching mathematics vocabulary for a unit on ratio and proportions to seventh grade students in a general education setting, but the student disability statuses were not reported. This study showed gains in vocabulary and mathematical skills for the
students who received vocabulary teaching over students who received the same amount of time on procedural skills related to ratios and proportion.

Limited peer-reviewed studies that demonstrate successful strategies for teaching vocabulary to secondary students with LD in academic domains other than algebra are published. Kennedy, Deshler, and Lloyd (in press) reported that secondary students with LD and nondisabled students learned social studies vocabulary about World War II effectively through a multimedia presentation. Kennedy et al. (in press) incorporated computer-assisted instruction with explicit instruction and methods for remembering definitions into a multimedia presentation and found these methods as effective for teaching vocabulary to students with LD.

While the positive findings for this intervention for teaching vocabulary are encouraging, there are three important points to consider. First, some of the 24 words taught were not Algebra I words, as originally planned, but words that would initially appear during earlier grades, such as product and sum. After giving the multiple-choice vocabulary test during the pilot study it became apparent that these students lacked the background knowledge needed for many of the algebra words. As pretest scores indicated, this was the correct assumption. The participants had very little knowledge of words that appeared in earlier grades. While it was appropriate to teach unknown prerequisite words that are not a part of the current grade level curriculum, with the pressures that teachers feel to cover the grade-level curriculum, this may not be done during Algebra I in the general education or resource setting. It appears to be important and necessary to teach mathematical vocabulary throughout the grades to ensure that
students have background knowledge needed to comprehend definitions for the more complex technical vocabulary in more advance mathematics.

Second, teachers may need to carefully scrutinize the definitions for the concepts they are teaching to ensure that the definitions do not contain words that are unknown to students. For example, *factor* is defined as “the number being multiplied” and was taught before *base* that is defined as “a factor that repeats.” Without attention to the definitions, teachers may teach definitions that cannot be comprehended by student with LD because of weak prior knowledge.

Third, definitions were created in an attempt to maintain the meaning of the words, but were written in student-friendly language. Some mathematicians may find these student-friendly definitions incomplete or oversimplified. For example, a *rational number* was taught as any number that ends. But textbook definitions are often “any real number of the form $\frac{a}{b}$, where $a$ and $b$ are integers and $b$ is not zero, as 7 or 7/3 or $n$” or “a number that can be expressed exactly by a ratio of two integers.” Neither of these definitions was used because the students did not learn the meanings of *real number* or *ratio*. In future research, the intervention should begin earlier in the year so that the complete definition can be learned as the students increase in their word knowledge. Last, the terms and definitions became more difficult as the intervention progressed, which may account for the smaller increases in scores over time for some participants.

**Research Question Two.** In response to the second research question, “What is the performance outcome on algebra skills for students with LD when explicitly taught vocabulary through explicit vocabulary instruction and graphic organizers through the
SAVI intervention?” the data analysis through visual inspection, treatment effect, and effect size revealed a functional relationship between the introduction of the intervention and the number of algebra skills assessment items answered correctly. Examples that included algebra problems appeared to support the understanding of the definitions and provided a way for students with LD to apply their new vocabulary knowledge to the algebra problems. The moderately high effect size on the algebra skills mastery measurement probes is interesting because the algebra problem-solving skills were not directly taught. While there were 2 sample problems included as illustrations with each term and definition, the students were not required to work these problems. Very little research has been conducted that investigated methods for teaching secondary students vocabulary and no available research has measured the effect of embedding algebra problems into instruction while teaching algebra vocabulary, but the results from this research indicate that more research is needed in this area.

Recently, CCSS (NGACBP CCSSO, 2010) included more focus on teaching comprehension of informational text like that in mathematics, and using discourse through multiple avenues that include writing and discussion of mathematical thinking. The new emphasis may lead to increased research in this area for students who have weak skills in content and vocabulary.

**Research Question Three.** The correlation of student scores on vocabulary knowledge to algebra skills was moderately positive. It is interesting to note some of the differences among student performance. For example, participants 1, 2, 3 and 4 had scores between 82-91% on the vocabulary mastery measurement and scores between 56-
65% on the algebra skills mastery measurement. Then, scores for students 6, 7, and 8 scores were reversed as they scored 78-88% on the algebra skills mastery measurement and between 26-42% on the vocabulary mastery measurement. Differential gains were made by students on vocabulary and algebra skills.

Also, all students achieved, but some achieved more than others. Scores for student 9 and student 10 increased the least on both measures, but they also had very low pretest scores and appeared less motivated than other participants during the study. Students may require a certain amount of background knowledge and skills to be successful from the intervention and may need additional motivation. In future studies, additional student information, such as mathematics and reading skill levels may useful for investigating which types of learners with LD this type of intervention benefits most.

Additionally, to measure increased depth of word knowledge, students were required to write definitions for the vocabulary words from memory instead of selecting answers from multiple choice items or fill-in-the-blanks. Kame‘enui, Dixon, and Carnine, (1987) found that the production of a definition is a more rigorous test of word knowledge than matching or fill-in-the-blank tests. Requiring students to recall the meanings of the words may have resulted in student performance on the maintenance measure and the vocabulary mastery measurement probe to be lower than if the students had been given a different format.

**Research Question Four.** An analysis of the surveys indicated that students agreed that the intervention was effective and appropriate. An interesting finding was that the students agreed that they would use the graphic organizer in other classes and that it
would benefit other students. The lowest scores on the survey were on questions if they liked algebra and whether their algebra teachers taught the definitions of the words used in algebra. Students only slightly agreed with both of these statements.

**Social Validity.** The special education teachers also perceived the intervention as effective and appropriate for secondary students with LD. While the survey illustrated a very positive perception and attitude about the vocabulary intervention, both teachers admitted that they were not certain how they could find the time to implement it in their resource setting. The time in resource is most frequently used for students with LD to catch up on work, take tests, and complete computer assignments from the content area teachers. Time for the special educator to work on preskills needed to be successful in the content area courses is very infrequent. When there is time to teach, they work on lessons that focus on study skills and test-taking skills.

**Limitations**

There are several limitations that need to be considered when interpreting these findings. First, 10 students participated in this single-case study. Replications of this study with additional students with LD and experimental studies with larger sample sizes would help with the generalizability of the findings. Second, the study was conducted in one high school in one school district. Results from replications across additional schools and districts would add to the generalizability of this intervention. Third, the sequence of vocabulary words did not follow the scope and sequence for Algebra I. This study occurred during the spring of a school year and the words taught were ones that students should have received exposure to earlier in the school year or in earlier grades. A study
that begins at the beginning of a course and/or follows the scope and sequence may yield very different results.

Third, the intervention was researcher-implemented and this may have impacted the results. While fidelity checks were conducted and the results were acceptable, the results may be different if implemented by someone who is not as familiar with the intervention. Fourth, the intervention and dependent variables were researcher-created. While the measures were designed and carefully implemented, technical data about the reliability and validity is not available.

Finally, questions regarding the social validity of the information are limited by the number of teachers completing the survey. Future research should investigate teacher perceptions of the intervention with a larger number of teachers. Examination of teacher perceptions might be examined through the use of videos of implementation the intervention.

**Implications for Practice**

The findings from this study revealed that students benefitted from explicit vocabulary instruction with a student-completed graphic organizer. Also, words were taught in a short period of time and learning the meanings of the words helped these students understand how to solve related algebra problems. Specifically, teaching mathematical vocabulary to students with LD through explicit instruction with a graphic organizer was successful for these students. It is important to determine the best strategies to assist students with learning the technical vocabulary that teachers use during Algebra I instruction.
However, enhancements to the intervention may increase the effectiveness. For example, a multimedia format, like the one used to teach high school history vocabulary by Kennedy, Deshler, and Lloyd (in press) might allow for more individualization of the vocabulary for students and increase the flexibility of use in a resource setting. Kennedy, et al. (in press) presented definitions to words that were included in a study of World War II through content-acquisition podcasts (CAPS), a multimedia-based instructional model. CAPS that included vocabulary instruction and keyword mnemonics were shown to be effective in teaching students with LD definitions. A multimedia format may provide special educators a method to individualize instruction for students in resource. Students could work on difficult content-area vocabulary as time permits and according to coursework demands.

Also, before the intervention could be implemented by special education teachers, specific training tools would need to be created. For example, there would need to be teacher training materials that include step-by-step directions and practice with scoring. Additionally, a technique for keeping track of words learned by students and a method for reviewing and reteaching words as needed should be included in the training materials.

**Future Research**

Although findings from this research added to findings from the seven studies included in the literature review, more research is needed to identify teaching strategies for assisting secondary students with algebra standards. Future research should examine strategies for teaching vocabulary in Algebra I in the general education setting, in
addition to students in a small group setting, such as a resource class. While positive gains were made by the students, these gains were not maintained. Future studies may include teaching fewer words more deeply and include multiple opportunities to be engaged with the words through mathematical problem solving and increased discourse.

A main goal for teaching technical vocabulary is improved comprehension of the content that leads to greater student gains. With that goal in mind, interventions for students with LD that measure the impact of vocabulary knowledge on the ability to be proficient in algebra would increase the relevancy of this line of research. Conducting a study that compares the knowledge of vocabulary to achievement in algebra skills may help to determine the connection between vocabulary and algebra skills. Also, measuring the outcomes in algebra for students when they are instructed in vocabulary compared to students in algebra who are not explicitly taught vocabulary may add insight into our understanding of how students learn algebra.

An additional research study could be investigating other avenues for using technology to assist students with LD who need opportunities for multiple exposures to the definitions. Technology could provide a method for students to work independently on the words that are being used in the current algebra unit of study to help support their understanding of the teaching methods in the general education setting. In summary, this research is important, but much work still needs to be done to address vocabulary deficits for secondary students in content area mathematics.
REFERENCES


APPENDICES

Appendix A

TEACHER AND PRINCIPAL SUMMARY SHEET

Information Concerning a Research Study
Clemson University

*Supplemental Algebra Vocabulary Instruction (SAVI)*

**Description of the Research**
Anderson Five School District is invited to participate in a research study conducted by Drs. Janie Hodge and Sara Mackiewicz, and a doctoral student, Joanna Stegall. The purpose of this research is to investigate student response to an academic intervention. The academic intervention is designed to teach mathematics and vocabulary to secondary students who have been diagnosed with learning disabilities and/or at risk in Algebra 1.

Mrs. Stegall will be completing this research as a part of her dissertation in Curriculum and Instruction: Special Education at Clemson University. Mrs. Stegall has over twenty-five years of teaching experience in public school settings and is currently fulltime faculty as Assistant Professor in the College of Education at Anderson University.

Participants will complete approximately 9 intervention sessions that will last approximately 25-30 minutes each. The total amount of time for student participation will be approximately 6 hours total during a three month period (May, 2013).

All participation will occur during the students’ study skills periods so students will not miss any time in core classes in order to participate in this research. The research will be conducted across one month (May, 2013) by Mrs. Stegall in a classroom at Hanna High School.

If you have any questions or concerns about this study, please contact Dr. Janie Hodge at Clemson University at 864-656-1613. If you have any questions or concerns about students’ rights as research participants, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-6460 or irb@clemson.edu.
Appendix B

STUDENT DEMOGRAPHIC FORM

Name ___________________________ Date________________________

Date of Birth _____________________ Algebra

Teacher(s)________________________

Student Race _____________________ Study Skills Teacher ____________

Student Gender ___________________ Grade_________________________

Free or Reduced Lunch ___yes_____no

1st semester grade in Algebra One ______

Repeating Algebra One ___yes_____no

Does the student have a learning disability (LD) according to South Carolina eligibility guidelines? _____yes_______no

Does the student have additional exceptionalities? _____yes (please explain) _____no

What special services does the student receive?

________________________________________________________________________

How much time and how often does the student receive special education services?

________________________________________________________________________

Area(s) of LD:

_____ Basic Reading-Decoding and word recognition

_____ Reading Comprehension

_____ Mathematics Computation

_____ Mathematics Problem Solving

_____ Written Expression

_____ Oral Expression

_____ Listening Comprehension

What types of accommodations are allowed through the student’s IEP?
___ n/a ___ Read Aloud ___ Computer Read ___ Extended Time ___ Scribe
___ Other (please describe) ___
Appendix C

SPECIAL EDUCATION TEACHER DEMOGRAPHIC FORM

Name __________________________

Age: _____18-25_____25-30_____31-40_____41-50_____51+

Highest Degree:
_____Bachelor’s Degree
_____Master’s Degree
_____Master’s Degree + 30 hours
_____Doctoral Degree

What degrees have you completed?
_____Elementary Education
_____Secondary Education
_____Special Education
_____Other:

How many years have you been teaching secondary students with diagnosed disabilities?

________________________

How many years have you been coteaching Algebra 1?

________________________

How many years have you been coteaching students who are repeaters for Algebra 1?

________________________

Months/Years at your current teaching position _________________________

How many study skills classes/sections do you teach this year?

________________________

Which grades and types in mathematics (ex. Algebra I, Calculus) are you coteaching?

________________________

How many total students do you have in each class you teach?

________________________

________________________

How many students with learning disabilities do you teach (per class)?

________________________

List mathematics’ education course(s) have you taken.
Appendix D

GENERAL EDUCATION TEACHER DEMOGRAPHIC FORM

Name ____________________________________________

Age: _______ 18-25 _______ 25-30 _______ 31-40 _______ 41-50 _______ 51+

Highest Degree:
_____ Bachelor’s Degree
_____ Master’s Degree
_____ Master’s Degree + 30 hours
_____ Doctoral Degree

What degrees have you completed?
_____ Elementary Education
_____ Secondary Education
_____ Special Education
_____ Other: ______________________________________

How many years have you been teaching secondary mathematics?
________________________________________________

How many years have you been teaching Algebra 1? ________________

How many years have you been teaching students who are repeaters for Algebra 1?
________________

Months/Years at your current teaching position _________________________

How many mathematics classes/sections do you teach this year? ________________

Which grades and types of mathematics (ex. Algebra I, Calculus) are you teaching?
________________________________________________

How many total students do you have in each class you teach?
________________________________________________

How many students with learning disabilities do you teach (per class)?
________________________________________________

Do you co-teach any of your mathematics’ classes with a special education teacher?
_____ yes (If yes, which ones? _________________________) _____ no

List special education course(s) have you taken.
Appendix E

STUDENT SURVEY

The purpose of this survey is to obtain information about the usefulness and practicality of Supplemental Algebra Vocabulary Instruction for use in Study Skills. Students in Study Skills could use this intervention. Please circle the number that best describes your agreement or disagreement with each statement using the scale below.

1= strongly disagree
2= disagree
3= slightly disagree
4= slightly agree
5= agree
6= strongly agree

1. I liked instruction with SAVI (PowerPoint presentation, graphic organizer, and teacher explanations).

2. SAVI helped me learn definitions.

3. SAVI helped me learn algebra skills.

4. The PowerPoint slides helped me learn definitions.

5. The PowerPoint slides helped me learn algebra skills.

6. Teacher explanations helped me understand the definitions.

7. Teacher explanations helped me understand the algebra skills.

8. The graphic organizer I completed helped me remember important definitions.

9. The graphic organizer helped me remember important algebra skills.

10. Seeing a picture with an explanation about a way to remember the definition helped me.

11. Writing down the definitions helped me remember the meanings of the words.

12. Writing down a math example helped me remember the meanings of the words.

13. Explaining how to use the words in math helped me to understand the meanings of the words.

14. Learning vocabulary for algebra is important to me.
Appendix E (Continued)

|   |   |   |   |   |   
|---|---|---|---|---|---|
| 15. | Learning algebra skills is important to me. | 1 2 3 4 5 6 |
| 16. | I liked receiving instruction during Study Skills with SAVI. | 1 2 3 4 5 6 |
| 17. | SAVI PowerPoint presentations could help other students learn. | 1 2 3 4 5 6 |
| 18. | The SAVI graphic organizer could help other students learn. | 1 2 3 4 5 6 |
| 19. | Overall, SAVI helped me learn algebra and vocabulary. | 1 2 3 4 5 6 |
| 20. | I would watch videos that presented information like SAVI if I had them. | 1 2 3 4 5 6 |
| 21. | On my own I would use a graphic organizer like the one used in SAVI to help me learn vocabulary for algebra. | 1 2 3 4 5 6 |
| 22. | I would use a graphic organizer like the one used in SAVI to help me learn vocabulary for other classes, like science and history. | 1 2 3 4 5 6 |
| 23. | The assessments I completed right **before** the Powerpoints were easy. | 1 2 3 4 5 6 |
| 24. | The assessments I completed right **after** the Powerpoints were easy. | 1 2 3 4 5 6 |
| 25. | My algebra teacher teaches me vocabulary and their definitions that help me in Algebra I. | 1 2 3 4 5 6 |
| 26. | I would understand algebra better if I knew the meanings of the words. | 1 2 3 4 5 6 |
| 27. | I like algebra. | 1 2 3 4 5 6 |
| 28. | I like learning definitions. | 1 2 3 4 5 6 |
| 29. | I am good at algebra. | 1 2 3 4 5 6 |
| 30. | I like SAVI. | 1 2 3 4 5 6 |

Appendix F

TEACHER SURVEY

The purpose of this survey is to obtain information about the usefulness and practicality of Supplemental Algebra Vocabulary Instruction (SAVI) for use in a study skills classroom because teachers in study skills classrooms could use this intervention. Please circle the number that best describes your agreement or disagreement to each statement using the scale below.

1= strongly disagree  
2= disagree  
3= slightly disagree  
4= slightly agree  
5= agree  
6= strongly agree

1. The SAVI Instructional package (PowerPoints, graphic organizer, and teacher explanations) benefitted my students with LD.

2. SAVI can help students with LD (LD) learn definitions.

3. SAVI can help students learn algebra skills.

4. The PowerPoint slides helped students with LD learn definitions.

5. The PowerPoint slides helped students with LD learn algebra skills.

6. Teacher explanations helped students with LD understand the definitions.

7. Teacher explanations helped students with LD understand the algebra skills.

8. The graphic organizer helped students with LD with remember important definitions.

9. The graphic organizer helped students with LD remember important algebra skills.

10. Seeing a picture with an explanation for remembering the definition helped students with LD.

11. Writing down the definitions helped students with LD remember the meanings of the words.

12. Writing down a math example for each word helped students with LD remember the meanings of the words.

1 2 3 4 5 6
Appendix F (Continued)

13. Explaining how to use the words in math helped students with LD understand the meaning of the words.  
1 2 3 4 5 6

14. Learning vocabulary for algebra is important to students with LD.  
1 2 3 4 5 6

15. Learning algebra skills is important to students with LD.  
1 2 3 4 5 6

16. I liked students with LD receiving instruction during Study Skills on SAVI.  
1 2 3 4 5 6
TEACHER: Today you will be presented four algebra vocabulary words, the definitions for these words, and how they are used in algebra problem solving. The presentation is called SAVI and it stands for Supplemental Algebra Vocabulary Instruction. During SAVI sessions you will watch me teach through a short Powerpoint presentation and you will complete a graphic organizer about the words I present. This information is designed to help you gain a better understanding of Algebra 1 vocabulary terms and how to use these words in algebra.

We will be working on SAVI for approximately four weeks. SAVI sessions will be every other day during your study skills class for around 30-40 minutes. For you, we will work on SAVI on (A or B day) at _______ (time period).

Each session of SAVI will follow the same routine and before and after each session there will be a quick assessment that you take.

So the SAVI routine will be quick pretests on vocabulary and algebra skills, a teaching and Powerpoint presentation or four words (with you completing a graphic organizer), and posttest on the words presented and algebra skills that use those words.

What will happen during each session? Review with the class.

Offer to answer any questions.
Appendix H

INTERRATER AGREEMENT SHEET FOR VMM

Participant’s Name ________________________________

Session Number__________

Rater’s Name ______________________________________

VMM Directions: Each vocabulary word receives a score of 0-4 according to the description provided on the Learning Sheet. Circle the score that the student should receive for each of the four vocabulary words.

<table>
<thead>
<tr>
<th>Vocabulary word #1</th>
<th>Word:</th>
<th>Score: 0 1 2 3 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary word #2</td>
<td>Word:</td>
<td>Score: 0 1 2 3 4</td>
</tr>
<tr>
<td>Vocabulary word #3</td>
<td>Word:</td>
<td>Score: 0 1 2 3 4</td>
</tr>
<tr>
<td>Vocabulary word #4</td>
<td>Word:</td>
<td>Score: 0 1 2 3 4</td>
</tr>
</tbody>
</table>

TOTAL POINTS:

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\]
Appendix I

INTER RATER AGREEMENT SHEET FOR ASMM

Participant’s Name ________________________________

Session Number __________

Rater’s Name ________________________________

ASMM Directions: Algebra items #1-8 are worth one point each if correct. If the answer is incorrect, the item receives a “0” score and correct answers receive a “1.” Please circle the score that the participant should receive next to each item and then write the total score.

<p>| | | |</p>
<table>
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<tbody>
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<td>0</td>
<td>1</td>
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<tr>
<td>8</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Total Points: ____/
Appendix J

OBSERVER CHECKLIST FOR
INTERVENTION AND ASSESSMENTS

Name of Observer: ____________________ Date: ____________________

School: Hanna High School
Class: Mrs. Thomas- 9th grade Study Skills
Start Time ____________ End Time ____________

Directions: A checkmark by “Yes” indicates this step was completed as described. A checkmark of “No” indicates it was not completed as described. For any “No” checkmarks, please elaborate specifically what occurred in the comments section.

Introduction to Intervention: Were these procedures followed?
Researcher reminds students that will take two pretests, one on four terms and one on math skills. After learning more about the four words covered in the session today, students are told that they will take a posttest on the four words and math skills that is the same as the pretests.

_____ Yes _____ No

Comments:

Before passing out the pretest on the words (VMM), the students are told that the assessments are untimed and to raise their hands when finished. As soon as students finish VMM they complete the assessment on the math skills (ASMM). Researcher passes out pretest VMM and collects it as students complete it. Then students are given ASMM to complete.

_____ Yes _____ No

Comments:

After all pretests are completed for all participants, the intervention routine immediately begins.

_____ Yes _____ No

Comments:

Intervention Routine: Were these procedures followed?
Students are given four blank SAVI graphic organizers to complete. Students are told to complete one for each word that is presented and that they can ask questions for clarification or for additional information.

_____ Yes _____ No

Comments:
Directions: Four math words are presented through a powerpoint presentation. For each word, the following steps are completed: (check off for each of the four words)

**Word #1**

**SAVI Intervention Session for each term**

Step One: Introduction of new term
____ Yes  ____ No

Step Two: Definition of new term
____ Yes  ____ No

Step Three: Method for remembering the meaning of the term
____ Yes  ____ No

Step Four: Application of term in a math problem
____ Yes  ____ No

Step Five: Application of term in an algebra problem
____ Yes  ____ No

Step Six: Illustrate a nonexample in algebra (if needed)
____ Yes  ____ No

Step Seven: Review the word, definition, and method for remembering definition
____ Yes  ____ No

Step Eight: Ask students if they have any questions about how to complete their graphic organizer for the word that was just presented.
____ Yes  ____ No

Once all students have completed their graphic organizers and all questions have been answered, the researcher will begin with the next word.
____ Yes  ____ No

**Word #2**

**SAVI Intervention Session for each term**

Step One: Introduction of new term
____ Yes  ____ No

Step Two: Definition of new term
____ Yes  ____ No

Step Three: Method for remembering the meaning of the term
____ Yes  ____ No

Step Four: Application of term in a math problem
____ Yes  ____ No

Step Five: Application of term in an algebra problem
____ Yes  ____ No

Step Six: Illustrate a nonexample in algebra (if needed)
____ Yes  ____ No

Step Seven: Review the word, definition, and method for remembering definition
____ Yes  ____ No

Step Eight: Ask students if they have any questions about how to complete their graphic organizer for the word that was just presented.
____ Yes  ____ No

Once all students have completed their graphic organizers and all questions have been answered, the researcher will begin with the next word.
____ Yes  ____ No

**Word #3**

**SAVI Intervention Session for each term**

Step One: Introduction of new term
____ Yes  ____ No

Step Two: Definition of new term
____ Yes  ____ No

Step Three: Method for remembering the meaning of the term
____ Yes  ____ No

Step Four: Application of term in a math problem
____ Yes  ____ No

Step Five: Application of term in an algebra problem
____ Yes  ____ No

Step Six: Illustrate a nonexample in algebra (if needed)
____ Yes  ____ No
Step Seven: Review the word, definition, and method for remembering definition
   ___Yes    ___No
Step Eight: Ask students if they have any questions about how to complete their graphic
   ___Yes    ___No
organizer for the word that was just presented.

Once all students have completed their graphic organizers and all questions have been
   ___Yes    ___No
answered, the researcher will begin with the next word.

Word #4

SAVI Intervention Session for each term:

   Step One: Introduction of new term           ___Yes    ___No
   Step Two: Definition of new term             ___Yes    ___No
   Step Three: Method for remembering the meaning of the term ___Yes    ___No
   Step Four: Application of term in a math problem ___Yes    ___No
   Step Five: Application of term in an algebra problem ___Yes    ___No
   Step Six: Illustrate a nonexample in algebra (if needed) ___Yes    ___No
   Step Seven: Review the word, definition, and method for remembering definition
               ___Yes    ___No

Step Eight: Ask students if they have any questions about how to complete their graphic
   ___Yes    ___No
organizer for the word that was just presented.

III. Conclusion of Intervention Session:        Were these procedures
   followed?
   Did the researcher tell the students that they may review/study the graphic organizers that
   ___Yes    ___No
they completed on the words presented today before taking the posttests?

Comment:

   Did each student indicate to the researcher when the student was ready to take the
   ___Yes    ___No
posttests?

Comment:

   Did the researcher collect all student work on graphic organizers before students began
   ___Yes    ___No
assessments?

Comment:
IV. Assessments: Were these procedures followed?

Did the teacher administer the vocabulary pretest (AIM –V VMM) as the first assessment and prior to the intervention session?  
___Yes  ___No

Comment:

Did the teacher administer the algebra skills pretest (SAVI ASMM) after VMM and prior to the intervention session?  
___Yes  ___No

Comment:

Did the researcher collect all student graphic organizers prior to posttests?  
___Yes  ___No

Comment:

Did the teacher administer the vocabulary posttest (AIM –V VMM) after the intervention session and prior to administering ASMM?  
___Yes  ___No

Comment:

Did the teacher administer the algebra skills posttest (SAVI ASMM) after administering VMM?  
___Yes  ___No

Comment:

Did the pretests (parts A and B), intervention sessions, and posttests occur within the same class period?  
___ Yes  ___ No

Comment:

Did students appear to complete all assessments without assistance from the researcher or anyone else?  
___ Yes  ___ No

Comment:

Other Comments:
### Appendix K

**WORD LIST AND DEFINITIONS FOR INTERVENTION SESSIONS**

<table>
<thead>
<tr>
<th>Session 1</th>
<th>Session 2</th>
<th>Session 3</th>
<th>Session 4</th>
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<th>Session 6</th>
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</thead>
<tbody>
<tr>
<td><strong>Value-number amounts</strong></td>
<td>Sum- <strong>value</strong> of addition problems</td>
<td>Integer-whole numbers and their opposites</td>
<td><strong>Terms</strong>- parts of an <strong>expression</strong> that can be a number, <strong>variable</strong>, or both</td>
<td><strong>Operators</strong>- signs for adding, subtracting, multiplying and dividing</td>
<td><strong>Coefficient</strong>- number in front of the <strong>variable</strong></td>
</tr>
<tr>
<td><strong>Addend</strong>- number being added</td>
<td>Parenthesis- used to form groups</td>
<td><strong>Base</strong>- a <strong>factor</strong> that repeats</td>
<td><strong>Like terms</strong>- the same <strong>variable</strong> raised to the same <strong>exponent</strong></td>
<td><strong>Constant</strong>- number without a <strong>variable</strong></td>
<td><strong>Equation</strong>- math sentence stating that two <strong>expressions</strong> are equal</td>
</tr>
<tr>
<td><strong>Factor</strong>- number being multiplied</td>
<td><strong>Variable</strong>- letter used to represent a <strong>value</strong></td>
<td><strong>Exponent</strong>- power of the <strong>base</strong></td>
<td><strong>Reciprocal</strong>- number whose <strong>product</strong> is equal to one</td>
<td><strong>Equivalent</strong>- equal number amounts</td>
<td><strong>Square root</strong>- one of two equal <strong>factors</strong> of a number</td>
</tr>
<tr>
<td><strong>Product</strong>- <strong>value</strong> for answer to multiplication problems</td>
<td>commutative property- order for adding and multiplying does not change the <strong>sum</strong> or <strong>product</strong></td>
<td><strong>Expression</strong>- combination of numbers, <strong>variables</strong>, and operations</td>
<td><strong>Inverse operations</strong>- <strong>value</strong> that cancels out another <strong>value</strong></td>
<td><strong>equivalent expression</strong>- combination of numbers, <strong>variables</strong>, and <strong>operations</strong> that give the same <strong>value</strong></td>
<td><strong>Rational numbers</strong>- numbers that end</td>
</tr>
</tbody>
</table>

*Note. Boldfaced words illustrate ones that were taught in previous sessions.*