THE EFFECT OF EXPLICIT VOCABULARY INSTRUCTION USING SPECIALIZED
GRAPHIC ORGANIZERS IN SECONDARY MATHEMATICS
FOR STUDENTS WITH DISABILITIES

by

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ABSTRACT

There is a clear and distinct difference in the levels of knowledge versus levels of understanding when measuring the ability of a student to reach mastery of a concept in the educational environment. Increased levels of rigor in today’s classroom exhibit the necessity of a paradigm shift related effective academic instruction. Mathematics as a content area currently focuses on conceptual understanding as opposed to traditional procedural knowledge. In accordance with this shift in educational practice, students must demonstrate a clear and concise understanding of the terminology used in the development of mathematical problems, specifically abstract word problems, used to assess levels of mastery of required content. The purpose of this study was to examine if a positive correlation exists between explicit vocabulary instruction in secondary mathematics using graphic organizers specially designed for mathematics vocabulary instruction in conjunction with an instructional routine (Explicit Instructional Routine) and increased student achievement in demonstrating knowledge and understanding of Algebraic concepts. Previous studies associated with academic enhancements, interventions, and routines for students with learning disabilities ascertain that increased levels of knowledge and understanding are reached when implemented with fidelity.
DEDICATION

This project is lovingly dedicated to an extraordinary group of people who, unknowingly, encouraged me to further my studies – my students. From preschoolers to college students over the span of 20 years, each precious life has provided a unique and precious impact on my world. I strive for excellence as an educator in order to make the world a brighter place for you.

“Always remember… You are braver than you believe, stronger than you seem, smarter than you think… and loved more than you will ever know.”
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CHAPTER I: INTRODUCTION

Twenty-first century classroom expectations are lofty; students are expected to engage, query, demonstrate, produce, and analyze information in order to demonstrate content literacy. Quality standards of secondary mathematics courses focus on conceptual understanding rather than procedural knowledge, which increases the ability of students to use prior knowledge to solve abstract problems (National Council of Teachers of Mathematics, 2000); The Common Core State Standards (CCSS) (corestandards.org, 2014) and College and Career Readiness Standards (CCRS) (2ed.gov., 2014) provide frameworks with increased rigor for the classroom, strengthening the levels of abstract thinking and problem solving abilities required of today’s student. While the inception of such standards does not prescribe how frontline educators should deliver instruction, it does provide accountability measures for all standards at grade levels. The cognitive level of functioning of students provides an additional challenge for teachers to meet expected outcomes of each standard. Teachers and students are together challenged with rigorous standards in relation to what constitutes an adequate education for people competing in a global society for jobs and resources; they continue to face challenges with traditional instructional schedules to meet the higher expectations set forth by educational policymakers. CCSS/CCRS demonstrate an educational shift in paradigm that has created an increased cognitive load for teachers (Porter, McMaken, Hwang, & Yang, 2011) who may feel unprepared to provide instructional methods and strategies in standards that are holistically different from the operating state standards that have been the governing standard for decades (Cobb & Jackson, 2011). In
order to reach the new standards, educators must no longer focus on the opportunity to learn; rather, the delivery of high-quality curricular content must become the focus on classroom instruction (Doro, Mosher, & Corcoran, 2011).

In addition to the adoption of CCSS/CCRS, teachers are responsible for fulfilling federal regulations regarding the education of students with disabilities. The Individuals with Disabilities Education Improvement Act (IDEIA) (ed.gov, 2014) mandates that students with disabilities are provided access to the general curriculum “to the maximum extent possible” (Section 682) resulting in an increase of students with disabilities receiving instruction in the general education classroom. In accordance with the idea of improvement of educational services, IDEIA provides an accountability measure for the educational growth of students with disabilities. In addition, IDEIA necessitates the implementation of evidence based interventions and progress monitoring to measure the effectiveness of the interventions. Required progress monitoring provides opportunities for measurement regarding the effectiveness of instruction when correlated to student performance, prompting teachers to adjust their instructional strategies and routines in order to meet the needs of students. With increased rigor and accountability for educators as well as students, the immediate issue is identification of deficit skills and foundational benchmarks in order address critical issues preventing student success.

**Academic Vocabulary Instruction**

Academic vocabulary is perhaps the most obvious aspect of academic language. Inconsistency in students’ ability to demonstrate knowledge of academic vocabulary has unfailingly been identified as an obstacle to student success (Nagy & Townsend, 2012). Attention to academic vocabulary is likely an important first step in raising teachers’ awareness of the need to better support students’ understanding and use of the language of the disciplines. Academic vocabulary is characteristically categorized by two methods: general and discipline-
specific (Hiebert & Lubliner, 2008). General academic words are employed in academic language with greater frequency than in nonacademic language while general academic words are often abstract words with dictionary entries that may include several definitions (Nagy & Townsend, 2012). Research in the area of vocabulary instruction demonstrates that student understanding of vocabulary is rooted in the need exposure in multiple contexts with multiple opportunities for practice (Blachowicz & Fisher, 2000; McKeown et al., 1985; Stahl & Fairbanks, 1986). This tends to be especially important for the acquisition of general academic words; however, traditional instructional methods have focused on the memorization of terms rather than understanding of relationships between words and contexts (Bowerman & Choi, 2003; Munnich & Landau, 2003). This type of instruction allows for students to use words in authentic contexts in order that they garner and support the meaning of technical or theoretical ideas (Nagy & Townsend, 2012).

Research in the area of vocabulary learning and instruction establishes there is a common theme that is particularly important for academic language (Blachowicz & Fisher, 2000; Graves, 2006; Stahl & Nagy, 2006). For students to demonstrate understanding of vocabulary, learning must occur within authentic contexts, providing multiple opportunities to learn how target words interact with, garner meaning from, and support meanings of other words (Nagy & Townsend, 2012). This idea lends itself to the need for teachers to identify the most critical or meaningful words for instruction prior to teaching, and support this instruction in multiple contexts for generalization to occur (Fang & Schleppegrell, 2008; Zwiers, 2008).

To fully investigate the need for vocabulary instruction in specific content areas, the difference between content area literacy and disciplinary literacy must be understood. Content area literacy “has been defined as the ability to use reading and writing effectively as tools for
Disciplinary literacy is one’s ability to engage in social, semiotic, and cognitive practices used by content area specialists. According to research, disciplinary literacy constitutes both deep knowledge of disciplinary content and acute understanding of disciplinary methods for creating meaning (Fang, 2012). This research suggests that literacy at the secondary level “must be anchored in the specifics of individual disciplines” (McConachie & Petrosky, 2010, pg. 15).

According to Lemke (2003), the content area of mathematics has a distinct language necessary for the construction of mathematical knowledge and reasoning. Comparable to studies in science, mathematics texts are “semiotic hybrids” (Lemke, 1998, 2003); drawing on linguistic resources (i.e., natural language) as well as symbolic and visual representations for the construction of meaning (Fang, 2012). In mathematics, words may be representative of processes exclusive to the content area, with terms such as *hypotenuse* or *hexagonal*; however, words with dual meanings may be particularly problematic for students as these words have a definition rooted in a mathematical context as well as a definition that has a linguistic reference with no connection to the mathematical application (e.g., *edge*) (Fang, 2012). This validates the need for prior explicit instruction of terminology in order to develop conceptual understanding prior to procedural application. Secondary mathematics course textbooks have both technical and semi-technical vocabulary representative of both linguistic and symbolic vocabulary that may present challenges for students with deficits in reading, understanding and problem solving skills. Vocabulary terms used in course texts may not be uniquely mathematical; consequently, students who lack foundational skills may exhibit poor understanding and a lack of prior knowledge necessary for understanding of applied or abstract problem solving necessary for advanced courses (Fang, 2012).
Instructional Practices in Mathematics Using Specialized Graphic Organizers

The ability to utilize abstract problem solving skills is progressively critical throughout mathematics curriculums in today’s educational environments. Mastery of content standards related to math problem solving is strongly correlated with the overall math achievement of a student (Bryant, Bryant, & Hammill, 2000), and the development of proficiency in this domain is relevant to students’ success in school and beyond (Krawec, Montague, Kressler, & deAlba, 2013). Problem solving skills extend throughout the five curricular content standards and are a goal of and means for learning mathematics (National Council of Teachers of Mathematics, 2000); furthermore, problem solving skills are essential for success as an indicator of career readiness (Hudson & Miller, 2006).

Research reveals that students with disabilities in the area of mathematics and those with both disabilities in the area of reading and mathematics lack the necessary skills to accurately solve word problems (Fuchs, Fuchs, Stuebing, Fletcher, Hamlett, & Lambert, 2008; Fuchs & Fuchs, 2002; Zheng, Flynn, & Swanson, 2012). During the 1980s and 1990s, national reform documents such as the National Council of Teachers of Mathematics Principles and Standards for School Mathematics (NCTM, 2000) articulated a vision for school mathematics where “all students should have the opportunity and the support necessary to learn significant mathematics with depth and understanding” (p. 50). The establishment of Common Core State Standards for Mathematics (CCSSM) (Council of Chief State School Officers & National Governor’s Association, 2010) addresses the demand of providing support to educators in order to ensure a direct and focused attention on students’ mathematical thinking in the context of new reform efforts. These standards are founded in part on “research-based learning progressions detailing what is known today about how students’ mathematical knowledge, skill, and understanding develop over time” (p. 4). For decades, instruction in the content area of mathematics has
centered a focus on procedural tasks and skills; currently, education is experiencing a shift in paradigm with a centralized focus on conceptual understanding to instill problem solving skills necessary for the classroom and a global society.

To address the necessity of problem solving proficiency, major strides have been made to reform the math curriculum from an emphasis on rote skills and procedural knowledge to problem analysis, interpretation, and conceptual understanding (National Council of Teachers of Mathematics, 2000). Pedagogical changes emphasize student engagement through investigations, multiple representations, and discussion, primarily through problem solving activities (Goldsmith & Mark, 1999). Despite the increased interest in mathematical problem solving by researchers and practitioners, students in general, and particularly students with learning disabilities (LD), continue to struggle. Difficulties in working memory and processing speed (Fuchs & Fuchs, 2002), identifying the correct operation and performing the computation (Huinker, 1989; Montague & Applegate, 1993), higher order reasoning (Maccini & Ruhl, 2001), and the comprehension demands inherent in word problems combine to make math problem solving one of the most challenging parts of the curriculum for this group (Lerner, 2000). Similar to reading comprehension, problem solving in mathematics is a complex skill that requires students not only to calculate an answer but also to comprehend and integrate the problem information, generate and maintain mental images of the problem, and develop a viable solution path (Montague, Warger, & Morgan, 2000). These tasks often require higher-order thinking abilities and a strategic approach (Hudson & Miller, 2006).

**Statement of the Problem**

Insufficient vocabulary knowledge is strongly associated with academic failure in grades three through twelve (Becker, 1977). An inadequate or incomplete academic vocabulary inhibits meaningful understanding of content material that is processed and generalized for future
utilization, creating a deficit in the student’s ability to comprehend instruction and generalize skills. Research in the area of vocabulary instruction provides a framework of word knowledge, suggesting four degrees of word knowledge: (1) words students have never seen before, (2) words students have heard but are unsure of the meaning, (3) words students recognize and know a little bit about, and (4) words students know well and can explain to others (Dale, 1965).

While explicit instruction in content vocabulary and the use of terminology in multiple contexts is commonly utilized for language arts, social studies, and the sciences, it is not a traditional instructional focus in the instructional plans and course sequences of mathematics, particularly in secondary courses (Thompson & Rubenstein, 2000). Erroneous or incomplete understanding of definitions and how terms are applied in context may cause students to exhibit an inability to apply problem solving in solving abstract calculations or word problems (Oyinloye & Popoola, 2013). Students with and without learning disabilities may arrive in secondary mathematics courses with vocabulary word recognition; however, a meaningful understanding of how the word is used in a mathematical context may be limited or erroneous; therefore, recognition of the word is not useful when activating prior knowledge or construction of new knowledge in relation to the student’s ability to solve problems which require abstract reasoning abilities (Nagy & Townsend, 2012). In short, lack of sufficient mastery of critical mathematics vocabulary likely acerbates students’ ability to develop problem solving thinking skills and ability to master key mathematics problem solving procedures.

Purpose of the Study

Rigorous standards developed through a national set of Common Core Standards (CCS) (corestandards.org, 2014) and College and Career Ready Standards (CCRS) (ed.gov, 2014) instill an increased emphasis on demonstrating knowledge through a variety of methods to achieve mastery. These standards (CCS/CCRS) emphasize content literacy for application of
skill and problem solving ability in the area of mathematics, to include a conceptual understanding rather than a sole focus on procedural operations. Traditional instruction (business-as-usual instruction) in secondary mathematics classrooms has predominantly focused on teaching computational skills (i.e., procedural instruction) in order to solve problems, including abstract word problems that require students to apply generalized knowledge from foundational courses (Cobb, Stephan, McClain, & Gravemeijer, 2011). The purpose of this investigation is to determine if graphic organizers specially designed for teaching mathematics vocabulary coupled with the use of an instructional routine succeed in improving student ability and performance in solving abstract word problems related to measures of central tendency, an Algebraic concept. Previous studies suggest that the academic performance of students with learning disabilities improves significantly when content enhancements are made.

**Research Questions**

The following research questions are addressed in this study:

1. Is there a difference in student knowledge of measures of central tendency following instructional intervention that includes the use of a specialized graphic organizer for teaching mathematical vocabulary terminology in addition to explicit verbal instruction that incorporates exposure to terms in multiple contexts using the Explicit Inquiry Routine related to measures of central tendency?

2. Is there a difference in student ability to demonstrate understanding by solving word problems that require the utilization of computation related to measures of central tendency following instructional intervention that includes the use of a graphic organizer specially designed for teaching mathematical vocabulary in addition to explicit verbal instruction that incorporates exposure to terms in multiple contexts using the Explicit Inquiry Routine (EIR) related to measures of central tendency?
**Definition of Terms**

For purposes of clarification, the following terms used in this study have been defined:

*Common Core State Standards* are defined as

“a set of high-quality academic standards in mathematics and English language arts/literacy (ELA). These learning goals outline what a student should know and be able to do at the end of each grade. The standards were created to ensure that college, career, and life, regardless of where they live. Forty-three states, the District of Columbia, four territories, and the Department of Defense Education Activity (DoDEA) have voluntarily adopted and are moving forward with the Common Core” (corestandards.org, 2014).

*Content area literacy* is defined as “the ability to use reading and writing effectively as tools for thinking about and learning from texts across different school subjects” (Fang, 2012, pg. 19).

*Content enhancement* is defined as an instructional method that relies on the use of research-based strategies and tools for the presentation and organization of content material during instruction in order to ensure that material is explicit, clear, and concise. Content enhancements focus on providing opportunities for student engagement in the learning process (www.ku-crl.org/sim/content/shtml, 2015).

*Disciplinary literacy* is defined as one’s ability to engage in social, semiotic, and cognitive practices used by content area specialists; disciplinary literacy constitutes both deep knowledge of disciplinary content and acute understanding of disciplinary methods for creating meaning (Fang, 2012).

*Learning disability* is defined as a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations, including conditions such as perceptual disabilities, brain injury, minimal brain
dysfunction, dyslexia, and developmental aphasia (http://idea.ed.gov/explore/view/p/,
root,dynamic,TopicalBrief,23, 2015).

Summary

Although research in the area of learning disabilities and the importance of conceptual
knowledge in mathematics to include specific vocabulary is increasing, research in the area of
reading continues to outnumber research in the area of mathematics at a rate of five to one
(Gerster, Clark, & Mazzocco, 2007) while it is estimated that 6% to 7% of school-age students
demonstrate a disability in the area of mathematics (Swanson, 2012). Additional research in the
area of teaching vocabulary in mathematics, specifically focused on conceptual knowledge and
understanding, should focus on how instructional enhancements impact the abstract problem
solving skills (i.e., word problem solving performance) of students with disabilities in the
inclusive setting. Academic performance is directly related to quality instruction (Leh &
Jitendra, 2012), which begins with a primary focus on prerequisite skills, requisite knowledge,
and skills and procedures needed for application in advanced mathematical problems and
calculations. Chapter II provides an in-depth examination of literature concerning instructional
interventions, routines, strategies, cognitive theories, and methods of assessment relevant to
effective methods for teaching students with learning disabilities in the area of secondary
mathematics.
CHAPTER II: REVIEW OF LITERATURE

As educators strive to implement the rigor and relevance required of 21st century learning environments, content enhancements (i.e., instructional tools, interventions, and routines) are at the forefront of academic discussion. Education as an entity has experienced a paradigm shift away from the premise of rote learning, which required memorization and regurgitation of facts in cross-contextual fashion spanning grade levels. Using empirical research, educators have learned and now acknowledge that information learned through memorization of fact is rarely stored effectively; thus generalization and application of skill are often difficult and lead to academic battles and failure for students. In order for students to meet the demands of rigorous standards set forth by national and state standards, teachers must serve as active facilitators of learning, using instructional tools and routines that engage learners and allow for the storage of information and retrieval of prior knowledge to ensure that foundational skills are gained and available for retrieval in an effective and efficient manner. The purpose of this review was to analyze the effectiveness of specific instructional routines, the use of specific instruction routines related to instruction of vocabulary terms, and cognitive theories related to explicit instruction of vocabulary in secondary mathematics.

This review of literature includes an overview of information on strategic instructional routines for explicitly teaching vocabulary in secondary mathematics courses for students with learning disabilities. Some of the specific instructional routines considered in this review incorporated graphic organizers to structure information processing. The review includes an overview of cognitive theories that are indices of the necessity for explicit vocabulary instruction
in secondary mathematics. The emphasis of this search was to explicate how cognition and information processing are enhanced through the use of specific routines and instructional tools related to the comprehension of content vocabulary. Additionally, research on instructional routines and strategies in secondary mathematics classrooms that focus on the comprehension of content vocabulary was included in the review. Research of effective instructional procedures in mathematics has not sufficiently addressed best instructional practices and instructional routines that utilize specific instructional tools for teaching concept vocabulary; however, empirical research in other content areas such as language arts and science yield results that demonstrate positive results based on similar topics. Finally, the review offers an overview of concept/criterion mapping as a method for demonstrating relational knowledge as a measure of student achievement following explicit vocabulary instruction.

For this review the researcher conducted electronic searches of books, journals, government publications, and dissertations by accessing the following electronic databases: Questia, SCOUT from the University of Alabama online library system, Educational Resources Information Center (ERIC), Academic Search Premiere, JSTOR, and PsychInfo. Search terminology includes “graphic organizers”, “content enhancements”, “strategic instructional routines”, “vocabulary acquisition”, “vocabulary instruction”, “cognitive theories”, “cognitive load”, “language and vocabulary development”, “concept mapping”, “criterion mapping”, “concept comparison routines”, and “mathematical vocabulary instruction” matched with “learning disabilities” and “mild/moderate cognitive disabilities”. The journals include articles from the fields of special education, educational methodology, educational research, educational psychology, speech and language, reading education and instruction, and mathematical education and instruction.
Content Area Literacy

Research of instruction in secondary classroom environments demonstrates a shift in paradigm from generic literacy strategy instruction to discipline-specific strategy instruction and practices (Fang & Coatoam, 2013). This change reflects an acknowledgement that literacy instruction in the content areas should promote a development in students’ ability to engage in social, semiotic, and cognitive practices compatible with those accepted by researchers and experts in discipline specific areas. The shift also recognizes advanced literacy development work is best carried out in the context of disciplinary learning and socialization. Influenced by the seminal work of Herber (1978) related to reading instruction in content areas, current research practices are constructed on the foundation that general reading and writing strategies may be expressed in a variety of classroom contexts.

Discipline Specific Literacy

Disciplinary literacy emphasizes the specialized knowledge and abilities possessed by those who create, communicate, and use knowledge within each of the disciplines (Shanahan & Shanahan, 2012, p.7). Draper and Siebert (2010) further defined their conception of disciplinary literacy, constructing a comprehensive definition of literacy and text, encompassing “the ability to negotiate (e.g., read, view, listen, taste, smell, critique) and create (e.g., write, produce, sing, act, speak) texts in discipline-appropriate ways or in ways that other members of the discipline (e.g., mathematicians, historians, artists) would recognize as ‘correct’ or ‘viable’” (p. 30).

Research demonstrates that a general strategies approach fails to achieve what was once believed to be effective instruction due to a content area instructional resistance to ideas and practices of content literacy (Dillon, O’Brien, Sato, & Kelly, 2010; Draper, Broomhead, Jensen, Nokes, & Siebert, 2010). In addition, disciplinary instruction in science, mathematics, social sciences, and literature should develop students’ ability and their capacity to think, read, and write with
expertise; therefore generic literacy strategies inadequately meet the objective of developing such skills (Moje, 2008; Shanahan & Shanahan, 2012).

Content area literacy focuses on specific skill sets that are required for students to learn subject area material from specific texts. In contrast, disciplinary or discipline specific literacy emphasizes specific knowledge and skills needed in order to create, communicate, and use learned knowledge from a specific discipline, providing specific tools for students to engage with the text in a meaningful manner. In order for students to comprehend grade-level course text as well as engage with disciplinary content, a clear and meaningful understanding of vocabulary is necessary. Students need sufficient opportunities for practice in cross-contextual environments in order for knowledge and understanding to generalize across disciplines and contexts. In respect to vocabulary instruction in content areas, studies indicate that students organize vocabulary in a hierarchical manner, displaying relations among terms. Content area literacy and disciplinary literacy together support vocabulary acquisition in distinctive modes. Content area reading often prescribes instruction in root words and combining forms; however, what is often deficient is the method for understanding why vocabulary is constructed and organized in a specific manner that is prescribed in a disciplinary approach (O’Brien, Stewart, & Moje, 1995).

**Procedural vs. Conceptual Instruction and Levels of Understanding in Mathematics**

Consistent with deficits in reading, inadequate comprehension of foundational skills in mathematics is associated with serious, lifelong difficulties (National Mathematics Advisory Panel, 2008; Rivera-Batiz, 1992). Research signifies that the prevalence of mathematics difficulty is great, with estimates of prevalence ranging between 5% and 9% (Dirks, Spyer, van Lieshout, & de Sonneville, 2008). Despite these indications, the area of learning disabilities manifested in the area of mathematics has received less research interest than disabilities manifested in the area of reading. Deficits in the area of mathematics may be compounded by
the fact that instructional curricula are organized in strands across grade levels, representing different component skills (Fuchs, Fuchs, & Compton, 2012). Measurement studies in the area of reading provide a basis for five component reading skills: phonological awareness, decoding, fluency, vocabulary, and comprehension (Mehta, Foorman, Branum-Martin, & Taylor, 2005). Similar studies for mathematics are limited at best; however, the assumption rooted in curricula is that the same component skills exist with additional disciplinary factors. Component skills are often given instructional support in reading/language courses; yet, the same attention is not focused in the area of mathematics. Failure to provide instructional support in word awareness, vocabulary, and comprehension of word meanings across contexts increases the potential for additional challenges and increases the need for ongoing, intensive support for students in the area of mathematics.

In order to differentiate between procedural and conceptual methods of instruction, the relationship between procedures and concepts has been examined in order to better understand student tendencies in learning algorithms using memorization techniques without developing a concrete understanding of what, how, and why they are completing the problem (Hiebert, 1986). From a developmental perspective, communicating how procedures and concepts interact is critical to an understanding of development of skills (Rittle-Johnson & Siegler, 1998). Procedural understanding may be best explained as ‘knowing how’, while conceptual understanding may be defined as ‘knowing that’ (Star, 2013). While both are critical to the development of skill and knowledge acquisition in the area of mathematics, one may not function in isolation of the other. Knowledge of procedures is concrete (i.e., students either know how to complete a task or they do not) while conceptual knowledge engages abstract thinking skills (i.e., defining a relationship between two or more factors or components, which
likely includes knowledge and understanding of how to apply specific vocabulary terminology).

Lack of explicit instruction in vocabulary in the content area of mathematics may inhibit students’ ability to construct word meaning as well as the ability to apply knowledge to procedures and calculations in a relational manner.

**Instructional Routines for Teaching Vocabulary**

Knowledge of the effectiveness of strategic instruction has been instrumental in the development of instructional routines used to teach students with learning and other cognitive disabilities. Methods of vocabulary instruction, including morphological instruction and concrete-representational-abstract integration, provide a research basis for identification of the characteristics of strategic instructional routines that support vocabulary acquisition across content areas.

**Scaffolded Instruction**

Scaffolded instruction is defined as “the systematic sequencing of prompted content, materials, tasks, and teacher and peer support to optimize learning” (Dickson, Chard, & Simmons, 1993, p. 12). Scaffolded instruction is intended to provide instructional support until students can apply new skills and strategies independently at a mastery level. Gradually decreasing instructional supports provided by the teacher accompanied by a gradual increase in independence in student responsibility transfers the responsibility for learning from the teacher to the student (Rosenshine & Meister, 1992). When teachers introduce new or difficult material, students require more direct assistance; as task mastery is demonstrated, scaffolded instruction allows for support to be gradually removed. Scaffolded instruction allows for students to experience success throughout the learning process, becoming more independent learners by becoming facilitators of their own learning as support is removed at appropriate intervals (Larkin, 2001). Stone (1998) outlines scaffolding as an interactive process occurring between
teacher and student who are both active participants in the learning process. Considering the practice of scaffolded instruction in mathematics, Pratt and Savoy-Levine (1998) assessed pretest and posttest math performances on four long-division problems during instruction of fourth and fifth grade students following periods of instruction of one week and one month after receiving in a one-to-one setting either fully contingent support \((N = 8)\), moderate support \((N = 8)\), high support \((N = 8)\), partly contingent support \((N = 8)\), or no support \((N = 8)\). For research purposes, nine levels of support were identified with differing conditions in regard to the levels used. During the fully contingent support condition, all levels of support could be used in relation to the responsive nature to the student; in contrast, during the moderate support condition, only certain levels of support were used. In the no-support condition, students did not receive instructional support between pre- and posttest. The students in the experimental conditions group received tutoring sessions for long-division problems. Students receiving contingent support, primarily modeling and prompts, experienced a significant increase in success of solving long-division problems than all of the students in the other conditions both at direct and follow-up assessment. This study was one of the first to implement a checklist to document fidelity of implementation of the intervention (Pratt & Savoy-Levine, 1998). In order to assess fidelity using the checklist method, sessions were audiotaped and coded to provide documentation of the actual support provided.

**Morphological Instruction**

The term *morphology* refers to the segmentation of words into affixes, root words, and the origin of words. Understanding the connection between words and meaning by spelling is essential for vocabulary development, even at the secondary level (Harris, Schumaker, & Deshler, 2011). Current research illustrates the significance of morphological awareness to a
student’s literacy growth and development (Nagy, Carlisle, & Goodwin, 2014). This emphasis has created a research focus regarding morphological awareness for development of vocabulary by increasing understanding of morphemic structure, spelling and meaning of written words (Carlisle, McBride-Chang, Nagy & Nunes, 2010). Students with learning disabilities who receive instruction in morphological awareness learn and apply generative and non-generative vocabulary strategies to create meanings for unknown words in multiple contexts, including assignments and tests (Harris, Schumaker, & Deshler, 2011). In 2011, Harris, Schumaker, and Deshler studied the effects of instruction using a morphemic analysis strategy for analyzing and predicting the meaning of words classes with high school students with disabilities and other students enrolled in heterogeneous general education. The study employed a pretest-posttest comparison-group design in three intact classes with random assignment of two conditions: the Word Mapping Strategy (WM) or Vocabulary Strategy (VS). A third group consisting of three classrooms was selected as a test-only (TO) group for the purpose of establishing a norm for knowledge of targeted words and growth during the study. Participants included 230 public school students enrolled in ninth grade English classes in an urban Midwestern community with a high school student population of 1,687 students. Two subgroups of participants were chosen: students with disabilities (SWDs) and students without disabilities (NSWDs). The students in subgroup one (SWD) had active Individualized Educational Programs (IEP) and were receiving special education services; the students in subgroup two (NSWD) did not receive special education services or have an IEP. Data from the Stanford Achievement Test (SAT-10) including vocabulary scores and reading comprehension scores in conjunction with demographic information were collected from school records for all participating students. The study was conducted in the students' regularly assigned general education "inclusive" English classroom.
Using randomized groups, students received three types of instruction: (a) instruction in the *Word Mapping Strategy*, (b) instruction in the *LINCS Vocabulary Strategy*, or (c) traditional vocabulary instruction. Each group received instruction for ten lessons; each lesson was 45 minutes long, for a total of 450 minutes or 7.5 hours. Each lesson occurred in three phases: (a) Phase I - Orientation, (b) Phase II - Instruction of Vocabulary Word List #1, and (c) Phase III - Instruction of Vocabulary Word List #2. Data was collected by Harris, the primary investigator, who had ten years’ experience as a special education teacher using a pretest/posttest design (reading comprehension test) during the intervention phase of the study. Students were assessed in their regularly assigned inclusive general education English classes. During pretest assessment, the WM and VL groups, pretests were group administered during two class periods (90 minutes each) in which all participants were given as much time as they needed to complete the tests. The tests were administered in the following order: (a) Word Knowledge Test, (b) Morphological Analysis Test, and (c) Strategy-Use Test. For the test-only control group, only two tests were administered during a 90-minute class period: the Word Knowledge Test and the Morphological Analysis Test. The Strategy-Use Test, designed to determine whether students sufficiently learned the strategy after instruction, was not given to the TO group as these students did not receive strategy instruction. Pretest scores were compared across the three groups on the tests using analysis of variances (ANOVAs); findings revealed no statistically significant difference for any test. Intervention phase results demonstrate that students receiving instruction using the *Word Mapping Strategy* can (a) demonstrate understanding of meanings of vocabulary words using application of the strategy and (b) can predict the meaning of notably more words than students who used a different vocabulary strategy with similar recognition for increase in student knowledge of words and definitions.
When measuring the students' ability to predict the meaning of unknown words, results exposed significant differences between the posttest scores of students with disabilities in the *Word Mapping* group and those in the *LINCS* group or the traditional instruction group. Substantial differences also were revealed between students without disabilities in the *Word Mapping* group and those in the *LINCS* group or the traditional instruction group. Students who received instruction using *Word Mapping* earned an average of 61 percent of available points on the prediction test compared to an average score of 24 percent earned by *LINCS* students.

An additional study by Fishley, Konrad, Hessler, and Keesey (2012) considered the effect of morpheme knowledge and students’ ability to state correct definitions of unknown words. High school students with learning disabilities in a suburban public high school outside a large Midwestern city were chosen to participate in the investigation. The study participants included three female high school students identified with high-incidence disabilities: (a) a 15 year old African-American sophomore with a specific learning disability (SLD), full-scale intelligence quotient (IQ) of 77 who received speech/language services, (b) a 16-year-old white, non-Hispanic sophomore with a SLD, full scale IQ of 76, and (c) an 18-year-old white, non-Hispanic senior with ADHD, full scale IQ of 84, who received S/L services. Researchers investigated the effectiveness of the instructional strategy, GO FASTER (Graphic Organizers; Flashcards Added up and Self-graphed to Track progress, Errors Reviewed). In the study, students received instruction using a routine that included morphemic analysis at a predetermined rate. The study employed a multiple probe across morphemes experimental design to determine the effects of an intervention package. Participants received baseline assessment using multiple choices and matching items to assess vocabulary knowledge. Participants did not receive feedback regarding the accuracy of their responses. The intervention phases included: Phase 1 – GO with scripted
teaching procedure and (2) Sprint training (required 25 correct responses in 30 seconds for 2 consecutive sessions). Pre-and posttest assessment was utilized to demonstrate levels of generalization; 45 new words were dictated to participants, each including a morpheme targeted during intervention. Participants were requested to spell each word and then state the definition. The maintenance condition was similar to baseline conditions, and morpheme decks were integrated into this condition once they were mastered. In this phase, students were provided direct instruction utilizing graphic organizers. In the assessment phase, the primary dependent variable was the number of correctly state morpheme definitions in 30 seconds. Three decks consisting of 15 morphemes written on flashcards were used; the morpheme was written on one side and the definition was written on the other. Participants were prompted to look at the morpheme printed on the card and state the definition or say “pass”, repeating this process as many times as possible in 30 seconds. The interventionist timed and observed student probes and recorded responses as correct or incorrect on a data sheet; a response was recorded as correct if it matched the definition on the card. Data analysis for the GO FASTER investigation utilized an item-by-item evaluation to score interobserver agreement (IOA). Keesey, fourth author in the study, collected data on the dependent variable for 38 percent of the sessions for 2 students and 31 percent of the sessions for the 3rd student. The data were compared to data collected by the interventionist. Total agreements were divided by the total of agreements plus disagreements and multiplied by 100. Mean IOA was 99 percent with scores ranging from 97 to 100 percent. Generalization IOA of correctly defined untaught words for the three participants was 98 percent. Levels of IOA were similar for both pre and post-assessments. Results indicated that this intervention was an effective method for increasing participants’ morpheme definition fluency based on the participants’ ability to understand and generalize morpheme definitions and
use untaught words. Study participants maintained gains and generalized morpheme definitions enabling them to define and use untaught words. Similar to research conducted by Katz and Carlisle (2009), investigators in the GO FASTER study found that students benefit from instruction targeting morphemes. Data indicated mastering morpheme definitions increased participants’ ability to apply knowledge to unfamiliar terms and formulate accurate word definitions. Although learning common morphemes appeared to be an effective method for improving students’ abilities to define new words containing targeted morphemes, data analysis did not demonstrate significant improvement in the ability to spell words containing those morphemes; two of the three participants experienced slight improvements on the spelling measure from pre-to posttest while one participant had a decrease in score, although only by one word (Fishley, et al., 2012).

**Concrete-Representational-Abstract Sequence of Instruction**

Concrete-to-representational-to-abstract (CRA) sequence of instruction is designed to ensure students exhibit a clear understanding of math concepts and skills presented during instruction (Powell, Fuchs, & Fuchs, 2013). Students who exhibit deficits in mathematical knowledge incur a deeper and more meaningful level of understanding by first developing a concrete understanding of the concept and/or skill (Strickland & Maccini, 2013). As a process in creation of concrete understanding of information, students must first be able to use the vocabulary related to the concept and/or skill in a meaningful way with multiple opportunities for practice (Rivera, 2014). Students who receive instruction using a CRA model with explicit instructional techniques including vocabulary instruction often outperform students who receive traditional instructional methods exclusively in secondary mathematics (Witzel, Mercer, & Miller, 2003). Research indicates that strategic and explicit instruction of vocabulary
terminology is a critical indicator of success for students with learning disabilities (Berkeley, Mastropieri, & Scruggs, 2011). The current depth of research in this area is related to language arts, reading, and science, leaving a research gap in literature regarding the use of content enhancements for vocabulary instruction in the area of secondary mathematics.

**Cognitive Theories Related the Necessity of Explicit Vocabulary Instruction in Secondary Mathematics**

In order to construct and utilize developmentally appropriate content enhancements, it is imperative to consider the individualized cognitive level of students with learning and other intellectual disabilities. Students with limited cognitive capacities for content material (i.e., mathematics) may demonstrate a defined lack or absence of foundational skills necessary for the acquisition of knowledge and demonstration of understanding (Hiebert, 1986; Hiebert, 2013). Students with limited capacity to use working memory and effectively store information into schemas may demonstrate limited engagement with instruction and text, impairing their ability to use prior knowledge for abstract problem solving in the area of mathematics (Ambrus, 2014).

**Cognitive Load Theory**

Cognitive Load Theory (CLT) suggests that cognitive capacity in working memory is limited, denoting that if new information requires extensive capacity, the capacity to learn will be impaired (Sweller, 1994). Intrinsic cognitive load refers to the inherent difficulty of content and prior knowledge that is used for comprehension of new material. Intrinsic load may not be manipulated by instructional treatments. Extraneous cognitive is induced by instructional material and does not directly contribute to schema construction. According to this theory, extraneous load is imposed by instructional design and may be lessened through intervention. Students with learning disabilities may experience an increased intrinsic cognitive load in secondary mathematics due to lack of prior knowledge of word meaning. In addition, extraneous
cognitive load may be increased due to lack of explicit instruction of vocabulary that is necessary to solve abstract word problems and concepts. The components of long-term memory are sophisticated structures that allow learners to perceive, think, and solve problems rather than a group of learned facts that have been learned through rote memorization. These structures, known as schemas, are what permit individuals to treat multiple elements as a single element. They are the cognitive structures that make up the knowledge base (Sweller, 1994). “A schema is a knowledge structure that accompanies or facilitates a mental process” (Winn, 1996, p. 2.). Schemas are acquired over a lifetime of learning, and may have other schemas contained within themselves. Essentially, schemas contain the contents of one’s knowledge, and are used to organize and process information. Schema formation is assembled through the construction of generalities, and allows students to link prior knowledge to incoming information. The development of graphic organizers as content enhancements is rooted in schema theory. In effect, schema theory states that new information must be linked to preexisting knowledge. The role of the teacher is to ensure that the student activates prior knowledge related to the concept and to provide opportunities for students to make the necessary connections between new information and the student’s prior knowledge (Dye, 2000). In regard to deficits in appropriate schema construction, Swanson, Jerman, and Zheng (2008) posit that students with disabilities have paired low working memory and problem solving skills that may directly impact the effectiveness of cognitive strategy interventions. Students who exhibit smaller working memory capacity may be overwhelmed, leading to deficits in learning outcomes following instruction. This aligns with the position of Sweller (2005), indicating that instruction should be aligned with the learner’s specific cognitive architecture, with consideration of a limited capacity for working memory. Specific instructional routines that utilize graphic organizers as
instructional tools may assist the student in creating meaningful and generalized relationships between prior and acquired knowledge.

**Cognitive Engagement**

The manner by which information is processed and stored has a direct effect on problem solving ability. Students with learning disabilities may lack cognitive engagement due to deficits in prior knowledge and understanding of vocabulary necessary to solve grade-level problems. The Cognitive Engagement Model (CEM) provides an approach to instruction that capitalizes on importance of student engagement and motivation in learning (Taylor, Pearson, Peterson, & Rodriguez, 2003). CEM is grounded in research of effective reading instruction, emphasizing the need to teach for meaning (Knapp, 1995; Taylor, Pearson, Clark, & Walpole, 2000). For maximum cognitive engagement to occur, concrete understanding of terms and contextual meanings should be taught and practiced in multiple context prior to application of skills, such as mathematical questions that require a deep understanding of the linguistic patterns and processes in order to determine the appropriate process of calculation to be used. In a study by LeFevre, Fast, Skwarchuk, Smith-Chant, Bisanz, Kamawar, and Penner-Wilger (2010), 182 students 4.5 to 7.5 years of age were assessed using a model of the relations among cognitive precursors, early numeracy skill, and mathematical outcomes over a three-year collection of data. Research collected from neuroimaging, clinical populations, and normal development in children and adults was utilized for the formation of the research model (Pathways to Mathematics) using three pathways: quantitative, linguistic, and spatial attention. The pathways considered early numeracy skills during preschool and kindergarten related differentially to demonstration of knowledge on varied mathematical outcomes after a two year time period (LeFevre, et al., 2010). Standardized measures were used, based on age or grade norms as appropriate and when
available. The analysis ensured maximum comparability with similar studies and provided a control for age-related effects. Second, z scores were calculated for age groups used in correlational and regression analysis for measures that did not have norms. Third, concurrent relations between (a) cognitive precursors and early numeracy measures from the 1st year of participation and (b) performance on conventional measures 2 years later were analyzed. Data from the investigation revealed that spatial attention proved significant relations to both number naming and processing of numerical magnitude, in support of the third pathway. This finding (spatial attention is related to the development of a variety of early mathematical skills) was consistent with similar studies in which measures of nonverbal working memory were related to children’s mathematical performance in the first few years of school (Bull, Espy, & Wiebe, 2008; Holmes, Gathercole, & Dunning, 2009; Krajewski & Schneider, 2009; Simmons et al., 2008). Commonly, attention processes may have a direct effect on a child’s ability to manage the complex requirements of mathematical tasks (Geary, Hoard, Byrd-Craven, Nugent, & Numtee, 2012). Results of this research also concurred that the roles of the linguistic, quantitative, and spatial attention pathways varied depending upon mathematical outcomes. Moderate variability on six of seven mathematical tasks was uniquely attributed to the spatial attention pathway. The linguistic pathway accounted for variability in all of the mathematical outcomes; however, strength of the relation varied. As hypothesized, the relative importance of the pathways depends upon how number system and numerical quantity knowledge is used in the mathematical task. For the quantitative pathway, modest strength was found in relation with the outcomes. Indications that linguistic, quantitative, and spatial attention pathways vary in their relation to mathematical outcomes provides two notable implications: (1) The Pathways model provides insight to understanding why some children may excel at one mathematical task but not
another. (2) The Pathways model may provide a standard for determining the psychological demands of tasks that are overtly designed as measurements of mathematical skill. This study demonstrated the need for fundamental linguistic skill and understanding for mathematical competence in children. The lack of linguistic skill in cognition directly impacts generalizability of scope and sequence in mathematics knowledge and understanding across grade levels.

**Instructional Routines and Strategies in for Teaching Vocabulary in Secondary Mathematics**

Studies confirm that students with reading disabilities often experience difficulties in decoding meaning in mathematic terminology as well (van Garderen, Scheuermann, & Poch, 2014; Capraro, R. M., Capraro, M. M., & Rupley, 2012). Word problems require application of concepts related to understanding of specific mathematical vocabulary, formulas, concepts, and procedures that are imperative to skill in calculation. Without explicit instruction in specific content terminology, students with learning disabilities may lack the ability to demonstrate knowledge due to the linguistic skill related to computation (Kingsdorf & Krawec, 2014). The selection of instructional materials should be carefully considered in relation to explicit skill knowledge required for each unit in order for students to generalize and maintain skill in the scope and sequence of mathematics at the secondary level. Often regarded as a language arts or science based instructional technique, vocabulary instruction is often discounted as an instructional practice in mathematics; this may have a negative impact on students’ ability to solve abstract problems, particularly in solving word problems in the secondary curriculum.

Seminal research of vocabulary instruction demonstrates that insufficient knowledge is strongly associated with academic failure in grades three through twelve (Becker, 1977). This association remains apparent in today’s educational culture. Cross-context reading instruction that includes comprehension and fluency of words and their specific meanings is a critical way to
support vocabulary development (Nagy & Townsend, 2012). Concurrently, data from studies in this area validate those students with learning disabilities lack reading skills due to their lack of wide independent reading (Faggella-Luby & Wardwell, 2011). This deficit has been studied extensively in subjects related to reading and language arts instruction; however, the impact remains evident in mathematics as students exhibit deficit skills and meaningful understanding of words in contexts and related critical features.

Students in secondary placements (middle and high school learning environments) with reading difficulties and/or learning disabilities experience increased success with explicit vocabulary instruction (Bowers & Kirby, 2010; McKeown & Curtis, 2014). Modeling, guided support and practice, checks for understanding, and multiple opportunities for practice in using words with explicit and timely feedback are critical indicators for demonstration of skill and knowledge (Swanson & Hoskyn, 2001). Direct instruction methods that include teaching words and their contextual meanings prior to application of skill are superior to reliance on context clues without explicit instruction prior to instruction (Pany, Jenkins, & Schreck, 1982). Increased opportunities for practice combined with explicit feedback are essential components of vocabulary instruction for students with learning disabilities (Swanson & Hoskyn, 2001). This allows for validation and confirmation of knowledge and understanding, as well as provides opportunities to clear misconceptions prior to application of the word to a specific skill. Students who exhibit erroneous understanding of words and contextual meanings may confuse mathematical procedures due to lack of understanding regarding words equating specific computational processes (Fuchs, L. S., Compton, Fuchs, D., Hollenbeck, Hamlett, & Seethaler, 2011).
Use of Graphic Organizers as Instructional Tools

Ellis and Howard (2007) describe graphic organizers as “visual devices that depict information in a variety of ways. Most commonly, graphic organizers employ lines, circles, and boxes, to form images which depict four common ways information is typically organized: hierarchic, cause/effect, compare/contrast, and cyclic or linear sequences (Ellis & Howard, 2007). These “images serve as visual cues designed to facilitate communication and/or understanding of information by showing how essential information about a topic is organized” (Ellis & Howard, 2007, p.1). Studies establish the effectiveness of utilizing graphic organizers as visual methods for teaching routine and concept vocabulary terms. Graphic organizers provide visual prompts designed to facilitate communication and/or understanding of information by demonstrating how essential information concerning a topic is organized (Ellis & Howard, 2007). The use of graphic organizers as content enhancement has been identified as a “Go For It” instructional practice to use with students with learning disabilities, indicating there is “ample research that documents a solid scientific base” for improved student performance in the areas of reading, writing, thinking, and content area learning (Ellis & Howard, 2007, p. 3). Used as instructional tools, graphic organizers also employ strategic text prompts that function as semantic cues for thinking about the content in various subject areas. Historically, the use of graphic organizers has demonstrated significant gain in the development of students’ ability to demonstrate understanding and knowledge in cross-contextual subject areas and grade levels (e.g. Bowman, Carpenter, & Paone, 1998; DeWispelaere & Kossack, 1996; Gallick-Jackson, 1997; Boyle & Weishaar, 1997; Scanlon, Duran, Reyes, & Gallego, 1992; Doyle, 1999; Sinatra, Stahl-Gemake, & Berg, 1984; Gardill & Jitendra, 1999).
A meta-analysis of special education interventions designed for secondary content by Scruggs, Mastropieri, Berkeley, and Graetz (2010) establishes the positive effects of classroom instruction utilizing graphic organizers for cognitive processing of information for students with learning disabilities. According to analysis of 70 experimental or quasi-experimental studies published between 1984 and 2006 that appeared in 15 publication outlets and included 203 participants, interventions that address information processing through spatial learning increased students’ ability to complete tasks, apply information, generalize learned information into multiple contexts, and increased scores on criterion-referenced tests. Future implications for research include standardized and high-stakes tests as outcome variables for more extensive treatments (Scruggs, et al., 2010). As educators move into full implementation of CCS and CCRS, the implications of measurements of accountability and benchmark will have a direct correlation to types of interventions and applications of tasks used for instructional purposes.

Studies confirm the position that students with learning disabilities in secondary Algebra courses demonstrate increased performance levels on related skill and concept measures when using graphic organizers as opposed to traditional instruction (Ives, 2007). Ives conducted a two-study research investigation to explore the following research questions: (1) Will secondary students with learning disabilities or attention disorders who have been taught to solve systems of two linear equations in two variables with graphic organizers perform better on related skill and concept measures than students instructed on the same material without graphic organizers? (2) Will the difference in performance cited in the first research question be maintained for 2-3 weeks after instruction and immediate post-testing are completed? (3) Will the findings of the first question be replicated when graphic organizers are used to teach secondary students with learning disabilities or attention disorders to solve systems of three linear equations in three
A two-group comparison experimental design investigated the effectiveness of using graphic organizers designed for teaching secondary students with learning disabilities to solve systems of linear equations. Following the first investigation, a second study was conducted to provide a systematic replication related to the use of the same graphic organizer with different students learning a different but related skill. The purpose of the second study was to provide a systematic replication of the first study with a different population and related content utilizing the same graphic organizer. The second study differed from the first study in four ways: (1) The mathematics content of the second study used systems of three linear equations with three variables rather than two linear equations with two variables. (2) The second study utilized a small group of student participants. (3) No follow-up test for maintenance was included in the second study. (4) A teacher-generated test was not included as a part of the second study. As a result, research question two regarding maintenance after instruction with immediate post-testing was not tested for the second study. The investigation was conducted in a private school in Georgia with a population of 6th through 12th grade students who have been identified as having learning disabilities and attention disorders. Approximately 200 students attend the school. With the exception of rare cases, class sizes at the school did not exceed ten students. Strategic instructional routines utilizing graphic organizers were provided to 14 students with language-based disabilities (reading, writing, and/or general language) who were assigned to the experimental group (GO). The control group consisted of 16 students identified with the same language-based disability who received traditional (business-as-usual) instruction in the first phase of the study. During the first study, groups received a teacher-generated test of prerequisite skills related to solving systems of linear equations by using linear combinations. The prerequisite assessment analyzed the consistency in language of the instruction across the
conditions. The second study involved using the same graphic organizer with a smaller, different group of students. Analysis of variance (ANOVA) was used to compare mean scores across the two groups on each section of the first study using investigator-generated tests based on an Alpha level of .10. The results of the two studies demonstrated a consistent difference in students who worked with graphic organizers in respect to their understanding and demonstration of skill with conceptual foundations for solving systems of linear equations (Ives, 2007). In addition, the advantage in understanding was maintained over a series of weeks during the first study. Though student performance in problem solving was less consistent between the experimental and control groups in the first study, students in the GO group (study two) were more successful at solving systems of equations. These results of the two studies suggest that the use of graphic organizers as instructional tools increased conceptual understanding of mathematical content knowledge in secondary level mathematics for students with language deficits. The results are also consistent with the assumption that students with learning disabilities related to language-based deficiencies may benefit from instruction using instructional tools supported by nonverbal associations. This study supports data suggesting there is increased comorbidity between students with disabilities in mathematics (calculation) and reading disabilities and also provides evidence that may guide instructional practices in classrooms for students with learning disabilities.

**Strategic Questioning**

The use of strategic questioning in vocabulary instruction promotes engagement that is often deficit in students with learning disabilities (Ebbers & Denton, 2008). Questions and/or prompts that encourage students to use reasoning skills related to new words and their meanings provide students with increased opportunities for practice in multiple contexts. Despite explicit
instruction, students who lack active engagement in construction of knowledge have a tendency to omit critical components of the lesson in both independent practice and in peer activities (Ross & Willson, 2012). For example, Bryant, Goodwin, Bryant, and Higgins (2003) concluded that

“interventions that engage students interactively with memory devices (mnemonics) and graphic depictions (e.g., semantic maps, grids) and that are paired with direct instruction seem most promising in promoting word meaning knowledge and reading comprehension of passages” (p.127).

Strategic questions and prompts engage learners, activating their prior knowledge and allowing for students to interact with new terms in both instructional and assessment contexts (Cleary & Zimmerman, 2012; Reeve, 2012). The use of instructional routines that utilize graphic organizers with strategic prompts accompanied by scaffolded instruction demonstrates increased potential for student engagement while decreasing cognitive load for students with and without disabilities.

**Multiple Exposures to Words in a Variety of Contexts**

As evidenced by examination of critical features of mathematical procedures, formulas, and procedures, there are varying degrees of word knowledge and application. Seminal research in vocabulary instruction provides a framework of word knowledge, suggesting four degrees of word knowledge: (a) words students have never seen before, (b) words students have heard but are unsure of the meaning, (c) words students recognize and know a little bit about, and (d) words students know well and can explain to others (Dale, 1965). If students are expected to demonstrate applied skill in order to solve abstract problems, a surface level knowledge of the word will not suffice. Ongoing exposure to words in both print and in speech is critical to the development of understanding and usage cross-contextually (Blachowicz & Fisher, 2000).

Implementation of instruction routines that utilize graphic organizers allow for increased opportunities for exposure to vocabulary terms in both speech and print across multiple contexts.
**Post-Graphic Organizers in Mathematics**

Relational understanding of concepts in mathematics is vital for students to demonstrate comprehension and generalization of skills and procedures as well as to establish critical connections between topics, skills, concepts, and procedures (Star & Stylianides, 2013). What is often disregarded in student assessment of knowledge is the learner’s ability to relate the features of a word to a specific concept. In order for students to achieve mastery of concepts in secondary mathematics, students must demonstrate understanding of the meaningful relationships amid concepts. The utilization of a post-graphic organizer may assist students to create relational understanding of concepts in mathematics (Lucas & Goerss, 2007). This permits the review of concepts presented during instruction and allows for a formative assessment of students’ individualized levels of understanding following instruction. As a formative assessment, this instructional device and routine may provide benefit prior to, during, and following explicit instruction of vocabulary. In addition, post-graphic organizers may be utilized effectively to assess levels of maintenance of skill.

**Dictionary/Glossary Usage for Instruction**

Traditional or “business as usual” classroom instruction of vocabulary terms frequently includes locating the definition of a term in a dictionary or glossary. Teachers often award a grade based on the students’ ability to locate the word in print and copy a definition by transfer of information. To assess the learned knowledge, students may be asked to use the new word in a sentence. While this method may have a degree of merit in some contexts, it does not allow for meaningful relationships between concepts to transpire. In mathematics, students must be able to define the term, demonstrate a clear and concise understanding of the connection to computation or process, recognize the term when they see it (i.e., identifying what term applies
and should be used when presented in a word problem that does not specifically utilize the term),
and understand when to use the term in relation to abstract problems that require more than one
process.

The use of a dictionary or glossary involves multiple skills, including using guidewords,
decoding of word parts, and discerning the correct definition related to specific contexts. Due to
the complexity of using a dictionary or glossary as a resource for word meaning, students with
learning disabilities often do not show benefits from this as a learning strategy (Nagy & Stahl,
2000). The nature of definitions when rewritten or elaborated as opposed to taken directly from
the dictionary affects student’s ability for comprehension and application of word meaning
(McKeown, 1993). In mathematics, learners need repeated exposure to explicit and meaningful
definitions related to the context the skills are presented in as well as the critical features (i.e.,
when to utilize the skills as opposed to when the skill does not apply) consistently. The act of
defining the word using a dictionary or glossary, as an exclusive activity, does not provide
opportunity for exposure to the concept related to the word, practice using the specific word, or
significant assessment of understanding. Students may memorize the definition; however, they
may not create a meaningful and relevant association for the word, and may further have a
misconstrued understanding of when the definition is applicable to specific skills and procedures
in a mathematical context.

Explicit Inquiry Routine

The use of visual tools such as graphic organizers during scaffolded instruction that
utilize strategic prompts allows for multiple opportunities for practice in using new terminology
in multiple contexts. Scheuermann, Deshler, and Schumaker (2009) conducted a study to
consider the effects of the Explicit Inquiry Routine (EIR), a teaching intervention, on the math
performance of 14 middle-school students with identified learning disabilities using a multiple baseline across participants design. EIR integrates validated mathematical teaching practices from general education (inquiry, dialogue) and special education (intensive, explicit instruction) to engage students in an interactive inquiry process across multiple modes (concrete, representation, and abstract) of illustration and manipulation to develop an understanding of the one-variable equation. Statistical analysis and visual inspection together indicated that student scores increased and were maintained for up to 11 weeks after instruction was terminated. In addition, students transferred their skills to textbook word problems and standardized math achievement measures.

**Relational Knowledge, Criterion Mapping and Concept Comparison Routines as Measures of Student Achievement**

While explicit instruction of vocabulary may be critical for students to demonstrate applied knowledge that is required under the rigorous standards of CCS (corestandards.org, 2014) and CCRS (2ed.gov, 2014), it is only one component of addressing the significant issue. Assessment of student knowledge, specifically relational knowledge, applied to mathematics provides a clear method for addressing the effectiveness of instructional practices in the classroom environment. Relational knowledge refers to how information is stored, applied, and is from what inferences are made. A clear, concise understanding of words related to computational skills is fundamental for students to generalize skills in the scope and sequence of secondary mathematics, particularly in abstract skill acquisition. Deficits and gaps in understanding during formative instruction leads to erroneous conceptions that may cause students to experience increased cognitive load. This has potential detriments for students with learning disabilities who may be experiencing academic failure in multiple core academic classes.
Concept/Criterion Mapping

Seminal research in the area of concept mapping for purposes of learning information is attributed to the work of Ausubel, Novak, and Gowin from research conducted in the early 1970’s (Rice, Ryan, & Sampson, 1998). Ausubel postulates that there is a clear distinction between rote memorization and meaningful learning (Ausubel, 1968). Rote learning, while used in traditional instruction for the memorization of vocabulary terms, does not allow for the relation of concepts to occur, linking new ideas to relevant prior knowledge in a hierarchical concept. Concept/criterion maps involve the use of a technique to engage students in the creation of a hierarchical structure representative of a specific concept. For purposes of construction, generalized information is foundational to the map, with supplementary inclusive or abstract ideas integrated within the structure. Mapping is designed to illustrate relationships critical for deep understanding of concepts presented during instruction, providing indication of how one concept is related to another (Novak & Cañas, 2006). Used as an instructional tool, students may demonstrate a deeper level of understanding because active participation in one’s learning is required for construction of the map. Furthermore, students use prior information that has been schematically stored to create a mental and later visual image of a target concept or word. Research conducted by Gerstner and Bogner (2009), Karakuyu (2010), and Gerstner and Bogner (2010) determined that students who used concept/criterion maps during instruction outperformed students who did not use concept/criterion maps when assessed. The level of understanding is represented based on information and elaboration students include on the visual, allowing for reflection on the part of both student and teacher. The impact of a teacher’s reflective thinking about vocabulary instruction is invaluable for effective instruction; therefore, concept/criterion maps as a collaborative activity following explicit vocabulary instruction
provide teachers with a source of data to demonstrate the depth of understanding following initial instruction (Wilson, Nash, & Earl, 2010). In addition, concept/criterion mapping provides the opportunity for teachers to identify gaps and reorganize existing knowledge through observation of visual representations created by individual students or a peer group. Using a concept/criterion map format for instructional assessment also provides increased opportunities for teachers to assess relational knowledge in conjunction with specific terms used as a focus of instruction.

While not a traditional form of assessment in secondary mathematics, concept/criterion mapping has the potential for providing data regarding levels of student understanding prior to application, preventing erroneous assumptions that may be further related to concepts and mathematical procedures. Used for assessment of knowledge following instruction, a concept/criterion map includes (a) a measure of evidence of knowledge, (b) a measure of student response, and (c) a rubric that may be evaluated accurately and consistently.

**Concept Comparison Routine**

The Concept Comparison Routine (CCR) utilizes a visual devise referred to as a Concept Comparison Table (CCT) to prompt students to relate two words/concepts and provide an analysis of the characteristics that the two different words/concepts share (Bulgren, Lenz, Schumaker, Deshler, & Marquis, 2002). CCR and CCT are intended for use by teachers during classroom content instruction to enhance sets of conceptual information and the similarities and differences between or among the items in the sets. The visual devises provide strategic prompts as directions for students to include information related to the characteristics in which the two words/concepts are alike, different, and provide a summary statement of the likenesses and differences. Students who receive instruction using CCR and CCT perform better when applying
the skill as the visual representation provides a manner for students to apply knowledge in a visual format prior to application (Bulgren, et al., 2002). To validate the effectiveness of the CCR and CCT, Bulgren, et al. (2002) investigated teachers’ use and effectiveness of a comparison routine to increase students’ understanding of comparisons of important content information in secondary content classes containing students with various levels of academic abilities. Two studies were completed in the investigation, involving single-subject and large-group experimental design. A population of 107 students in grades seven, eight, ten, eleven, and twelve participated on a voluntary basis after student assent and parental consent forms were obtained. Participating teachers in the study completed random assignment of student participants to control or experimental groups. Subgroups within the control and experimental groups included the following: students who were identified as being academically high achieving (HA), students with normal achievement (NA), students with low achievement (LA), and students identified with a learning disability (LD). The following indices were used for assignment of subgroups: HA students had received no more than one grade below the A or B level in academic courses in either semester of the current school year and maintained a grade point average (GPA) of 3.5 or higher on a 4.0 scale, NA students received no more than one grade below the C level in academic courses in either semester of the current school year and maintained a GPA below 3.5, LA students received at least two grades below the C level in academic courses during at least one of the two semesters of the current school year, and students identified with LD had been identified by the school district following district and state guidelines for eligibility for special education services for learning disability. Measures of data collection included students’ knowledge of information involving comparisons, the numbers and types of comparisons teachers used, teachers’ use of the instructional routine, and teachers’ and
students’ satisfaction with the instruction. In the first study, evidence demonstrated that NA, LA, and LD students could benefit from the use of the Concept Comparison Table and Routine. A multivariate analysis revealed that students in the experimental group/LD subgroup who received instruction using the Concept Comparison Routine performed significantly better than students in the control group/LD subgroup who did not receive instruction using the Concept Comparison Routine. Results indicated that students most likely to benefit were those identified in the LA and LD student subgroups. Students in the LD subgroup within the experimental group scored significantly higher than control students with LD on both recall measures and the recognition measure. Students in the experimental group/LA subgroup scored significantly higher than control group/ LA subgroup students on both recall measures. Students in the experimental group/NA subgroup scored significantly higher than control group/NA subgroup students on recall measures requiring complete sets of characteristics and categories. Effect sizes indicated substantial differences between groups. Experimental NA, LA, and LD subgroups demonstrated a higher number of students who compiled scores in the passing range than in the respective control groups; therefore, the first study demonstrated that students in the NA, LA, and LD subgroups increased performance on measures of higher order thinking (i.e., recall of conceptually related information), suggesting performance can be enhanced through the use of a graphic device and an interactive instructional routine. The investigation provided a two-hour professional development session for teachers; evidence gained following the session demonstrated that when teachers receive appropriate professional development, they can learn to prepare graphic comparison devices and quickly construct graphic comparison devices with their students. Following professional development, all teachers except one exceeded the established mastery level on their first attempt with using the routine in classrooms. The remaining teacher
exceeded the established mastery level on her second attempt following feedback from a researcher. Satisfaction ratings of teachers indicated satisfaction with the routine and the graphic device in several identified areas. These results suggest when instructional innovations are well defined and teachers are provided professional development that includes explicit instruction and concrete examples of using the innovation, classroom implementation of routines may significantly increase retention and expression of information by students compared with students who receive instruction via traditional lecture-discussion format.

While visual representations as forms of assessment are beneficial for students to provide a manner of demonstration of acquired knowledge through a visual format, they may also provide benefit for teachers to identify areas of deficit in understanding of critical vocabulary terms and related procedures. The construction of a concept/criterion map and/or use of CCR/CCT provide a direct relation from the use of graphic organizers as a manner of information processing through a visual representation, which may provide potential for benefit for students with learning disabilities in secondary mathematics courses.

**Statistical Methodology**

Federal and state policies necessitate that interventions and classroom-based instruction provide evidence-based practices as measures of accountability in the field of education (Maggin, Briesch, & Chafouleas, 2012). Emphasis on such practices is designed to increase the effectiveness and fidelity of implementation of strategies with the most therapeutic potential (Maggin, Briesch, & Chafouleas, 2012). According to Slavin (2008), the adoption of such practices requires that scientifically valid interventions be distinguished from those with little to no empirical evidence or support. Due to the need for differentiation between methods and interventions with a research basis as opposed to those with only practical implications, study methodologies have been developed to identify evidence-based practices (Donaldson, Christie, &
Mark, 2009). A limitation of such studies that has been noted is the criteria for assessing rigor of interventions validated with single-subject research, which may be especially limiting for studies in areas such as special education with limited or small sample sizes which are often the norm (Shadish & Rindskopf, 2007).

The objective of single-subject methodology is to judiciously observe arrangements of individual behavior both in the presence and absence of selected environmental stimuli (i.e., educational interventions) (Gast, 2010). Single-subject research designs may involve only one research participant; however, it typically includes multiple participants within a single study. As research denotes, single-subject designs are widely adopted for the investigation of educational problems related to students with special needs (Shadish & Rindskoph, 2007). The use of such research designs in educational contexts, specifically in the field of special education, has led to improved understanding of how behavioral processes affect the ability of students to learn in complex environments (Kennedy, 2005).

Multiple baseline design was introduced by behavioral researchers Baer, Wolf, and Risley (1968) in their seminal article regarding applied behavior analysis (ABA). A decade later, Horner and Baer (1978) refined multiple baseline research in a concept they coined “multiple probe technique.” Both designs utilize the same baseline logic for the evaluation of threats to internal validity and demonstration of experimental control (Gast & Ledford, 2014). Multiple baseline designs require a plan for the continuous measurement of all targets prior to the introduction of the independent variable. This establishes that multiple baseline designs are well-suited for educational purposes for applied research because the designs have program efficacy measures, no withdrawal of intervention requirements, and are easy to conceptualize and implement (Gast & Ledford, 2014).
Multiple baseline design requires variables to have specific features in order to ensure the operational effectiveness desired of a research study. Dependent variables must be operationally defined to allow for valid and consistent assessment of the variable within replication of the assessment process (Horner, Carr, Halle, McGee, Odom, and Wolery, 2005). Dependent variables must also be measured consistently within and across the controlled conditions of the study to allow for identification of performance patterns during the baseline and comparison of performance patterns following intervention (Horner, et al., 2005). Independent variable (i.e., the practice or intervention) is the investigative mechanism of the study that allows for interpretation of results during replication (Horner, et al., 2005). Multiple baseline design allows for the comparison of effects of an intervention with performance with baseline evidence or while baseline conditions exist. Following the establishment of baseline conditions, this research design will allow observers to contrast the patterns of performance under conditions of specified interventions.

**Summary**

This review of research concludes that students with learning and other cognitive disabilities may directly benefit from specific instructional routines including graphic organizers, and assessment through concept/criterion maps as means of demonstrating knowledge and understanding of vocabulary terms in secondary mathematics. This review also demonstrates that explicit instruction of vocabulary using specially designed graphic organizers in conjunction with an instructional routine in secondary mathematics, providing students opportunities to master new terminology through the use of vocabulary in multiple contexts, may reduce both intrinsic and extraneous cognitive load that prevents information from being learned and stored effectively. Use of specific instructional routines that utilize graphic organizers in multiple contexts may increase cognitive engagement and decrease cognitive load for students who
exhibit limited working memory. Existing research promotes the effectiveness of explicit instruction in vocabulary for students with learning disabilities and other cognitive disabilities in specific content areas such as language arts and science; however, a need for research related to vocabulary instruction using an explicit instructional routine in secondary mathematics courses exists. Students who do not possess a clear and concise understanding of vocabulary related to mathematical concepts and procedures may experience difficulty with abstract problems, including word problems. An inability to understand what the question is asking provides an indication that the student will not know what process of calculation to employ to solve the problem. Students may demonstrate a limited ability to utilize procedural instructional constructs; however, demonstrating knowledge through a conceptual basis without explicit instruction and focus on foundational skills has the ability to create further negative impact on mathematics learning. Research indicates a comorbidity of learning disabilities in reading and mathematics; yet there is little data to demonstrate the effectiveness of strategic instructional routines for teaching vocabulary using graphic organizers in secondary mathematics. With the inception of CCS and CCRS, solid foundational, conceptual, and procedural skills are needed for application in solving abstract problems in a variety of methods. Explicit instruction coupled with multiple opportunities to practice use of specific vocabulary cross-contextually may improve application, generalization, and of foundational skills required for success for students with learning disabilities in secondary mathematics courses.
CHAPTER III: RESEARCH METHODS AND PROCEDURES

The first purpose of this study is to examine the effect of explicit instruction of vocabulary using graphic organizers specially designed for teaching mathematical vocabulary on student knowledge related to a specific Algebraic concept (measures of central tendency) for students with identified learning disabilities in the inclusive secondary classroom environment. The second purpose of this study is to examine if explicit instruction vocabulary using graphic organizers specially designed for teaching vocabulary in mathematics coupled with explicit instruction using EIR versus traditional or “business-as-usual: classroom instruction will produce differences in levels of student understanding student based on measurements of performance on abstract math problem solving processes (i.e., word problems related to the concept of measures of central tendency).

Research Questions

The following research questions are addressed in this study:

1. Is there a difference in student knowledge of measures of central tendency following instructional intervention that includes the use of a specialized graphic organizer for teaching mathematical vocabulary terminology in addition to explicit verbal instruction that incorporates exposure to terms in multiple contexts using the Explicit Inquiry Routine related to measures of central tendency?

2. Is there a difference in student ability to demonstrate understanding by solving word problems that require the utilization of computation related to measures of central tendency following instructional intervention that includes the use of a graphic
organizer specially designed for teaching mathematical vocabulary in addition to explicit
verbal instruction that incorporates exposure to terms in multiple contexts using the
Explicit Inquiry Routine (EIR) related to measures of central tendency?

Research Design and Procedures

For the purposes of this research study, a single subject multiple baseline design across
participants design was utilized. This design involves the introduction of an intervention related
to specific target skills at distinctive points in time (Kazdin, 2011). According to Kratcohill,
Hitchcock, Horner, Levin, and Odom (2010), valid causal inferences may be assumed due to
strategic sequential implementation across phases of the intervention. Furthermore, Kazdin
(2011) identified that multiple baseline design allows for stronger inferences to be constructed
related to the participant when baselines achieve stability in each phase of the study.

This study utilized three research participants for collection of data related to math
instruction of selected terms related to the concept of measures of central tendency. Terms
selected for the study included (a) mean, (b) median, (c) mode, and (d) range, as identified under
the concept of measures of central tendency in the Algebra I textbook Algebra I Common Core,
12th edition, published by Prentice Hall. Participants were between the ages of 14 and 16 and
enrolled in Basic Algebra in a metropolitan area in West Alabama. Study participants received
special education services with an identified exceptionality of specific learning disability.
Participants receive specialized instruction and accommodations following the guidelines of the
Individuals with Disabilities Act (IDEA) as prescribed in their Individualized Education Program
(IEP). The participants’ identified area of deficit was in mathematics, as measured by
psychoeducational testing that included both an intelligence battery and academic achievement
battery. In order for the participants in the study to receive special education services in the State
of Alabama under Alabama Administrative Code, a 16-point discrepancy between their predicted
achievement and intellectual scores was documented. Prior to initial baseline data collection, a formative assessment was administered to ensure that student participants would benefit from the instructional interventions and routines in the research protocol. The formative assessment prompted participants to indicate their level of familiarity with each term using a specially designed graphic organizer that allows for elaboration of knowledge of each term. According to results from the formative assessment, all participants were suitable for inclusion in the study. Following completion of the pre-assessment, each participant received “business-as-usual” instruction. No intervention or instructional routine was introduced during baseline instruction. Students received exposure to information from a textbook and were presented with instruction that included procedural application for solving problems related to each term. Study participants received instruction that included (a) traditional or “business-as-usual” instruction with no intervention and (b) instruction that utilized specialized graphic organizers designed for teaching mathematics vocabulary terms related to Algebraic concepts and explicit verbal instruction utilizing exposure to words in multiple contexts using the EIR (Scheuermann, Deshler, and Schumaker, 2009) related to selected mathematical vocabulary. Traditional instruction included a reference to and review of terms with no explicit instructional practice related to vocabulary prior to computational application and problem solving exercises.

During the intervention phase, each participant was assessed for three target skills related to the selected vocabulary terms used in the study: (1) ability to correctly define each term by stating, writing, or identifying each term (mean, median, mode, and range) and the corresponding correct definition on a specialized graphic organizer designed for teaching vocabulary, (2) ability to apply knowledge of vocabulary terminology by identifying, creating, or stating relevant mathematical situations that utilize calculation of measures of central tendency, and (3) ability to
apply understanding of vocabulary by solving word problems that include scenarios related to measures of central tendency. Preconditions for baseline were established prior to intervention. These conditions included the following: (a) the student had prior knowledge of the concept and terms (i.e., the student had encountered the words in a prior lesson or has visual familiarity with each term) and (b) the student demonstrated the ability to solve problems that involve addition, subtraction, multiplication, and division singularly and in conjunction with one another.

In this study, explicit instruction of vocabulary prior to procedural instruction and application of problem solving skills was hypothesized to positively affect students’ ability to solve word problems that require calculation of measures of central tendency (mean, median, mode, and range). It was further hypothesized that following intervention baseline and during of the intervention, study participants would sustain increased levels of performance in solving word problems that require calculation of measures of central tendency. This study utilized a single subject multiple baseline across participants design to determine if intervention that includes specialized math graphic organizers in addition to explicit direct instruction of vocabulary terms using the specified instructional routines are more successful than traditional instructional practices or “business-as-usual” as instructional practices to solve problems that require knowledge, understanding and application in solving word problems related to measures of central tendency.

**Dependent Variables**

For the purposes of this research study, student knowledge of vocabulary was assessed utilizing a graphic organizer specially designed for teaching vocabulary in mathematics. Acknowledged in Chapter I, research demonstrates that insufficient vocabulary knowledge is strongly associated with academic failure in grades three through twelve (Becker, 1977). The role of the teacher is to ensure that the student activates prior knowledge related to the concept
and to provide opportunities for students to make the necessary connections between new
information and the student’s prior knowledge (Dye, 2000). The first dependent variable in this
research study was the measure of increase in knowledge related to content vocabulary following
intervention of utilizing a graphic organizer specially designed for mathematics vocabulary in
conjunction with instruction that included the Explicit Inquiry Routine (Scheuermann, Deshler,
and Schumaker, 2009). The target terms are related to the concept of measures of central
tendency, an Algebraic concept. The second dependent variable in this research study was
student achievement scores on a teacher made test collection of data related to trials to mastery
of a specific, teacher-made word problem. Students demonstrated their individualized level of
understanding of computational procedures by solving abstract word problems related to selected
terminology (mean, median, mode, and range).

**Independent Variables**

As stated in Chapters I and II, research confirms that explicit instruction in vocabulary
increases student knowledge and understanding of content material. There is a demonstrated
lack of research related to vocabulary instruction in the area of mathematics; thus, this research
study investigated the effectiveness of vocabulary instruction that utilized a graphic organizer
specially designed for teaching vocabulary in mathematics and the use of multiple opportunities
for exposure to terms across contexts using EIR. The first independent variable in this study was
the intervention of instruction that includes use of specially designed graphic organizers and
instructional routines in contrast with traditional instruction that does not include the use of a
graphic organizer or instructional routine. The second independent variable in this study was
trials to mastery, which demonstrated the amount of time required for students to produce
knowledge and/or understanding of selected Algebraic vocabulary terms related to measures of
central tendency.
Setting

Participants in the investigation were students in a large, suburban high school in metropolitan Alabama who are currently enrolled in Basic Algebra. The total student population is approximately 1350 students enrolled in grades 9-12. Sixty-one percent of the student population is black, 31% is white, three percent is Asian, and two percent Hispanic (approximations based on 2013-2014 reported data). Forty-seven percent of the students at this high school receive federal free lunch subsidies, in comparison with a state average of 55%. The school district has a total student population of approximately 10,200 students in grades Kindergarten through 12th grade. The district is comprised of 24 schools, including 13 elementary schools, six middle schools, three high schools and two campuses which provide specialized educational programs: one for students with special needs and those receiving alternative education, and a career technical facility for grades nine through twelve. Based on former Alabama High School Graduation Exam scores, a test formerly used to determine skills required for graduation in the state of Alabama, 62% of students in the eleventh grade passed the mathematics portion of the test. With the inception of Common Core/College and Career Ready standards, this test was replaced with the standardized ACT End-of-Course assessment that is given to students at the conclusion of Algebra IB or Algebra I. Assessment of mathematical abilities is also currently assessed during the 11th grade year utilizing the ACT + Writing, a standardized college entrance exam.

Instruction during baseline and intervention procedures occurred in both the inclusive general education environment during the participant’s Basic Algebra course as well as a resource room during Math Review, a course designed for students who receive special education services where remedial and targeted deficit instruction is provided as a provision of services provided in the student’s IEP. In accordance with procedural safeguards specified by
the Institutional Review Board (IRB), it should be noted that students were not adversely affected by the instructional procedures and interventions of the study, as the service delivery was typical of their normal method of instructional delivery.

**Participants**

Three participants were selected from a random drawing for inclusion in the study (i.e., all potential participants were assigned a number, and numbers were placed in a container with three selections being drawn). The following characteristics were required for inclusion in the research study: (a) current mathematical course placement (Basic Algebra), (b) identified eligibility for special education services under the eligibility of Specific Learning Disabilities (SLD), with primary area of deficit identified in mathematics as demonstrated by psychoeducational assessments of intelligence and academic achievement, (c) enrolled in Basic Algebra during the 2014-2015 school year, (d) between the ages of 14 and 16 years old. To ensure anonymity, all students were assigned a pseudonym corresponding to their participation number (e.g., Alana, participant one in the study). Following selection of participants, the three students selected to participate completed a self-rating scale as a formative assessment of their level of knowledge of the selected vocabulary terms. If a participant demonstrated mastery on the self-rating scale, which required participants define each term correctly, they would have been removed from the study and replaced with a participant who demonstrated deficits in knowledge as measured by the self-rating scale. The three participants who were selected as participants from the initial drawing demonstrated less than 30% mastery of knowledge; therefore, they met the required deficit level of knowledge (less than 50%) for inclusion in the study.

Following dissemination of information related to the purpose of the study and a parent/participant informational meeting, parent consent and student assent forms were
completed and retained. Student attendance during the research study was required to ensure the instructional methods are utilized with fidelity. An attendance policy for the study stated that after two absences, students would be removed from participation in the study.

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Gender</th>
<th>Race/Ethnicity</th>
<th>Years Receiving Special Education Services</th>
<th>Primary Area of Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alana</td>
<td>14</td>
<td>Female</td>
<td>African American</td>
<td>7</td>
<td>Mathematics/Reading</td>
</tr>
<tr>
<td>Ben</td>
<td>15</td>
<td>Male</td>
<td>Caucasian</td>
<td>4.5</td>
<td>Mathematics</td>
</tr>
<tr>
<td>Cordell</td>
<td>15</td>
<td>Male</td>
<td>African American</td>
<td>7.5</td>
<td>Mathematics</td>
</tr>
</tbody>
</table>

Table 1: Student Participant Demographics

Participant one, “Alana”, is a 14 year-old ninth grader who has an identification of specific learning disability and is eligible for special education services under Alabama Administrative Code. Alana was referred by her teacher for an evaluation for special services in the second grade. Since this time, Alana has received specialized instruction and accommodations through her IEP. According to her latest psychoeducational battery of tests, Alana has a verbal intelligence quotient (IQ) of 103 and a nonverbal IQ of 107, which falls in the average range of 90-110. This was measured using the Reynolds Intellectual Assessment Scale (RIAS) in 2013. Her achievement score was measured using the Kaufman Test of Educational Achievement, Second Edition (KTEA-2). On this assessment, Alana had a reading composite of 82 and a math composite of 78. She demonstrated deficits in math concepts and applications as well as math computation. Alana does not exhibit any behaviors that impede her learning or the
learning of others in the classroom, and did not exhibit any behaviors that are of significance of are in the at-risk category on the Behavior Assessment System for Children, Second Edition (BASC-2). In terms of eligibility for special services, Alana’s composite IQ was a 105, with her predicted achievement being 106. Her obtained achievement score was an 80; therefore, Alana’s scores demonstrate a discrepancy of her ability to achieve and her current level of achievement in the classroom environment. Alana’s grade for the first nine weeks in Basic Algebra was an 80, with her grade for the second nine weeks being a 78. The teacher reports that Alana is eager to learn, completes all assignments, and asks questions in class. She consistently displays erroneous calculations when working without the use of a calculator or other technology, and has a difficult time applying formulas correctly and consistently. Alana reported that she feels good about the progress that she has made this year; however, she worries about taking Algebra II as a senior. She also stated that she has a difficult time doing math “in her head” and often forgets the order that procedures follow. Alana’s daily schedule reflected that she received mathematics instruction in Basic Algebra during 2nd period while receiving instruction in Math Review during 6th period.

Participant two, “Ben”, is a 15 year-old ninth grader who has an identification of specific learning disability and is eligible for special education services under Alabama Administrative Code. Ben was referred by his parents for an evaluation for special services at the end of his fourth grade year. Ben has received specialized instruction and accommodations through his IEP since the beginning of his fifth grade year. According to his latest psychoeducational battery of tests, Ben has a verbal intelligence quotient (IQ) of 100 and a nonverbal IQ of 102, which falls in the average range of 90-110. This was measured using the Reynolds Intellectual Assessment Scale (RIAS) in 2014. His achievement score was measured using the Kaufman Test of
Educational Achievement, Second Edition (KTEA-2). The KTEA-2 revealed that Ben had a reading composite of 80 and a math composite of 74. Ben demonstrated deficits in math concepts and applications as well as math computation. Ben has no history of exhibiting behaviors that impede his learning or the learning of others in the classroom, and did not exhibit any behaviors that are of significance of are in the at-risk category on the Behavior Assessment System for Children, Second Edition (BASC-2). In terms of eligibility for special services, Ben’s composite IQ was a 101, with his predicted achievement being 102. His obtained achievement score was a 77; therefore, Ben’s scores demonstrate a discrepancy of his ability to achieve and his current level of achievement in the classroom environment. Ben’s grade for the first nine weeks in Basic Algebra was an 86, with his grade for the second nine weeks being an 82. The teacher reports that Ben is compliant in the classroom, completes all assignments, and prefers not to ask or answer questions in front of his peers. Ben receives private tutoring in the home to address deficits and assist with homework. Ben has difficulty with abstract concepts, specifically with solving word problems that require multiple steps to solve. He reported that he is doing fine in class, but he has a difficult time remembering “all of the steps to solving stuff.” Ben also stated that he does not “really see the point in learning Algebra when I probably won’t use it.” Ben’s daily schedule reflected that he received mathematics instruction in Basic Algebra during 1st period while receiving instruction in Math Review during 7th period.

Participant three, “Cordell”, is a fifteen year-old ninth grader who has an identification of specific learning disability and is eligible for special education services under Alabama Administrative Code. Cordell was referred by his teacher for an evaluation for special services at the end of his second grade year. Cordell began receiving special education services in the third grade following evaluation for services. According to Cordell’s latest psychoeducational
battery of tests, he has a verbal intelligence quotient (IQ) of 100 and a nonverbal IQ of 104, which falls in the average range of 90-110. This was measured using the Reynolds Intellectual Assessment Scale (RIAS) in 2014. His achievement score measured on the Kaufman Test of Educational Achievement, Second Edition (KTEA-2) exhibited a reading composite of 80 and a math composite of 76, with deficits in math concepts and applications as well as math computation. Cordell does not exhibit behaviors that impede her learning or the learning of others in the classroom, and does not exhibit any behaviors that are of significance of are in the at-risk category on the Behavior Assessment System for Children, Second Edition (BASC-2). In terms of eligibility for special services, Cordell’s composite IQ was a 102, with his predicted achievement being 103. His obtained achievement score was a 78; therefore, Cordell’s scores demonstrate a discrepancy of his ability to achieve and his current level of achievement in the classroom environment. Cordell’s grade for the first nine weeks in Basic Algebra was an 85, with his grade for the second nine weeks being an 81. The teacher reports that Cordell is pleasant in the classroom, works well with peers during learning stations and small groups, completes both in-class and homework assignments, and seeks assistance from the special education teacher when he has questions or concerns. Cordell has a difficult time applying formulas and procedures and solving multi-step equations. Cordell reported that tries hard and is happy that he is making B’s in Algebra, but he is concerned about taking Geometry because he does not like word problems. Cordell also stated that he would rather work “normal” math problems (i.e., procedural concepts) rather than word problems that require him to “read and then decide what to do on my own.” Cordell’s daily schedule reflected that he received mathematics instruction in Basic Algebra during 3rd period while receiving instruction in Math Review during 5th period.
For the purpose of establishing reliability and fidelity of the study, two special education teachers were invited to participate as raters of student work samples. The teachers are highly qualified in the field of Special Education by the State of Alabama and have experience as collaborative co-teachers in the Basic Algebra inclusive general education classroom. In addition, both teachers have experience providing individualized instruction to students using graphic organizers and are familiar with the production of student responses related to the Algebraic concept of measures of central tendency. Prior to involvement in the study, the investigator provided explicit information regarding the research protocol and responsibilities involved with participating in a research study. The participating teachers signed consent statements and were informed that all data would be used for the purposes of a research study and anonymity applied to all participants, including names of participating students and teachers as well as the location of the school and district. The teachers were provided with three 30 minute training sessions that provided instruction in using the prescribed rubric to assess levels of knowledge on the graphic organizers used as criterion maps in the study. Teachers were also given explicit training on the use of the instructional fidelity checklist used to rate the instruction provided to students by the investigator. Multiple opportunities for questions were provided during and following the training sessions.
Name | Gender | Title                     | Age | Location     | Years of Experience |
-----|--------|---------------------------|-----|--------------|--------------------|
Shannon | Female | Collaborative Special Education | 47  | High School  | 8                  |
John    | Male   | Collaborative Special Education | 27  | High School  | 5                  |

*Note:* For both raters, the highest degree earned was a bachelor’s degree

**Table 2: Rater Demographics**

**Informed Consent Procedures**

Informed consent from participants in the study was gained through written permission by student assent and parental permission and consent to participate. Information regarding and informational meeting was distributed to students in selected Basic Algebra who met the inclusion criteria for the study. Informed consent and assent forms were provided to students who met the criteria for inclusion and interested participants were encouraged to attend the informational session. The study investigator conducted a telephone contact with all interested participants to check for understanding and ensure consent from parent/guardian. Following the informational session, pseudonyms and corresponding numbers were assigned to interested parties and entered into a random drawing to determine selection of the three participants. Special education teachers serving in the role of raters of student work samples for the purpose of reliability and fidelity of intervention during the study completed informed consent in written form and return to the primary researcher. Permission to collect data for purposes of a research study was obtained in written form from the district Superintendent prior to collection. All assent and consent documents were collected and stored in a locked filing cabinet by the study
investigator. The study investigator released no information that included any identifying information (i.e. names of participating students, teachers, or parents, specific class periods, or location of school or district. All information gathered was for the sole purpose of a research study and was treated as confidential information at all times during and following completion of the study.

**Description of Methods to Maintain the Security of Data**

Student participants in the study were assigned pseudonyms for purposes of identification. All data collected was recorded and retained utilizing the pseudonym and number rather than by student name. The study investigator removed all identifying information (student name) from work samples. The coding system for student work samples was formulated to indicate the student’s gender and specific visual tool utilized for instructional purposes. The research study investigator provided instruction during initial baseline and intervention and phases. Two highly qualified special education teachers participated in the rating of student production of work samples to ensure validity, fidelity, and reliability of the study. Raters received no information indicative of identifying information related to the participants in the study. All assent/consent letters, student work samples, and collected data were kept and stored by the principle investigator in a locked file cabinet. Results and findings from the study were reported in a manner that did not permit identification of the individual participant(s).

**Validity of Specially Designed Graphic Organizers**

In order to validate the professional use of the specialized graphic organizers used for mathematical vocabulary instruction for the purposes of this research study, a team of highly qualified educators and specialists in the area of secondary mathematics in the school district where the study was conducted convened for discussion. The team was briefed on the research protocol and intended usage of explicit instruction and use of specialized graphic organizers
through the use of a document that included the (a) intervention name, (b) brief description of the study, (c) overview of the problem statement the intervention is designed to address, (d) overview of the intervention procedures, (e) overview of the critical components of the intervention, (f) materials needed for implementation of intervention, and (g) overview of training for implementation of the routines and graphic organizers used for the research study.

**Fidelity**

Treatment fidelity in a research study refers to the methodological strategies used to monitor and enhance the reliability and validity of behavioral interventions (Bellg, A. J., Borrelli, B., Resnick, B., Hecht, J., Minicucci, D. S., Ory, M., Ogedegbe, G., Orwig, D., Ernst, D., & Czajkowski, S., 2004). The assessment of fidelity of intervention allows for enhanced confidence of results. Treatment fidelity may also be assessed for a goal of improving study design for future research (Kazdin, 1994). Fidelity processes that monitor and improve delivery of the intervention are essential components of effective research protocols (Bellg, et al., 2004). In order to effectively measure the fidelity of a research study, participants responsible for delivery of intervention components must receive adequate and effective training. Furthermore, reflection post-instruction may provide a sense of completion of necessary components for effective delivery (Bellg, et al., 2004). Conceptually and pragmatically, enactment is one of the most challenging aspects of treatment fidelity. Enactment of treatment skills consists of processes to monitor and improve the ability of students to perform skills gained through instruction in relevant environments, of the degree to which the skill may be adopted into an appropriate setting. In order to measure the effectiveness of a study, the researcher must be able to measure not only the degree to which the instruction was effective, but also the degree of which the new skill is performed appropriately in generalized contexts or environments. For the purpose of this study, a team of highly qualified teachers in the area of secondary mathematics in
the State of Alabama reviewed the instructional and behavioral routines and prompts. The instructional practice and specialized graphic organizers used for teaching selected mathematics vocabulary terms related to measures of central tendency were reviewed and approved as valid instruments. To further ensure fidelity of implementation, an inter-rater checklist was utilized. Inter-rater fidelity was established when the checklist demonstrated that the steps of the intervention, as implemented by the principal investigator, was at or greater than 80%. This was derived by dividing the number of observed indicators by the total number of indicators recorded on the checklist. To ensure implementation of instruction activities to fidelity, instruction was assessed for 25% of all instructional sessions (Appendix C). A 56-item fidelity checklist was completed by one of the two trained raters to determine if all steps of the processes involved in instruction were followed correctly.

Inter-rater Observation and Reliability

Inter-observer reliability signifies a predetermined and acceptable level of agreement between multiple raters who utilize a specific instrument while conducting analysis on a target group of participants (Kazdin, 2011). For the purpose of establishing the validity and reliability of this study, two special education teachers assisted the primary researcher in rating student work samples. The teachers are highly qualified in the field of Special Education by the State of Alabama and have experience as co-teachers in the Basic Algebra inclusive classroom. In addition, both teachers have experience providing instruction to students using graphic organizers and are familiar with the production of student responses related to the Algebraic concept of measures of central tendency. Teachers serving as raters of student work samples received three training sessions for a minimum of 30 minutes in order to provide instruction in the completion and production of student work samples on the identified specially designed graphic organizers being utilized as an instructional intervention for this study. In order to
establish inter-rater reliability, this study employed a point-by-point agreement method that allows for the comparison of rater results as establishment of inter-observer reliability (Kazdin, 2011). Agreement was reached when raters agreed upon the level of mastery (demonstration of knowledge and/or understanding) following the prescribed level of instruction and/or intervention at each stage of the study for each research participant. Potential disagreements were calculated when one rater identified a component as evident on the graphic organizer while another did not find the same component to exist or found it incomplete. Ratios were calculated by first finding the sum of agreements between observers. Second, the sum of the agreements was be divided by the sum of agreements and disagreements. Finally, quotients were multiplied by 100, which provided a conversion of the value to a percentage of agreement. For this research study, an acceptable allowed measure of error for observer agreement was 20%, accordingly setting inter-observer reliability at 80%.

**Scoring of Student Criterion Maps**

The rubric designed to assess student indices of knowledge was based on use of a criterion map. For this study, the specially designed graphic organizer, serving the purpose of a criterion map, was purposefully designed by the principal researcher and determined valid by a committee of specialist in the area of secondary mathematics to evaluate specific knowledge gained following instruction using an instructional routine that utilized specially designed graphic organizers. In addition, the principal researcher in conjunction with general education and special education teachers who collaboratively co-teach in an Basic Algebra classroom determined the specific concept (measures of central tendency) and related terminology to be evaluated. Prior to instruction, the principal researcher and two highly qualified mathematics teachers constructed specially designed graphic organizers for teaching vocabulary with discipline specific prompts to be used in alignment of instruction of specific terms related to
measures of central tendency, to include the terms of mean, median, mode, and range. Following
collection of the graphic organizers used for instruction, the instructional routine was discussed
in relation to the amount of elaboration that would be used during instruction, specifically in
relation to the depth of student understanding required to complete the graphic organizers, and
ultimately the concept map used for assessment.

The criterion maps employed for assessment of student knowledge of terminology were
scored using a rubric adapted from Ruiz-Primo, Schultz, Li, and Shavelson (2001) (Appendix B).
Each term received a proposition score. For purposes of grading, the raters utilized the following
system: (a) The participant received zero points awarded if no valid proposition existed for the
terms according to the criterion map. (b) The participant was awarded one point if the
proposition was valid and appeared on the criterion map but was factually inaccurate or
incomplete. (c) The participant received two points if the term appeared on the criterion map and
the information related to the prompt was factual and complete; however, the student
demonstrated deficits in elaboration on the concept, including summaries of concepts,
predictions, and examples/non-examples of when the term applied. (e) The participant received
three points if the term was present with factual and complete relationships as well as a
demonstrated and complete understanding of elaborated concepts, as measured by student
written response to the prompt(s) provided on the criterion map.
CHAPTER IV: RESEARCH FINDINGS

The purpose of this study was to examine if explicit vocabulary instruction in secondary mathematics using graphic organizers specially designed for mathematics vocabulary instruction in conjunction with an instructional routine (EIR) effects increased student achievement in demonstrating knowledge and understanding of Algebraic concepts. A total of three students participated in the research study. The study utilized a single subject multiple baseline across participants design to test the hypothesis in a functional nature. Each participant received the same methods and quality of instruction in both baseline and intervention phases. Baseline included traditional or “business-as-usual” instruction that included reference to the selected terminology but did not utilize graphic organizers for teaching vocabulary or explicit verbal instruction of selected terms using an instructional routine. The intervention phase consisted of the use of graphic organizers that were specially designed for teaching mathematics vocabulary that included specific visual prompts, allowing students to demonstrate their scope of knowledge following instruction that included explicit verbal instruction utilizing EIR as an instructional routine. The implementation of EIR allowed for (a) increased dialogue between the participants and investigator, (b) facilitated inquiry (e.g., students posed questions related to the selected terms and provided answers to their questions on the graphic organizers), (c) intensive support from the investigator utilizing direct modeling and explicit verbal prompts and explanations, and (d) multiple modes of representation across contexts.

Research participants attended two sessions daily during the study. The first session was during the participants’ routinely scheduled Basic Algebra class, which consists of 47 minutes of
instruction daily. During this time, students were engaged with peers in traditional instruction that did not include the use of intervention or specific instructional routines for a period of 20 minutes. During classroom instruction, participants were exposed to standardized text materials with no explicit references made to vocabulary terms related to the specific concepts being studied (measures of central tendency). Students were instructed in a group situation with peers, and although opportunities for question/answer sessions were presented, limited formative assessment of student understanding was demonstrated. For the remaining 27 minutes, study participants received one-on-one instruction with the investigator. Participants received individualized instruction as a normally method of instructional delivery; therefore, normal protocol was followed and students were not subjected to methods that might cause undue anxiety or embarrassment. One-on-one instruction was provided in a vacant classroom near the Basic Algebra classroom. The investigator encouraged dialogue with the participants in order to establish a level of rapport with the participant. Materials used for the study were placed in the vacant classroom prior to instruction in order to be efficient with time. Instruction included explicit reference to vocabulary related to the concept (measures of central tendency), and opportunities for student inquiry through scaffolded instructional procedures and strategic questioning were present.

The second daily session occurred during the students’ routinely scheduled Math Review class period. This course is offered to students who receive special education services as a means of providing individualized services to address specific deficits in the area of mathematics. Each session during Math Review consisted of 47 minutes of one-on-one instruction with the investigator. Special education teachers participating as raters were routinely in the room to conduct fidelity checklist observations; however, they did not interact
with or provide instructional services for the student during the study. Again, rapport was easily established. The sessions took place in a vacant classroom as opposed to the Math Review classroom in order to provide an environment conducive to one-on-one instruction and assessment. During the study, no absences were recorded; therefore, the attendance policy for replacement in the study following two absences was null.

**Fidelity**

Implementation of instructional interventions and routines to fidelity is critical; however, the intended use or protocol for content enhancements is deviated by teacher preference or bias. Fidelity of implementation is defined as how well an intervention is implemented in comparison with original program design when reviewed (O’Donnell, 2008). According to Rogers (2003), until the 1970s, studies regarding fidelity of implementation were rare as researchers assumed that fidelity of implementation would be high as teachers followed protocols of commercial instructional programs. Federal mandates such as the 2001 No Child Left Behind Act required that teachers use research-based methods and that adopted programs have statistical evidence of effectiveness (Slavin, 2003). In order to evaluate the instruction that included intervention of specially designed graphic organizers and implementation of EIR, participating teachers completed the instructional procedures checklist (Appendix C) for 50% of instructional sessions for each student participant. Fidelity of implementation of intervention and instructional routine used for the purpose of this study was calculated by dividing the total number of observed procedures by the total number of expected procedures and multiplying by 100%. The percentage measured by calculation based on rater observation of instruction as documented on the checklist was: Alana, 94.8% (range, 91%-98%); Ben, 93.8% (range, 91%-96%); and Cordell, 94.2 (range, 91%-98%).
**Inter-Rater Observation and Reliability**

Assessment of inter-rater reliability (IRR) is a necessary component of research designs in protocols that call for raters (trained or untrained) to provide ratings of collected data (Hallgren, 2012). IRR demonstrates a means for consistency of rating when data are evaluated by multiple raters, allowing for objectivity in scoring. For purposes of this research study, an acceptable allowed measure of error for observer agreement was 20%, accordingly setting inter-observer reliability at 80%. For establishment of inter-rater reliability, this study employed a point-by-point agreement method that allows for the comparison of rater evaluations as establishment of inter-observer reliability (Kazdin, 2011). Agreement was reached when raters agreed upon the level of mastery (demonstration of knowledge and/or understanding) following the prescribed level of instruction and/or intervention at each stage of the study for each research participant. Potential disagreements were calculated when one rater identified a component as evident on the graphic organizer while another did not find the same component to exist or found it incomplete. Ratios were calculated by first finding the sum of agreements between observers. Second, the sum of the agreements was divided by the sum of agreements and disagreements. For purposes of calculation and determination of percentage of IRR established, quotients were multiplied by 100, which provided a conversion of the value to a percentage of agreement. IRR was calculated for 50% of all student work samples using a rubric adapted from Ruiz-Primo, Schultz, Li, and Shavelson (2001) (Appendix B). The IRR percentage for all participants was 100% consistently for rated samples of student work. It should be noted that this percentage may be likely attributed to training sessions that were provided for participating teachers as well as clarity of components as listed in the rubric. Teachers involved in the study as raters also had prior experience with using graphic organizers as content enhancements with students with learning disabilities; therefore, they demonstrated a clear and consistent understanding of the
expectation for levels for student response related to the selected graphic organizers used for the study.

**Alana**

During initial baseline data collection, data revealed that Alana had familiarity with the vocabulary terms selected for use in this research study; however, she was unable to identify the specific term that applied when referenced in a word problem. For example, in a word problem that asked for the student to find the average number of points scored during a game, Alana was unable to recognize the corresponding terminology of “mean” and apply the calculations independently without assistance. She was unable to give examples of when the term might apply or have relevance to solving a real-life problem, and had erroneous computation due to incorrectly applying procedures in word problems (e.g., she utilized the procedure for median to calculate the mode).

Alana demonstrated an interest in the research study, asking the principal investigator questions regarding how the study would be utilized. She stated that she “had seen the words before but gets them confused” in the classroom environment. She responded positively to feedback from the investigator during the study, and did not exhibit any behaviors that would indicate a lack of engagement, such as failure to complete tasks or verbally expressing disinterest. She was easily motivated by praise and interested in her progress, often asking the investigator if she “got the problem correct.”

In relation to demonstration of knowledge of mathematical vocabulary terms selected for the study using a specially designed graphic organizer as a criterion map, Alana’s baseline mean score was 20%, calculated on potential for the student to receive a score of zero to three using a rubric for assessment of student written response. The intervention mean score increased to 90%, demonstrating a 70% increase in score related to student knowledge of terminology.
Stability during intervention was reached after three sessions. During the study, there were no overlapping data points between baseline and intervention for any participant.

During assessment of understanding related to Alana’s ability to demonstrate understanding of an Algebraic concept in terms of solving abstract word problems, Alana’s baseline mean score expressed was 16%, calculated on potential for the student to receive a score of zero to five when given five word problems related to specified vocabulary terms, receiving 1 point for each correct final answer. The intervention mean score increased to 84%, demonstrating a 68% between baseline and intervention. Stability during intervention was reached after three sessions. During intervention, no overlapping data points were exhibited,

**Ben**

Data collected during initial baseline revealed that Ben was able to recognize the selected vocabulary terms; however, he had erroneous notions of how to apply the definition to provide an example of when the term might apply in solving a problem. When presented with word problems that did not specifically indicate the specific term used to solve the problem, Ben demonstrated difficulty in choosing the appropriate term and related procedures for solving the problem. During this phase, Ben was unable to articulate when the selected terms might apply in real world applications. In addition, Ben displayed erroneous calculations when solving word problems though the procedures were written correctly.

Ben displayed a positive attitude throughout the study. He stated that he enjoyed working one-on-one because “I just learn more that way.” Ben responded positively to feedback from the investigator during the study, and did not exhibit any behaviors that would indicate a lack of engagement, such as failure to complete tasks or verbally expressing disinterest. He was encouraged and motivated by verbal praised, and would often exhibit this in a physical manner by giving the investigator a ‘high five’ when he correctly completed a task.
In relation to demonstration of knowledge of mathematical vocabulary terms selected for the study using a specially designed graphic organizer as a criterion map, Ben’s baseline mean score was 31%, calculated on potential for the student to receive a score of zero to three using a rubric for assessment of student written response. Intervention for Ben, participant two in the study, began after 13 sessions of initial baseline data collection. The intervention mean score increased to 86%, demonstrating a 55% increase in score related to student knowledge of selected terminology. Stability during intervention was reached after three instructional sessions.

During assessment of related to Ben’s ability to demonstrate understanding of an Algebraic concept in terms of solving abstract word problems, Ben’s baseline mean score was 25%, calculated on potential for the student to receive a score of zero to five when given five word problems related to specified vocabulary terms, receiving 1 point for each correct final answer. Intervention began after 13 sessions of initial baseline instruction and data collection. The intervention mean score increased to 86%, demonstrating a 61% increase in score. Stability during intervention was reached after three sessions. During intervention, no overlapping data points were exhibited.

**Cordell**

Initial data for participant three, Cordell, revealed that familiarity with the selected vocabulary terms existed; however, the student confused procedures that exist specific to each term. Cordell exhibited difficulty with constructing responses to prompts on graphic organizers that required elaboration in using the correct definition. For example, when asked to construct a question related to the term and provide an answer, Cordell exhibited difficulty in the construction of a question related to who, why, when, where, or how the term would be used. Cordell also exhibited difficulty in articulating the definition in his own words, even when presented with the definition in technical words (i.e., the definition presented in the textbook or...
by the investigator). During the formative assessment, Cordell indicated that he had seen or heard the term before, but his explanation was limited or erroneous.

During both phases of the study, Cordell was pleasant and easily encouraged. Cordell displayed confidence in his ability, even when he did not correctly answer questions or solve problems with accuracy. Cordell responded positively to feedback from the investigator during the study, and did not exhibit any behaviors that would indicate a lack of engagement, such as failure to complete tasks or verbally expressing disinterest. Cordell stated that when he was in elementary school, he “did math in a different room with the special education teacher” and he did not like to ask questions in front of his peers in the general education classroom. This is consistent with the information given by the general education teacher, who stated that Cordell seeks assistance from the special education co-teacher in the Basic Algebra classroom.

In relation to demonstration of knowledge of mathematical vocabulary terms selected for the study using a specially designed graphic organizer as a criterion map, Cordell’s baseline mean score was 33%, calculated on potential for the student to receive a score of zero to three using a rubric for assessment of student written response. Intervention for Cordell, participant three in the study, began after 16 sessions of initial baseline data collection. The intervention mean score increased to 67%, demonstrating a 34% increase in score related to student knowledge of selected terminology. Stability during intervention was reached following three instructional and assessment sessions. During intervention, no overlapping data points were exhibited.

Data related to Cordell’s ability to demonstrate understanding of an Algebraic concept in terms of solving abstract word problems indicated a baseline score of 33%, calculated on potential for the student to receive a score of zero to five when given five word problems related
to selected vocabulary terms, receiving 1 point for each correct final answer. Intervention began after 16 sessions of initial baseline instruction and data collection. The intervention mean score expressed in percentage increased to 85%, demonstrating a 52% increase. Stability during intervention was reached following three sessions. No overlapping data points were exhibited during intervention.

**Results**

All participants in the study demonstrated an increase in scores measuring both knowledge and understanding during intervention, which included the use of specially designed graphic organizers for teaching vocabulary in mathematics as well as use of EIR. Visual analysis of data indicates a similar trend across all participants during baseline (i.e., all participants experienced an increase in both knowledge and understanding); however, analysis of mean average increases demonstrate an increase in score and mastery of both levels of knowledge and understanding across participants in a positive trend. Increases during baseline may be attributed to maturation over instructional sessions, indicating that increased exposure to the concept allowed for an increase in skill. While this may cause one to question the presence of a functional relation, it should be noted that no overlapping data points were demonstrated between baseline and intervention. Visual analyses of graphed data demonstrate that as knowledge increased (as measured by completion of criterion maps), so did students’ levels of understanding (as measured by scores from word problems) in an almost identical mode. Participants expressed familiarity and use of similar content enhancements in other content areas (e.g., English and Biology); however, none of the participants acknowledged any prior use of interventions or routines for teaching vocabulary during mathematics courses. All participants reported an increased level of confidence in solving word problems independently when utilizing the graphic organizer as a source of reference during assessment. Participants also demonstrated
increased levels of cognitive engagement with selected content material throughout the study, and reported that the selected terms were easier to remember with the establishment of relevant real-world applications and connections that were explicitly recorded on the graphic organizers (Dye, 2000). Dialogue with participants indicated potential for a decrease in cognitive load (Sweller, 1994) as students were provided with materials that did not increase extraneous cognitive load. As exhibited in research by Swanson, Jerman, and Zheng (2008), students with learning disabilities have coexisting low levels of working memory and problem solving skills that may impair the effectiveness of strategy interventions. Content enhancements such as graphic organizers demonstrate potential for increasing conceptual understanding of mathematical content knowledge for students who exhibit deficits in skill acquisition and problem solving abilities (Ives, 2007).
<table>
<thead>
<tr>
<th>Method of Assessment</th>
<th>Initial Baseline Mean (%)</th>
<th>Intervention Mean (%)</th>
<th>Effect Change (%)</th>
<th>Non-overlapping Data Points (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criterion Map</td>
<td>Alana: 20% (6/30)</td>
<td>Alana: 90% (27/30)</td>
<td>Alana: 70%</td>
<td>Alana: 100%</td>
</tr>
<tr>
<td></td>
<td>Ben: 31% (12/39)</td>
<td>Ben: 86% (18/21)</td>
<td>Ben: 55%</td>
<td>Ben: 100%</td>
</tr>
<tr>
<td></td>
<td>Cordell: 33% (16/48)</td>
<td>Cordell: 86% (12/18)</td>
<td>Cordell: 53%</td>
<td>Cordell: 100%</td>
</tr>
<tr>
<td>Word Problems</td>
<td>Alana: 16% (7/25)</td>
<td>Alana: 84% (42/50)</td>
<td>Alana: 68%</td>
<td>Alana: 100%</td>
</tr>
<tr>
<td></td>
<td>Ben: 25% (16/65)</td>
<td>Ben: 86% (30/35)</td>
<td>Ben: 61%</td>
<td>Ben: 100%</td>
</tr>
<tr>
<td></td>
<td>Cordell: 33% (26/80)</td>
<td>Cordell: 85% (17/20)</td>
<td>Cordell: 52%</td>
<td>Cordell: 100%</td>
</tr>
</tbody>
</table>

Table 3. Assessment Scores for Participants
Figure 1. Assessment of Criterion Map
Figure 2. Assessment of Word Problems
Summary

This chapter provided a detailed description of the results of the study based on the data collected during initial baseline and intervention instruction. Following analysis and visual representation of data, it was concluded that student participants did increase scores in assessment of both knowledge and understanding using explicit vocabulary instruction that utilized graphic organizers specially designed for mathematics vocabulary instruction in conjunction with an instructional routine (EIR). The following chapter offers further discussion of the results and implications for future research related to the nature of this study.
CHAPTER V: DISCUSSION

Purpose of the Study

The purpose of this investigation was to examine if specialized graphic organizers specially designed for teaching mathematics vocabulary in conjunction with explicit instruction using an instructional routine were successful tools for improving student ability and performance in solving abstract word problems related to measures of central tendency, an Algebraic concept. Previous studies indicate that increased levels of knowledge and understanding are reached when academic enhancements, interventions, and instructional routines are used for instructing students with learning disabilities. According to an investigative review by Watt, Watkins, and Abbitt (2014), data from 2013 revealed a 46-point difference in the average subtest score scale when comparing eighth grade students with and without disabilities and a 40-point difference between twelfth grade students in the same corresponding factions. Substantial gaps in math performance on subtests in conjunction with inclusive math composition scores demonstrate a need for further research related effective practices in designing services for students with learning disabilities in mathematics that align with the CCSS.

Summary of Findings

The findings of the study suggest that explicit instruction using the Explicit Inquiry Routine (Scheuermann, Deshler, and Schumaker, 2009) in conjunction with the use of graphic organizers specially designed for teaching vocabulary in mathematics may be effectively used with students with learning disabilities in secondary mathematics courses to improve knowledge
acquisition and demonstration of understanding. The CCSS implement algebraic standards of algebraic thinking beginning in Kindergarten as foundational skills prerequisite to abstract concepts. Presently, completion of Algebra I is a prerequisite for graduation for most districts in the United States (Witzel, 2005). In preparation of this course, middle schools students, including students with learning disabilities, are now enrolled in pre-Algebra courses.

Knowledge and understanding of algebraic concepts and the ability to solve problems that require abstract thinking is thus essential for many reasons, one being that “it serves as a gatekeeper to a postsecondary education” (Watt, Watkins, and Abbitt, p. 1, 2014). Additionally, candidates for jobs, including vocations that do not require two and four year degrees, are more likely to be hired if they demonstrate a strong background in mathematics (Gonzales & Kuenzi, 2012); hence, in order to be competitive in the workforce, students with learning disabilities must receive instruction that includes strategic interventions and enhancements in order to master requisite skills.

Two research questions were posed in this study:

1. Is there a difference in student knowledge of measures of central tendency following instructional intervention that includes the use of a specialized graphic organizer for teaching mathematical vocabulary terminology in addition to explicit verbal instruction that incorporates exposure to terms in multiple contexts using the Explicit Inquiry Routine related to measures of central tendency?

2. Is there a difference in student ability to demonstrate understanding by solving word problems that require the utilization of computation related to measures of central tendency following instructional intervention that includes the use of a graphic organizer specially designed for teaching mathematical vocabulary in addition to explicit
verbal instruction that incorporates exposure to terms in multiple contexts using the Explicit Inquiry Routine (EIR) related to measures of central tendency?

**Summary of Methods**

To address the questions, the study investigator utilized a single subject multiple baseline across participants design to investigate functional significance of the stated hypothesis. According to Horner, Carr, Halle, McGee, Odom, and Wolery (2005), this type of design demonstrates effectiveness in that it allows one to determine whether a causal relationship exists when an independent variable is introduced, causing a change in the dependent variable. For the purposes of this study, the relationship between the uses of graphic organizers specially designed for teaching vocabulary in secondary mathematics (Basic Algebra) in conjunction with implementation of explicit instruction using EIR was established; following intervention, a change in the ability to demonstrate both knowledge and understanding was established. All study participants experienced increased success in their ability to recognize the term in multiple contexts and articulate the meaning and usage of the term as well their ability to solve abstract word problems related to the concept of measures of central tendency. Replication of this study is recommended to validate the establishment of criteria of evidence-based standards. Criteria used for this study include outcome variables measured over time (established at least three data points), establishment of inter-rater reliability, establishment of fidelity regarding implementation the instructional procedures using inter-rater checklist, and systematic manipulation of the independent variable. Systematic replication of the effect was documented within the duration of the research period, with procedures for instruction consistent for each participant.
Limitations

It should be noted that due to the research design chosen for this study, the following limitations to the study may exist:

1. Due to the existence of prior exposure to selected vocabulary in earlier grades, learning effects or maturation effects may exist. This effect may have led to increases in scores during baseline data collection.

2. A maturation effect may exist during baseline data collection. A maturation effect occurs when changes are seen in subjects because of the time that has elapsed since the study began and that may not be the result of any program effects.

Delimitations

The following delimitations affected the applicability of results to individual participants and settings beyond those used in the research study:

1. The study utilized a single subject multiple baseline design. The study was limited to three participants from one location.

2. The population from which participants were invited and randomly selected was limited to one school district in West Alabama during the 2014-2015 school year. Thus, the ability to generalize information to a greater population of students and teachers was limited.

4. This research study was limited to the content area of Basic Algebra in a public high school in the state of Alabama. Results have limited generalizability to other secondary mathematics courses or other content areas.

5. The primary investigator is a certified special education teacher.
Implications for Current Practice

The use of graphic organizers in conjunction with specific instructional routines as evidence-based practice has the potential to provide educators with an effective method of service delivery for students with specific learning disabilities (Scheuermann, Deshler, & Schumaker, 2009; Ellis & Howard, 2007; Ives, 2007; Bowman, Carpenter, & Paone, 1998; DeWispelaere & Kossack, 1996; Gallick-Jackson, 1997). The importance of clear and concise knowledge and understanding of critical terminology is demonstrated as a critical skill in the shift from procedural to conceptual instruction in the area of mathematics in grades K-12. The use of graphic organizers in conjunction with explicit instruction utilizing an instructional routine has the potential to increase levels of knowledge and understanding by allowing students to make explicit connections between the definition in terms of specific context and procedures for application. The use of different graphic organizers during instruction allows for teachers to scaffold instruction, providing strategic prompts at each level of expected student independence. This method of instruction also allows for the student to construct visual representations that allow for important connections to be made between the definition of the term and the procedures for application.

The intervention (specially designed graphic organizers) and instructional routine (EIR) employed for this research study may be used in a variety of settings with scaffolded instruction. Literature regarding scaffolding instruction reflects the importance of student-facilitated learning processes (Rosenshine & Meister, 2002), which was apparent throughout the intervention phase of this study as students increased independence and responsibility for their own learning as prompts and supports were gradually decreased. As documented through literature included in this study, there is the potential for student-facilitated learning through inquiry, which has the prospective indices for efficient schematic storage in memory (Scheuermann, Deshler, &
Schumaker, 2009). In addition, due to the nature of student participation in the construction of the graphic organizers using EIR that provided opportunities for strategic and specific inquiry, student engagement was increased. It is recognized in literature related to learning disabilities that students with LD may lack cognitive engagement due to deficits in prior knowledge and understanding, therefore impacting their ability to solve grade-level problems, demonstrating a need for interventions that capitalize on student engagement and motivation during instruction (Taylor, et al., 2003). The results of this study demonstrate an increased level of potential for student engagement and increased levels of knowledge and understanding that may be generalized across multiple contexts and content levels.

The study revealed that the use of content enhancements such as graphic organizers and instructional routines demonstrate potential for increasing students’ knowledge and understanding of both terminology and problem solving skills with expediency. Traditional classroom instructional methods often allocate minimal instructional minutes or class periods to requisite vocabulary knowledge required for problem solving application in the area of mathematics, making an ambitious assumption that students arrive prepared with foundational skills necessary for mastery of new material. Educators may argue that course of study and pacing guides drive the length of time devoted to a specific content lesson; however, due to the linear nature of mathematics, deficits that develop in knowledge and understanding may increase the chance of failure at the secondary level. This argument leads to the need for foundational skills, including a deep and meaningful knowledge and understanding of vocabulary related to a mathematical context, be constructed prior to entry in secondary mathematics courses. According to research by Ritchie & Bates (2013), knowledge of mathematical concepts at age seven has a more profound indication of socioeconomic status.
(SES) of an adult at age 42 than familial SES, even when controlling statistically for the IQ of the student at age seven, their reading achievement scores, and their individualized academic motivation. In addition to the need for students to demonstrate mastery of mathematical concepts in order to seek competitive employment, especially for students who do not attend two or four year degree programs (Gonzales & Kuenzi, 2012).

In order for educators to plan meaningful instruction, there should be a clear understanding of the level of prior knowledge that students in a classroom or group possess. The study utilized a formative assessment that provided students the opportunity to rate their own level of knowledge of selected terms for the study. According to the Executive Summary of the Principles and Standards for School Mathematics published by the National Council for Teachers of Mathematics (NCTM) in 2000 which remains current for practice, effective instruction in mathematics requires teachers to understand what students know and what they need to learn in order to challenge and support them in the process of learning. Formative assessment is often used in the classroom environment to assess levels of knowledge and understanding following instruction, providing the opportunity for deficits and erroneous notions related to content material to be established; however, this use is only effective if intended to drive subsequent instructional practices and encourage the process of reflective and self-regulated learning by the student (Clark, 2015; Clark, 2012). Heritage (2007) stated that while the purpose of formative assessment is to further promote learning, its validity pivots on the effectiveness of subsequent lessons. Awareness of students’ levels of prerequisite and requisite skills prior to instruction allows educators to maximize instructional time, concentrating on critical areas of deficits in knowledge and skill required for mastery of new content material. This conception further promotes the importance of instructional fidelity, ensuring that content is delivered in the manner
intended and that levels or methods of implementation of research-based programs, tools, and interventions are not left to teacher discretion. Furthermore, the utilization of formative assessment prior to the lesson provides an opportunity to effectively plan for differentiated instruction to address individual strengths and needs in the classroom environment.

For the duration of this study, the investigator provided instruction that was scaffolded in order to provide a balance between assistance and independence based on the levels of understanding and knowledge the student possessed. It is critical that educators understand the need to provide direct and explicit instruction with specific modeling in order for students to obtain concrete levels of understanding prior to representational or abstract levels of demonstration. Graphic organizers are exemplary tools for use during scaffolded instruction in that teachers may individualize the specific prompts as well as level of prompting prior to use. Students may also complete graphic organizers individually, in pairs, or in small groups in order to design instruction that relates to the level of independence the teacher wishes for the student to demonstrate.

Although the focus of this study was to investigate the potential for increased levels of knowledge and understanding of students with learning disabilities following explicit instruction using content enhancements use of such tools and routines with all students in the mathematics classroom also are merited. As evidenced by traditional classroom instruction, students with and without learning disabilities had erroneous ideas and lacked the abilities to construct meaningful relationships due to deficits in prerequisite and requisite vocabulary knowledge from prior mathematics courses (e.g., Bowerman & Choi, 2003; Munnich & Landau, 2003). As mathematics as a content area is a linear subject (i.e., skills progress from one course to the next in a specific sequence), it is essential that students develop a deep and meaningful level of
knowledge prior to the implementation of applied understanding and problem solving activities. In other words, students must have the ability to recognize the term and define it in a succinct manner with accuracy prior to applying the term as an application or procedure (Nagy & Townsend, 2012). During this study, it was observed by the investigator that students with and without disabilities had varying degrees of knowledge related to the selected terms; however, traditional or “business-as-usual” instruction did not allow for correction or an opportunity to expound on the limited knowledge students possessed. This lack of knowledge led to deficits in relational understanding of and between terms and applied process. For example, students who were able to define the term did not consistently apply the definition in constructing a question related to the problem with an appropriate method of solving the problem, evidencing a deficit in the ability to apply the term with relevance to a mathematical context (Appendix E). This gap in students’ ability to apply knowledge might otherwise be overlooked in traditional instructional methods. The use of graphic organizers for teaching critical vocabulary provides opportunities through the use of specific prompts for students to utilize reflection in order to expand on their level of knowledge in written form, thereby providing teachers data regarding individualized levels of knowledge within the classroom community.

Sweller’s work in the area of cognition and Cognitive Load Theory (CLT) posits that new information requiring extensive capacity potentially impairs students’ ability to learn altogether (1994). This leads to an implication that in the area of secondary mathematics, there is potential for both intrinsic and extraneous cognitive load to impair the ability to learn, store, and maintain, and generalize information, specifically for students with disabilities. Intrinsic cognitive load may be decreased by increased exposure to terminology across grade-level contexts and increasing the chance that students would be able to activate prior knowledge in secondary
courses. Extraneous cognitive load is directly related to instructional materials and may be imposed by instructional design. This research study demonstrated the effectiveness of both intervention and instructional routine for students with learning disabilities versus traditional instruction that was primarily text based. In addition, it should be noted that students with learning disabilities are often presented with text-based instruction, utilizing semi-technical vocabulary not consistent with research that demonstrates the need for meaningful language during instruction in order for students to process and use information successfully (Fang, 2012).

Finally, this study indicates that students with learning disabilities may possess the ability to demonstrate mastery of grade-level content with appropriate instruction. A concern consistently articulated by general education teachers is that content material is “watered down” for students with disabilities, and that grades may not reflect true performance on grade-level material but rather a modification of the content. Participants in the study were assessed using grade-level word problems, and received a score based on acquisition of the correct answer. Their increased ability to correctly solve the problems following intervention may demonstrate that with appropriate instructional content enhancements, students with LD may reach mastery of the same content as peers without disabilities.

**Implications for Future Research**

As indicated in Chapter III, a wealth of research has been conducted associated to the significance of vocabulary instruction in content areas such as language arts and the sciences; however, research in the area of explicit vocabulary instruction in mathematics is limited. As CCRS are implemented with fidelity and an increased level of rigor, there is a growing attention to the importance of conceptual understanding in mathematics. Students who do not present clear and succinct knowledge and understanding of terminology may demonstrate limited mastery of concepts (Fang, 2012; Lemke, 2003). In addition, words have multiple meanings
across contexts; therefore, students may often confuse which context the word is to be applied within (Lemke, 2003).

Additional studies are needed to replicate the procedures and findings of this study. In order to expand the research parameters of the use of graphic organizers specially designed for teaching vocabulary in mathematics in conjunction with an instructional routine such as EIR, it is recommended that studies include multiple grade levels and additional course subjects in the content area of mathematics (e.g., Geometry or Statistics). It is recommended that studies include participants in earlier grades (i.e., elementary and middle school) in order to assess how explicit instruction in the area of mathematics vocabulary may increase foundational skills necessary for secondary courses. Future studies should include a greater number of participants in order to control for factors that may have confounded the effects of this study. Future studies may also benefit from the inclusion of teachers trained in the implementation of the intervention and instructional routine as providers of instruction in addition to any investigators to explore student response to instruction from multiple sources. It should be noted that all parties providing instruction during intervention should be trained and proficient in the methods described in the research protocol. Additional research in the area of teaching vocabulary in mathematics, specifically focused on conceptual knowledge and understanding, should have a centralized focus on how content enhancements impact the abstract problem solving skills (i.e., word problem solving performance) of students with disabilities in the inclusive setting.

It is further recommended that studies include students without disabilities or students who have been referred for tiered instruction in Response to Intervention/Instruction (RTI) prior to referral for an evaluation for special education services. Students who exhibit such deficits
may certainly benefit from instruction that includes specially designed graphic organizers and EIR.

Finally, it is recommended that a qualitative component be included to examine participant (teacher and student) perceptions of both traditional instructional methods as well as content enhancements. Information gained from participant focus groups may further research in predicting response to levels of intervention in the classroom environment. Although student and teacher interviews were not conducted, documented or reported in this study, it should be noted that there is a disconnect in beliefs of general and special education teachers related to instructional interventions in the general education classroom that may lead to issues of fidelity of implementation of interventions.

**Conclusion**

This research study evaluated the effect of intervention on student ability and performance in solving abstract word problems related to measures of central tendency, an Algebraic concept. Intervention included the use of graphic organizers specially designed for teaching mathematics vocabulary in conjunction with explicit instruction using an instructional routine. The project differed from other studies in the area of vocabulary instruction in considering the impact of explicit vocabulary instruction in the area of mathematics. The investigator and raters involved in the study observed an increase in participants’ ability to demonstrate knowledge of terminology, including application of definition and critical features of each term, across contexts as well as an increase in participants’ ability to solve abstract word problems during the study. Participants in the study also demonstrated increased levels of confidence, and were encouraged and motivated to continue use of the strategy following participation. Due to the positive trend from initial baseline through intervention, it may be unclear if a functional relationship is present; however, all participants did demonstrate an
increase in scores measuring both knowledge and understanding in the intervention phase. In order for students to experience success with the rigor required of CCRS, it is critical that educators provide students with disabilities tools and instructional strategies designed to provide explicit, clear, and concise information in an organized and scaffolded manner. This has the potential to decrease cognitive load while increasing cognitive engagement during instruction. There is also potential for increased levels of generalizability of procedural skill across grade levels in the content area of mathematics.
REFERENCES


Gallick-Jackson, S. A. (1997). Improving narrative writing skills, composition skills, and related attitudes among second grade students by integrating word processing, graphic organizers, and art into a process approach to writing. Fort Lauderdale, FL: M. S. Practicum Project, Nova Southern University. (ERIC Documentation Reproduction Service No. ED420062)


van Garderen, D., Scheuermann, A., & Poch, A. (2014). Challenges students identified with a learning disability and as high-achieving experience when using diagrams as a visualization tool to solve mathematics word problems. *ZDM, 46*(1), 135-149.


February 13, 2015

Mary Elizabeth Long
SPEMA
College of Education
Box 870232


Dear Ms. Long:

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your application has been given expedited approval according to 45 CFR part 46. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies

Your application will expire on February 11, 2016. If your research will continue beyond this date, complete the relevant portions of the IRB Renewal Application. If you wish to modify the application, complete the Modification of an Approved Protocol Form. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, complete the appropriate portions of the IRB Request for Study Closure Form.

Please use reproductions of the IRB approved stamped consent/assent forms to obtain consent from your participants.

Should you need to submit any further correspondence regarding this proposal, please include the above application number.

Good luck with your research.

Sincerely,

Carpanato T. Myles, MSM, CRM, CIP
Director, Research Compliance Officer
APPENDIX B: RUBRIC FOR ASSESSMENT OF GRAPHIC ORGANIZERS

<table>
<thead>
<tr>
<th>ZERO POINTS (0)</th>
<th>ONE POINT (1)</th>
<th>TWO POINTS (2)</th>
<th>THREE POINTS (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No valid proposition exists for the terms according to the criterion map related to the given prompts</td>
<td>The proposition is valid and appears on the criterion map but is factually inaccurate or incomplete related to the given prompts</td>
<td>The term appears on the criterion map and the information related to the prompt is factual and complete; however, the student demonstrated deficits in elaboration on the concept, including summaries of concepts, predictions, and examples/non-examples of when the term applies related to the given prompts</td>
<td>The term is present with factual and complete relationships as well as a demonstrated and complete understanding of elaborated concepts related to the given prompts</td>
</tr>
</tbody>
</table>

Adapted from Ruiz-Primo, Schultz, Li, and Shavelson (2001)
**APPENDIX C: INTER-RATER INSTRUCTIONAL FIDELITY CHECKLIST**

*Directions for rater: Observe all elements of instruction. Instruction should follow process listed below in order. If investigator exhibits procedure, write “1” in the corresponding box, indicating the process was followed. If process is not exhibited, write “0” in box indicating process was omitted in order of procedure or not exhibited. Following completion, sum the number of observed procedures and complete calculation listed at end of checklist.*

<table>
<thead>
<tr>
<th>Procedural Steps</th>
<th>Observed (1 point) or Not observed (0 points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide an objective for the lesson in concrete and measureable terms</td>
<td></td>
</tr>
<tr>
<td>Provide a rationale and relevance for the graphic organizer</td>
<td></td>
</tr>
<tr>
<td>Investigator introduces the graphic organizer to be used, providing student copy</td>
<td></td>
</tr>
<tr>
<td>Investigator reads each written prompt aloud, pointing to the specific location/box</td>
<td></td>
</tr>
<tr>
<td>Investigator uses explicit instructions and modeling to demonstrate how to record responses in each prompt box</td>
<td></td>
</tr>
<tr>
<td>Investigator reminds students to use their own language (<em>i.e., not technical definition</em>)</td>
<td></td>
</tr>
<tr>
<td>Investigator reviews an example from previous lesson and models expectations for complete answers on investigator’s copy of graphic organizer</td>
<td></td>
</tr>
<tr>
<td>Investigator points to first box, and directs student to read silently as she reads prompt aloud</td>
<td></td>
</tr>
<tr>
<td>Investigator points to box on graphic organizer, and asks student, “Based on the definition we learned related to this term, how might you answer this prompt?”</td>
<td></td>
</tr>
<tr>
<td>Investigator allows time for student to brainstorm answer</td>
<td></td>
</tr>
<tr>
<td>Investigator provides feedback to student for answer, facilitating student in constructing the correct answer if the student has an erroneous understanding based on prior explicit instruction</td>
<td></td>
</tr>
<tr>
<td>Investigator has student state correct answer aloud prior to recording answer on graphic organizer</td>
<td></td>
</tr>
<tr>
<td>Investigator provides positive feedback to student</td>
<td></td>
</tr>
<tr>
<td>Investigator points to correct box on graphic organizer, and instructs student to record the answer</td>
<td></td>
</tr>
<tr>
<td>Investigator checks to ensure student records response in correct location</td>
<td></td>
</tr>
<tr>
<td>Investigator points to second box related to specific term, and follows same procedure, providing explicit feedback and same level of student inquiry to construct appropriate answer</td>
<td></td>
</tr>
<tr>
<td>Investigator provides explicit instruction for each prompt on the graphic organizer, stating the term aloud and requiring inquiry related to definition of each term from student</td>
<td></td>
</tr>
<tr>
<td>Investigator checks for understanding of each prompt, providing explicit feedback and facilitates student response (<em>i.e., investigator refers to lesson and allows for student to use knowledge to construct answer rather than providing answer for student</em>)</td>
<td></td>
</tr>
<tr>
<td>Investigator allows sufficient time for student to construct answer, and provides explicit references to instruction to assist student in constructing answer</td>
<td></td>
</tr>
<tr>
<td>Investigator requires student to state all answers aloud prior to recording on graphic organizer</td>
<td></td>
</tr>
<tr>
<td><strong>Investigator provides positive feedback at each level (completed box) to encourage and motivate student</strong></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td></td>
</tr>
<tr>
<td>At conclusion of lesson (completion of graphic organizer), investigator asks student to explain how using the graphic organizer helps them to organize their thoughts</td>
<td></td>
</tr>
<tr>
<td>Investigator asks student to explain how this strategy might be helpful in learning new terms in Basic Algebra</td>
<td></td>
</tr>
<tr>
<td>Investigator asks student to explain how this graphic organizer might help them to solve word problems</td>
<td></td>
</tr>
<tr>
<td>Investigator presents student with sample word problem on additional paper</td>
<td></td>
</tr>
<tr>
<td>Investigator points to word problem, and instructs student to read silently as she read the problem aloud</td>
<td></td>
</tr>
<tr>
<td>Investigator asks student which term from the graphic organizer applies to solving this problem while pointing to the graphic organizer</td>
<td></td>
</tr>
<tr>
<td>Investigator prompts student to circle key words that indicate what term might be used to solve the problem</td>
<td></td>
</tr>
<tr>
<td>Investigator prompts student to state aloud what term might be used to solve the word problem</td>
<td></td>
</tr>
<tr>
<td>Investigator directs student to identify the term by pointing to the term on the graphic organizer</td>
<td></td>
</tr>
<tr>
<td>Investigator prompts student to re-read the word problem aloud</td>
<td></td>
</tr>
<tr>
<td>If student identifies an incorrect term, investigator facilitates discussion regarding why the term chosen would not solve the problem, allowing student to use prior knowledge to identify the critical elements of the term chosen</td>
<td></td>
</tr>
<tr>
<td>Investigator allows time for student to respond</td>
<td></td>
</tr>
<tr>
<td>Investigator provides positive feedback</td>
<td></td>
</tr>
<tr>
<td>Investigator redirects student to chose correct term by pointing to the term on the graphic organizer - if student chooses wrong term, investigator follows steps listed above</td>
<td></td>
</tr>
<tr>
<td>Following positive feedback, investigator prompts student to re-read the word problem aloud</td>
<td></td>
</tr>
<tr>
<td>Investigator prompts student to draw a line through any information that may be used as a distractor in the word problem (i.e., <em>not applicable to the computation and problem solving process</em>)</td>
<td></td>
</tr>
<tr>
<td>Investigator facilitates process, providing explicit questions for students to use strategy of inquiry (i.e., “Why would this word/phrase not be important in helping you to solve the problem?”)</td>
<td></td>
</tr>
<tr>
<td>Investigator has student re-read word problem aloud, avoiding distractors</td>
<td></td>
</tr>
<tr>
<td>Investigator prompts student to use knowledge to set up first process of calculation on paper, using graphic organizer as reference</td>
<td></td>
</tr>
<tr>
<td>Investigator checks for accuracy. If student did not set problem up correctly, investigator provides specific inquiry for student to detail their process. If student set process up correctly, investigator prompts student to state aloud their process and reasoning</td>
<td></td>
</tr>
<tr>
<td>Once first step is complete, investigator prompts student to follow same process for second step</td>
<td></td>
</tr>
<tr>
<td>Once problem is correctly set up and student has articulated their reasoning correctly without facilitation from investigator, prompt is given for student to solve the problem</td>
<td></td>
</tr>
<tr>
<td>Investigator prompts student to repeat reasoning for all steps in addition to calculation procedures aloud</td>
<td></td>
</tr>
<tr>
<td>If student solves problem correctly, investigator provides positive feedback</td>
<td></td>
</tr>
<tr>
<td>If student incorrectly solves problem, investigator facilitates inquiry process (i.e., “From your steps, explain how you solved the problem?”)</td>
<td></td>
</tr>
<tr>
<td>Investigator redirects student to graphic organizer and examples that may assist student in identifying answers independently</td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Investigator allows student to verbally explain process and use inquiry strategy to identify errors in calculation</td>
<td></td>
</tr>
<tr>
<td>Once student has identified error, investigator prompts student to draw a line through the incorrect calculation and solve - investigator directs student not to erase as this allows student to see visual of incorrect process as reference</td>
<td></td>
</tr>
<tr>
<td>If student’s answer is correct, investigator provides positive feedback – if answer is incorrect, investigator follows process listed above</td>
<td></td>
</tr>
<tr>
<td>Following completion of steps to solve word problem, investigator places both graphic organizer and word problem sheet side-by-side in front of the student, and prompts student to identify how graphic organizer assisted in helping the student to learn the term</td>
<td></td>
</tr>
<tr>
<td>Investigator allows student to facilitate discussion, providing specific feedback to student’s response about graphic organizer and inquiry routine</td>
<td></td>
</tr>
<tr>
<td>Investigator prompts student to articulate how the information on the graphic organizer was used as a reference to solve the word problem</td>
<td></td>
</tr>
<tr>
<td>Investigator allows student to facilitate discussion, providing specific inquiry as to how knowledge is transferred to understanding (i.e., “How does knowing the definition and examples related to the term allow you to solve the problem?”)</td>
<td></td>
</tr>
<tr>
<td>Investigator provides positive feedback about the process and activity, and prompts student to articulate how the graphic organizer intervention and instructional routine might be used in other classes to learn vocabulary words</td>
<td></td>
</tr>
<tr>
<td>Investigator facilitates discussion and provides positive feedback to student regarding answers</td>
<td></td>
</tr>
</tbody>
</table>

**Number of observed procedures:** ________________

**Total number of procedures:** 56

**Calculation:** ______/ 56 = _________________%

**Fidelity of implementation = _________________%**
APPENDIX D: VOCABULARY SELF-RATING SAMPLE

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Set</td>
<td>Something scientist collect</td>
</tr>
<tr>
<td>Mean</td>
<td>The middle</td>
</tr>
<tr>
<td>Median</td>
<td>The most of something</td>
</tr>
<tr>
<td>Mode</td>
<td>Space of something</td>
</tr>
</tbody>
</table>

Vocabulary Self-ratings (SAMPLE)
### Measures of Central Tendency

The analysis of a data set to draw a conclusion or make an informed decision about a specific set of numbers.

<table>
<thead>
<tr>
<th>Rank of Importance</th>
<th>TERM</th>
<th>Definition (in understandable words)</th>
<th>Make up a WHY, WHY, WHEN, or HOW question</th>
<th>Answer to your question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean</td>
<td>The average of a group of numbers in a data set</td>
<td>When might you find the average of a set of numbers?</td>
<td>To determine your grade in this class!</td>
</tr>
<tr>
<td>2</td>
<td>Median</td>
<td>The middle number in a set of numbers that are listed in order</td>
<td>How can I remember the meaning of “median”?</td>
<td>Think: Where is the median located in a highway? In the middle!</td>
</tr>
<tr>
<td>3</td>
<td>Mode</td>
<td>The number that occurs most often in a data set</td>
<td>What word sounds like mode that would help me to remember this term’s meaning?</td>
<td>MOST</td>
</tr>
<tr>
<td>4</td>
<td>Range</td>
<td>The difference between the highest and lowest numbers in a data set</td>
<td>What word indicates the type of calculation is used to determine range?</td>
<td>Difference. When we find the difference in two numbers, we subtract!</td>
</tr>
</tbody>
</table>
### Word Charts #2 (SAMPLE)

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition in my own words</th>
<th>The word in a sentence</th>
<th>Words that mean the same or similar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>The average of a group of numbers</td>
<td>What was the mean score on the test?</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$90 + 100 + 95 + 97 + 80 = 462$</td>
<td>Words that mean the same or similar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$462 / 5 = 92.5$</td>
<td>Example</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Median</th>
<th>The middle number or mean in a group of numbers</th>
<th>The word in a sentence</th>
<th>Words that mean the same or similar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>What was the median score for Bowler A and Bowler B in 4 games?</td>
<td>Middle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$104, 104, 104, 109, 113, 117, 136, 189$</td>
<td>Words that mean the same or similar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$109 + 113 = 222$</td>
<td>Example</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$222 / 2 = 111$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode</th>
<th>The number that occurs most frequently</th>
<th>The word in a sentence</th>
<th>Words that mean the same or similar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What was the mode of student scores on the test?</td>
<td>$95, 87, 95, 100, 89$</td>
<td>Most</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$95$ occurs 2 times while other scores occur only once</td>
<td>Frequent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Popular</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Repeating</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Picture</td>
</tr>
</tbody>
</table>
### APPENDIX G: VOCABULARY GRAPHIC ORGANIZER CONNECTIONS SAMPLE

#### VOCAULRY CONNECTIONS (SAMPLE)

<table>
<thead>
<tr>
<th>TERM</th>
<th>TECHNICAL DEFINITION</th>
<th>STUDENT FRIENDLY LANGUAGE DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>The mean equals the sum of the data values divided by the total number of the data values</td>
<td>The “mean” is the average of a group of numbers.</td>
</tr>
</tbody>
</table>

Use “mean” to describe the middle of a set of numbers that does not have an outlier. When you calculate the mean (average) of your grade in this class, you will add all of your grades together, and divide by the total number of grades that you have. This will give you the mean, or your average, in this class.

- RELATED WORDS / KNOWLEDGE CONNECTIONS
  - Sum – the total of a group of numbers that are added together
  - Data values – groups of numbers, scores, or letters (variables) that represent numbers

| **Median** | The median is the middle value in an ordered set of numbers. | When you have a group of numbers that are put in order from least to greatest, this is the number that is in the middle. If you have an even number in your set of numbers, you will find the sum of the 2 numbers in the middle and divide by 2 (find the MEAN of the 2 middle numbers). THINK MEDIAN OF A HIGHWAY! |

When you have several scores, the median is the best measure to describe the scores. An example would be scores from a game. Player A’s scores are 10, 11, and 13, while Player B’s scores are 9, 7, and 14. To find the median score of the games played, put all scores in order from least to greatest: 7, 9, 10, 11, 13, 14. Since there are an even number of scores, find the mean of 10 and 11 (the middle 2 scores). The sum of 10 and 11 are 21. 21 divided by 2 is 10.5. This would give you a median game score of 10.5.

- RELATED WORDS / KNOWLEDGE CONNECTIONS
  - Mean – the average of a group of numbers
  - Ordered set – numbers that are put in order from least to greatest

| **Mode** | The mode is data item (number) that occurs the most times. A data set can have no mode, one mode, or more than one mode. | The number that occurs most frequently in a set or group of numbers. MODE sounds like MOST! The mode is the MOST POPULAR number. |

Sarah’s grades for the nine weeks are as follows: 91, 90, 100, 100, 87, 84, and 94. To determine the mode, we look for a repeating number. In this set of grades, 100 would be the mode because it repeats while other numbers do not. When you are looking for mode, underline all numbers that occur more than once. This helps you to identify numbers that are most common.

- RELATED WORDS / KNOWLEDGE CONNECTIONS
  - Frequent – happens more than once
  - Repeating – the score or number is present more than once (same as frequent)

| **Range** | The range is the difference between the greatest and least data values. | Range means the space between the smallest and largest number. It is expressed in number value and is determined by subtracting the smallest number from the largest number. To make finding range easy, first put the numbers or scores into an ordered set (put in order from least to greatest). |

Over the past 5 seasons, one baseball player’s batting averages were .265, .327, .294, .300, and .350. To find the range, put the scores into an ordered set: .265, .294, .300, .327, and .350. Now, subtract .265 (the smallest score) from .350 (the largest score). The player’s range in batting average over the past 5 seasons would be .085.

- RELATED WORDS / KNOWLEDGE CONNECTIONS
  - Ordered set – numbers that are put in order from least to greatest (smallest to largest)