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Embedded Strategies in Mathematics Vocabulary Instruction: A Quasi-Experimental Study

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EMBEDDED STRATEGIES IN MATHEMATICS VOCABULARY INSTRUCTION:
A QUASI-EXPERIMENTAL STUDY

A Dissertation
Presented to
the Graduate School of
Clemson University

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

by
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Accepted by:
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ABSTRACT

Recent accountability requirements increase the emphasis on mathematics achievement for all students, including low-performing students and students with learning disabilities. However, these students progress very slowly, with weaknesses evident in computation and problem solving. These limitations affect their success in mathematics at lower grades and make earning a high school diploma difficult. It is imperative to isolate components of mathematics comprehension and identify methods to teach them in order to help these lower performing students be successful. Research indicates a strong relationship between vocabulary and mathematical comprehension, identifying vocabulary understanding as a key component in understanding the subject. Vocabulary instruction incorporating mnemonic strategies has consistently resulted in substantial increases in learning and retention for students with disabilities as well as nondisabled peers when compared with other approaches.

The research reported here focused on the use of keyword mnemonics in mathematics vocabulary instruction. This mixed model multi-strand study with a quasi-experimental quantitative design tested for significant differences between groups on a vocabulary assessment and conducted a repeated measures analysis of variance was on two levels of instruction (direct instruction versus keyword mnemonic instruction) and across three measures (pretest, posttest, and follow-up). Although both groups did show significant improvements, the students who participated in the keyword mnemonic classes outperformed the students in the direct instruction classes as measured on the both the posttest and the follow-up test of the vocabulary assessment. There was no significant

difference between the groups on overall mathematics achievement as measured by Curriculum-Based Measurement probes or on attitudes toward mathematics. The qualitative data identified a relationship between the use of elaboration techniques, level of performance, and conceptual misunderstandings. However, as always, the effective use of any retrieval technique is dependent on the accuracy of the information encoded.

DEDICATION

This dissertation is dedicated to my family: to Steve, Sara, Sam, Seth, Thomas, and Stephanie for all their love and support. And finally to my beautiful granddaughter, Emma, who was born and celebrated her first birthday during this study. Her smiles, hugs and antics kept me focused on the important things in life.

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It is my name on the title page of this dissertation, but I could not have done it without incredible amounts of help and support from many in my life. I would like to thank those who have been instrumental in the completion of this document.

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CHAPTER 1

INTRODUCTION

NCTM posited that knowing mathematics is doing mathematics. In other words, to know mathematics means that one is able to apply mathematics. With this philosophy, one can pair the position that doing mathematics necessitates reading mathematics. The words, symbols, and numerals that give the discipline its substance, framework, and power are the same words, symbols, and numerals that students must use to communicate ideas, perform procedures, explain processes, and solve problems. Hence, a knower of mathematics is a doer of mathematics, and a doer of mathematics is a reader of mathematics (Adams, 2003, p. 794).

Since the launch of Sputnik, American education has been criticized for students' overall poor mathematics achievement. Current studies, such as The National Assessment of Education Progress (NAEP), found American students often have trouble with higher level mathematical skills such as comprehension and problem solving (Perie, Grigg, & Dion, 2005). The Third International Mathematics and Science Study and TIMMS-Repeat studies, which assess students in approximately 40 countries, confirm that students in the United States are not performing at the level of students in many other developed countries, especially those in Asia (Gonzales, et al. 2004).

The recent accountability initiatives emphasize improvement efforts for all students, including low-performing students and students with disabilities. However, these students progress very slowly in mathematics with weaknesses evident in computation and problem solving. These limitations affect their success in mathematics

at lower grades (Cawley, Parmar, Yan, & Miller, 1996) and make earning a high school diploma difficult. With more than 30 states now requiring a passing grade in algebra for high school graduation; it is imperative that researchers focus on identifying and addressing the components of mathematical comprehension, especially for low-performing students and students with disabilities.

Significance to the Field of Mathematics

Researchers in the field of reading research have identified various components of reading comprehension, finding vocabulary understanding a significant factor. In its examinations, the National Reading Panel (NRP) concluded that vocabulary development is critical to reading comprehension (National Institute of Child Health and Human Development, 2000).

Researchers have found a similar relationship in mathematics between vocabulary and comprehension, also identifying vocabulary understanding as a key component in understanding the subject (Miller, 1993). Many research studies have demonstrated that mathematics vocabulary understanding is an important component of mathematics comprehension (e.g., Aiken, 1972; Capraro & Joffrion, 2006; Gardner, 1992; Jackson & Phillips, 1983; Stahl & Fairbanks, 1986).

Recognizing that vocabulary is an important component, however, is only the first step in the process; effectively teaching vocabulary is the essential next step. Hogue (2003) stressed that vocabulary must be learned to mastery because of its critical role in students' mathematical success. It is not enough that students are simply exposed to new vocabulary words; they must completely understand them in order to be successful. However, there are varying degrees of vocabulary understanding. The model used in this

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research was developed by Stahl (1986), and identifies four levels of word knowledge: (a) little to no knowledge, (b) associative processing, (c) comprehension processing and (d) generation processing. Mathematics textbooks often present mathematics vocabulary in context during application procedures. Research by Griffin (1992) suggests that contextual learning may work best for advanced learners, but not for lower level learners, supporting other research findings that incidental learning is not effective with low-performing students and students with disabilities (e.g., Baker, Gersten & Lee, 2002; Swanson, 1999; Woodward, Baxter, & Robinson, 1999). It is, therefore, imperative for teachers to utilize effective mathematics vocabulary instruction to teach low-performing students.

Effective Mathematics Instruction

One group of especially effective vocabulary instruction strategies is mnemonics. Vocabulary instruction using mnemonic strategies has consistently resulted in a substantial increase in learning and retention for both students with disabilities as well as nondisabled peers when compared with other approaches (Mastropieri & Scruggs, 1998, Mastropieri, Sweda, & Scruggs, 2000; Scruggs & Mastropieri, 1990; Scruggs, Mastropieri, Levin, & Gaffney, 1987). The research reported focused on the keyword mnemonic strategy, which incorporates components of clear, direct instruction with visual and acoustic cues that aid in connecting, encoding, and retrieving the information.

A large body of research supports the effectiveness of the keyword mnemonic strategy (e.g., Levin, 1985; Levin, Glasman, & Nordwall, 1992; Pressley, Levin, & McDaniel, 1987; Stahl & Fairbanks, 1986). Researchers in these studies consistently demonstrated that this strategy has one of the largest effect sizes for any intervention used

in special education (Forness, Blum, & Lloyd, 1997). Several studies have indicated students with disabilities who were taught new vocabulary using keyword mnemonic strategy outperformed higher performing students who were taught using various other strategies (Mastropieri & Scruggs, 1989). In fact, a study conducted by Levin, McCormick, Miller, Berry & Pressley (1982) found that using keyword mnemonics for vocabulary instruction was more effective than using contextual vocabulary instruction with fourth grade students.

Although no research on keyword mnemonics for mathematics vocabulary instruction were found to date, an exhaustive search did find that the use of keyword mnemonics has been studied in many content areas, including: (a) foreign language vocabulary (Mastropieri et al., 1985), (b) science content (Mastropieri, Scruggs, & Graetz, 2003), (c) names and order of U.S. Presidents (Mastropieri, Scruggs, & Whedon, 1997), and (d) name of states and capitals (Mastropieri, Scruggs, Bakken, & Brigham, 1992). These studies demonstrated that keyword mnemonics not only improve the learning of specific vocabulary terms but also improve comprehension as well (Mastropieri, Scruggs, McLoone, & Levin, 1985; McLoone, Scruggs, Mastropieri, & Zucker, 1986). The studies took place in a variety of settings and group sizes, and on all levels of schooling, beginning in third grade (Mastropieri & Scruggs, 2000). In some of these studies, students indicated a preference for learning vocabulary terms using keyword mnemonics over other methods (Terrill, Scruggs, & Mastropieri, 2004; Scruggs & Mastropieri, 2000), an important finding given the importance of utilizing strategies that increase the interest of low-performing students.

Affective Components of Mathematics Instruction

Researchers demonstrated that affective factors such as motivation and attitude impact student achievement (Cote & Levine, 2000; Singh, Granville & Dika, 2002). Recent TIMSS data suggest that most U.S. mathematics curricula need to place greater emphasis on attitudes towards learning mathematics, since it is a salient predictor of academic performance (Reynolds & Walbert, 1992). The National Math Panel also acknowledged that anxiety about mathematics performance is correlated to low test scores, stressing the importance of using interventions that significantly reduce anxiety to improve scores (National Math Panel, 2007).

Another component related to a positive attitude toward mathematics is a feeling of self-efficacy. Defined as self-judgment of a domain-specific ability to perform a task successfully (Bandura, 1977), self-efficacy is a predictor of both mathematics and science achievement as well as of avoidance (Reynolds & Walberg, 1992). Regardless of the method of instruction, students are likely to exert effort based on the effects anticipated, regulated to a large extent by the importance attached to mathematics, enjoyment of the material, and the motivation to succeed (Tapia & Marsh, 2004).

Keyword mnemonic research, as shown above, is effective in increasing vocabulary comprehension. Students also indicate a preference toward learning using keyword mnemonics than other methods (Terrill, Scruggs, & Mastropieri, 2004; Scruggs & Mastropier, 2000). Since research supports using keyword mnemonics for increased vocabulary understanding, positive attitudes toward mathematics along with decreased anxiety may occur as a result of use, thereby positively influencing future mathematics achievement and perseverance.

Purpose of the Study

Given the importance of vocabulary (e.g., Aiken, 1972; Capraro & Joffrion, 2006; Gardner, 1992; Hills, 1981; Jackson & Phillips, 1983; Stahl & Fairbanks, 1986) and attitude toward mathematics (Brooks, 1992) to mathematics comprehension and achievement, the current study investigated the three components of (a) vocabulary knowledge, (b) mathematics achievement, and (c) attitudes toward mathematics to explore the effectiveness of keyword mnemonics in mathematics. Specifically, the purpose of this investigation was to determine the effects of direct instruction and direct instruction with embedded keyword mnemonic strategies in regular mathematics vocabulary instruction on the achievement, comprehension, and attitudes toward mathematics of third grade students in eleven Upstate South Carolina elementary schools. Quantitative analyses were used to determine differences between matched pairs of students randomly assigned to two groups. The contrast group received direct instruction in vocabulary, and the treatment group received direct instruction with embedded keyword mnemonics instruction. Quantitative analyses were conducted to determine significant differences between the groups on the measures of mathematics achievement and comprehension, as well as to document any changes in attitudes and self-efficacy toward mathematics over the course of the study. In this concurrent mixed model multi-strand design, qualitative assessments were used as authentic assessments of students' mathematics comprehension and understanding, providing explanatory data for quantitative results on vocabulary understanding.

Research Questions

The specific research questions that guided the study were:

- Is there a significant difference between scores on vocabulary assessments for third grade students taught mathematics vocabulary by direct instruction without keyword mnemonics and those taught by direct instruction with keyword mnemonics?
- Is there a significant difference between mathematics achievement measures for third grade students taught mathematics vocabulary by direct instruction without keyword mnemonics and those taught by direct instruction with keyword mnemonics?
- Is there a significant difference on student attitudes toward mathematics between third grade students taught mathematics vocabulary by direct instruction without keyword mnemonics and those taught by direct instruction with keyword mnemonics?

Definitions of Terms

Key terms used in this investigation are defined below:

Comprehension: Intentional thinking during which meaning is constructed through interactions between the content and the learner (Harris & Hodges, 1995).

Comprehension Strategies: Deliberate, planned procedures that learners use to actively derive meaning. Strategies may include cognitive strategies such as preparing, organizing, elaborating, and rehearsing (Gunning, 2005).

Low-performing learner: A learner who does not experience success in grade-level materials with fluency and comprehension (Flood, Lapp & Fischer, 2003).

However, these students do not qualify for special education assistance.

Self-efficacy: A self-judgment of a domain-specific ability to perform a task successfully (Bandura, 1977).

Students with disabilities: A student who has been identified with a disability that inhibits learning. These students have an Individual Education Plan on file and receive special education services in some form.

Vocabulary understanding: Knowledge of a word's meaning and its use. One model, developed by Stahl (1986), identifies four levels of word knowledge: (a) little to no knowledge, (b) associative processing, (c) comprehension processing and (d) generation processing.

CHAPTER TWO

REVIEW OF RELEVANT LITERATURE

The effectiveness of the keyword mnemonic strategy for mathematics vocabulary instruction is presented in this dissertation. This chapter provides a thorough review of the literature base and presents the research questions. It covers the topics of (a) Importance of Mathematics Achievement, (b) Reading Vocabulary, (c) Mathematics Vocabulary, (d) Difficulties with Mathematical Vocabulary, (e) Vocabulary Instruction, (f) Mnemonics, (g) Affective Components of Mathematics Success, and (h) Research Questions.

Importance of Mathematics Achievement

Students need a strong mathematical background for success in today's global economy. This emphasis on the attainment of high standards in mathematics began with the launch of Sputnik, gaining momentum in 1989 with the *Everybody Counts* report from the Mathematical Sciences Education Board (MSEB). This report stated that the "current mathematical achievement of U.S. students is nowhere near what is required to sustain our nation's leadership in a globally technological society" (MSEB, 1989, p.1). More current studies, such as The National Assessment of Education Progress (NAEP), found that American students often have trouble with higher level mathematical skills such as comprehension and problem solving (Perie, et al., 2005). The Third International Mathematics and Science Study and TIMMS-Repeat studies, both of which assess students in approximately 40 countries, confirm that students in the United States exhibit weaker mathematical skills than students in many other developed countries, especially those in Asia (Gonzales, et al., 2004).

The national weakness in mathematics led to public calls for more rigorous accountability measures monitored by increased assessment. Recent accountability reports, particularly those required by the *No Child Left Behind* Act, determine educational success ratings on the performance of all students. Although students in general struggle in mathematics, this subject is a real concern for low-performing students and students with disabilities. Difficulties in mathematics often make obtaining a basic high school diploma difficult for these students, especially since over 30 states now require a passing grade in Algebra for graduation.

Low-performing Students

The National Association of School Psychologists (NASP) defines low-performing students as “students with below average cognitive abilities who are not disabled, but who struggle to cope with the traditional academic demands of the regular classroom” (Carroll, 1998, p. 205). Low-performing students do not meet the criteria for special education identification, remaining in general education classrooms with students of all ability levels. These students perform below grade level but must meet standards established for average and above average students. According to Shaw and Gouwens (2002), “For this population, even minimal expectations of a regular classroom often exceed optimal levels of performance” (p.2). A study conducted by Kaznowski (2004) found there were few significant differences in school performance between low-performing students who did not qualify for special education and slow learners who did. More importantly, these significant differences occurred primarily in mathematics and reading grades given, where students with learning disabilities actually earned higher grades in their resource classes, than those earned by slow learners in regular classes. In

addition, low-performing students are generally not granted extra accommodations to assist in test-taking or when qualifying for a high school diploma as are students with an Individualized Education Plan (IEP) on file. This places low-performing students at a disadvantage, as are students with disabilities.

Students with Disabilities

Research consistently documents that the progress of students with disabilities in mathematics is very slow, about one year of growth for every two years in school (Fuchs & Fuchs, 2001), ultimately peaking at approximately a fifth grade level with very little progress evident between the ages of 10 and 12 (Wagner, 1995). Research shows that weaknesses are especially evident in computation and problem solving, and that these weaknesses limit the success of these students in mathematics even in lower grades (Cawley, Parmar, Yan, & Miller, 1996). However, merely identifying areas of difficulty is very different from determining effective instructional methods to address these areas in mathematics.

Reading Vocabulary

The reading research base is much more robust than the mathematics base in many ways. Specifically, reading research has identified several factors that contribute to reading success. In 1997, Congress asked the Director of the National Institute of Child Health and Human Development (NICHD) and the Secretary of Education to convene a national panel to assess the effectiveness of various approaches to reading instruction in existing research base. The National Reading Panel (NRP) reviewed over 100,000 studies identifying five critical factors for reading success; (a) alphabeticity, (b) fluency, (c) comprehension, (d) teacher education and reading instruction, and (e) computer

technology and reading instruction. Of these, comprehension was deemed the “essence of reading” (NICHD, 2000) with its three components of vocabulary instruction, text comprehension instruction, and teacher preparation and comprehension strategies instruction being identified as the foundation for developing the ability (NICHD, 2000).

In 1999, the Department of Education's Office of Educational Research and Improvement (OERI) asked The Reading for Understanding (RAND) research group to examine how to improve the quality and relevance of funded educational research in reading. The subgroup created, the RAND Reading Study Group, subsequently defined reading comprehension as “the process of simultaneously extracting and constructing meaning through interaction and involvement with written text” (RAND, 2002, p. 11). This subgroup found that to comprehend, a student must have cognitive capacities, motivation, and background knowledge, with vocabulary understanding identified as one of the components of the latter. According to this subgroup report, vocabulary development can contribute to increased comprehension, providing a sound basis for focused vocabulary instruction (RAND, 2002).

An examination of effective intervention practices found that vocabulary instruction as a component of reading comprehension had an effect size of .79 in one study and .62 in another. These strong effect sizes support that vocabulary contributes strongly to reading comprehension (Mastropieri, Sweda, & Scruggs, 2000). Laflamme (1997) reported, “researchers have acclaimed vocabulary knowledge as the single most important factor in reading comprehension” (p.1).

Levels of Vocabulary Understanding

However, vocabulary knowledge is not a simple construct. Nagy and Scott (2000) identified the complexity of word meanings and the metalinguistic sophistication required by most vocabulary related tasks as two main difficulties in vocabulary acquisition. Although definitions are the traditional way to teach meaning, Stahl (1986) found that definitions do not provide adequate understanding of the concept. Students can gain word knowledge in this manner, but only if given other information about the word along with application opportunities. Additionally, verbs and abstract nouns may be more difficult to learn from definitions than concrete nouns.

The second difficulty, metalinguistic sophistication, is especially a problem in the lower grades because fundamental concepts about words as units of form and meaning are still developing. Piaget (Piaget, 1926; as cited in Nagy & Scott, 2000) claimed that children do not recognize words as arbitrary labels for things until the age of nine or ten. However, educational accountability requires students younger than this to learn specific, technical vocabulary terms and to understand the concepts represented as well. This would necessitate the students having high levels of vocabulary understanding.

It is generally accepted that there are varying levels of vocabulary understanding, which represent the level of comprehension attained, but there is no one accepted model for delineating these levels. A model developed by Stahl (1986) identifies four levels of word knowledge: (a) little to no knowledge, (b) associative processing, (c) comprehension processing and (d) generation processing. In the lowest level of understanding, little to no knowledge, the student does not remember hearing the word before or cannot remember what it means. In the associative processing level, the student

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can link the word to a synonym, a definition, or a specific context. In the comprehension processing level, the student can use the word in context and can fill in a blank or can group similar words together. In generation processing, the highest level, the student can use the word in expressive vocabulary and in multiple contexts. These levels delineate the process students move through as they assimilate a new vocabulary term into their knowledge base. The highest level is obviously the goal since knowledge at this level indicates a solid understanding of the term.

If the definition of reading comprehension is applied to mathematics, then mathematics comprehension becomes the process of extracting and constructing meaning through written text in mathematics, indicating that comprehension is as important in mathematics as it is in reading.

Mathematics Vocabulary

Several researchers have found a similar relationship in mathematics between vocabulary and comprehension, identifying vocabulary understanding as a key component in understanding mathematics (Miller, 1993). In examining the role that vocabulary plays in mathematical understanding, Lindgren, Roberts, & Sankey (1999) said, “Mathematics is a language. Reading a mathematics text is somewhat like reading Tolstoy's *Anna Karenina* in the original Russian” (p. 16). Adams (2003) stated that weakness in students’ mathematics ability is often due to difficulties in reading “the language of mathematics” (p. 787). In other words, learning the vocabulary of mathematics is like learning a new language and students must understand this language if they are to communicate and apply mathematics with proficiency (Monroe, 2002).

Early studies by Dresher (in Aiken, 1972) found gains in problem-solving ability when students received specific training in mathematics vocabulary. Stahl and Fairbanks (1986) found that mathematics vocabulary instruction directly improves mathematics comprehension while the research of Capraro and Joffrion (2006) demonstrated that a weak understanding of the vocabulary handicaps a student in mathematics. These findings were further supported by an experimental study of mathematics vocabulary which indicated that students who received specific vocabulary instruction achieved higher scores than their control group counterparts (Jackson & Phillips, 1983).

A report from the Department for Education and Employment (DfEE) in the United Kingdom also stressed that mathematical vocabulary is critical to understanding;

If children don't have the vocabulary to talk about division, or perimeter, or numerical difference, they cannot make progress in understanding these areas of mathematical knowledge. Teachers often use informal, everyday language in mathematics lessons before or alongside technical mathematical vocabulary. Although this can help children to grasp the meaning of different words and phrases, you will find that a structured approach to the teaching and learning of vocabulary is essential if children are to move on and begin using the correct mathematical terminology as soon as possible (p. 2).

As Miriam A. Leiva, president of TODOS: Mathematics for All, testified before the National Math Panel (2007), vocabulary must be a central point of investigation as it begins its analysis of the research. Therefore, many mathematicians and researchers have

demonstrated that mathematics vocabulary understanding is an important component of mathematics comprehension.

Difficulties with Mathematical Vocabulary

Many mathematicians consider mathematics a language, with its own specific meanings and symbols (Lindgren, 1999). According to Adams (2003), “The words, symbols, and numerals that give the discipline its substance, framework, and power are the same words, symbols, and numerals that students must use to communicate ideas, perform procedures, explain processes, and solve problems” (p. 794). This relationship implies that learning mathematical vocabulary is similar to learning a new language, perhaps contributing to the difficulty low-performing students and students with disabilities have with mathematics.

There are many components unique to mathematics vocabulary that cause problems for these lower performing students. The variety of usage as well as the context of mathematics vocabulary compounds the already difficult problem of students who possess low basic reading skills (Dolgin, 1977). Miller (1993) found that problem solving is often difficult for low-ability readers because mathematics vocabulary not only includes words specific to components and processes of mathematics but also includes unique usage of everyday words. For example, a problem asking for students to compute the *difference* between two values would be confusing if the student did not know that this word is used in mathematics class to represent the answer to a subtraction problem.

In her testimony to the National Math Panel in July 2007, Miriam A. Leiva, President of TODOS: Mathematics for All, emphasized the need for more mathematics vocabulary research, because of its importance to mathematics comprehension:

Mathematics Vocabulary Instruction

Communication in mathematics is complex because it takes so many modes: words in English or the academic language of mathematics, symbols, graphs, through visuals, manipulatives or models, etc. Mathematics is a language with its own syntax, grammar, words, phrases and sentences.

Students *whose first language is English* have difficulty with word problems: for example, in a problem in the NC End of Course Assessment there was a question about ‘toll roads’ but there are no toll roads in our state. Many students that could do the math were stumped because of the language. This difficulty is then confounded when we are dealing with words ***that are not*** part of the student’s experiences, culture, background, and even language.

As Ms.Leiva explained, mathematics vocabulary has many levels of form and usage. Table 2.1 below illustrates the four categories used to classify mathematics vocabulary: (a) technical, (b) subtechnical, (c) general, and (d) symbolic (Monroe & Panchyshyn, 1995).

Table 2.1

The Four Categories of Mathematical Vocabulary

Category	Definition
Technical	Terms specific to mathematics and difficult to express in everyday words, for example, integer
Subtechnical	Terms that may have a meaning outside of mathematics but that have a meaning specific to mathematics, for example, plane
General	Terms not specific to mathematics but that have vague, general meanings and are not considered specific enough to define, for example, greater than
Symbolic	The many symbols used in mathematical expressions; for example, =, < and >.

Monroe and Panchyshyn (1995)

Technical vocabulary consists of terms which represent mathematical concepts difficult to express in everyday words. For example, integer and quadrilateral are technical terms with one meaning and that meaning is specific to mathematics. In addition, specific definitions unique to the subject are often defined by other technical terms, making learning these similar to learning a foreign language.

Subtechnical terms have more than one meaning. Students may know one of the more common meanings but may not be familiar with the mathematical definition. For example, volume and plane are two subtechnical terms. Although they are familiar, the mathematical definitions may not be. Because of the varied meanings, learning

subtechnical terms may be even more difficult than the technical ones as low-performing students and students with disabilities may struggle understanding new definitions of words they are already familiar with in other contexts. For example, most students have an understanding of the commonly used word *plane*; however, during geometry units, this word takes on an entirely different meaning, one for which the original understanding provides no context, further compounding the problem (Carter & Dean, 2006). Therefore, students learning mathematics must learn the meanings of new words as well as new meanings for words they already know. (National Institute for Literacy, cited in Capraro & Joffrion, 2006).

General vocabulary words make up the greatest number of unknown words, yet these are typically ignored in mathematics instruction. Mathematics textbooks often fail to define these words adequately, making comprehension even more difficult.

Panchyshyn and Monroe (1992) report that more than 50% of the general vocabulary terms used in elementary mathematics textbooks are not used frequently in other reading materials. As a result, students are not exposed to the correct meanings of these words unless the teacher specifically plans for vocabulary instruction. For example, a teacher who asks, “What is the difference between 9 and 4?” could get a wide range of answers from “9 is odd and 3 is even” to “5” to “one has a circle and one has a triangle.” Students are also taught the terms and symbols for greater than and less than at an early age.

However, the word *greater* can mean something that is just better, not necessarily larger, confusing novice learners.

The mathematics symbolic vocabulary presents difficulty as well. Mathematics uses not only the alphabet but numerous other symbols as well. Abbreviations are often

used, as well as symbols representing specific operations and others that explain the power or use of a numeral at any given time, as in fractions and exponents, such as $\frac{2}{3}$ or 4^2 . The symbols $<$ and $>$ are introduced very early and children often remain confused for many years as to which symbol represents greater than and which is less than. The crocodile mouth analogy is frequently used to help them fill in the blanks with the symbol pointed in the right direction.

Another problem is mathematical vocabulary is not reinforced outside the classroom in the same way reading vocabulary is supported (Capps & Pickreign, 1993). Most of the terminology specific to mathematics never becomes a topic discussed over the dinner table or while riding in a car pool. Thus, students may never hear the term *obtuse angle*, for example, mentioned at any time other than during a 50-minute mathematics class in the middle of the year when the geometry unit is presented.

Aside from specific vocabulary issues in the language of mathematics, there are other confounds. It is commonly accepted that “curriculum drives instruction” in education because a high percentage of what goes on in the classroom is dictated by textbooks. Therefore, weaknesses in textbooks often translate directly into weaknesses in instruction. For example, one such curricular problem is the readability level of mathematics textbooks. Even accomplished readers often have difficulty reading and comprehending the texts of common mathematics curricula, and low-performing students and students with disabilities, already functioning and reading below grade level, have been found to have difficulty reading higher level definitions (Jones, 2001). This problem is particularly evident in third grade, the year in which Pickreign (1996) found the sharpest increase in the number of new words and phrases presented typically occurs in

mathematics textbooks. In addition, it is the first year of standardized testing, meaning that every student beginning in third grade takes high stakes achievement tests to measure mathematical achievement, especially important given the current emphasis on accountability.

Effective Vocabulary Instruction

Hogue (2003) stressed that vocabulary must be learned to mastery, due to its critical role in students' mathematical success. It is not enough, then, that students simply be exposed to new vocabulary word;, they must completely understand them if the goal is mathematical ability. One or two exposures to a new word or simply memorizing the definition does not improve comprehension or increase vocabulary (Stahl, 1986). Bryant, Goodwin, Bryant, & Higgins (2003) stated, "effective vocabulary instruction consists of providing numerous encounters with words and concepts with discussions and opportunities to use these words and concepts across a variety of contexts" (p.5).

Though research shows students must be exposed to a word several times before it is learned, vocabulary is often not reinforced multiple times within the classroom. In one study, Miller (1993) reported interviews with teachers who said they did not use the word *quotient* during a lesson because they knew that the students would not know its meaning. Another teacher was observed teaching a lesson on denominator and numerator, though she did not use those terms even once in the lesson (Miller, 1993). Even when the term is used in the lesson, it is often not repeated enough for low-performing students and students with disabilities to become familiar and comfortable with it.

Curricular issues also contribute to this problem. Some of the new reform mathematics curricula use the spiral approach, which presents new material at an

introductory level at first, then moves on to other material. The original material is then revisited several times throughout the year, though at a higher level. The National Math Panel has already focused on this method as being detrimental to student learning as the material is not presented to mastery the first time, yet is revisited at a higher level weeks later (National Math Panel, 2007).

Students must become confident and proficient in their mathematics vocabulary in order to succeed and advance to higher level mathematics (Monroe, 2002). Because of the importance of vocabulary mastery to mathematical comprehension and the high incidence of unfamiliar vocabulary in mathematics, effective instruction of unknown words becomes central to mathematical achievement (Monroe and Orme, 2002).

Although there is no one accepted model vocabulary understanding levels, this research used a model developed by Stahl (1986) that identifies four levels of word knowledge: (a) little to no knowledge, (b) associative processing, (c) comprehension processing and (d) generation processing. To ensure mathematical success, it is important that students learn mathematics vocabulary words well and attain the highest level of vocabulary understanding possible.

The National Council of Teachers of Mathematics (NCTM, 2000) places all mathematical problems in realistic applications using contextualized instruction. These reform-based mathematics textbooks do not offer the clear, direct vocabulary support necessary for students with learning disabilities and often present many ideas at the same time, compounding the issue (Baxter, Woodward, & Olson, 2001) and typically require students to determine their own meaning of words by analyzing the context in which they are used (Pickreign, 1996). Research conducted with low-performing students and

students with disabilities suggest they do not succeed in this “figure it out for yourself” type of learning (Baker, Gersten & Lee, 2002; Swanson, 1999).

Research by Griffin (1992) suggested that contextual learning may work for advanced learners but not lower level learners. This finding is supported by research conducted in 1989 suggesting that students learned vocabulary taught directly more effectively than vocabulary learned in context (Jenkins, Matlock, & Slocum, 1989). In fact, Baker, Gersten & Lee (2002) conducted a meta-analysis of studies comparing explicit instruction to contextualized instruction with low-performing students and students with disabilities. This study found the overall effect size of the studies with contextualized instruction to be .01, basically a zero effect, but a positive, moderately strong effect (.58) for the approaches that used explicit. This meta-analysis included results from a study by Woodward, Baxter, & Robinson (1999; cited in Baker, Gersten & Lee, 2002) on the effect of the *Everyday Mathematics* program, a reform-based mathematics curriculum, with students with disabilities, finding a negative effect size of -.24 (Woodward, Baxter, & Robinson, 1999).

In addition, the National Math Panel report in September, 2007 (National Math Panel) reported that explicit instruction is necessary for at least the bottom third of the students. Baker, Simmons, and Kameenui (1995) also argue that clear, explicit instruction is generally more effective for teaching vocabulary than is contextual learning. Therefore, the conclusion that incidental learning is not effective with low-performing students and students with disabilities is supported by much research (Baker, Gersten & Lee, 2002; Baker, Simmons, and Kameenui, 1995; Baxter, Woodward & Olson, 2001; Gardner,

1992; Griffin, 1992; Jenkins, Matlock, & Slocum, 1989; Johnson et al., 1983; Woodward, Baxter, & Robinson, 1999).

Simply put, explicit instruction increases vocabulary acquisition (Harmon & Hedrick, 2005). According to Vacca and Vacca (1996), “Most vocabulary words need to be taught directly and taught well.” Clear and direct instruction appears to play an important part in mathematics achievement since an exact and well-understood definition is an important factor in developing a clear understanding of the concepts taught (Carter & Dean, 2006). This is not to neglect concept development, of course and merely means that teachers should clearly explain the concept while directly presenting the new vocabulary term. In fact, an early research review indicated that providing conceptual information along with definitional information, called mixed methods, appears to produce significantly better vocabulary achievement than methods providing only one set of information (Stahl & Fairbanks, 1986). In fact, the methods that provided definition-only information did not produce reliable gains in comprehension, nor did methods that provided only one or two exposures of the words.

Nagy (1988) characterized effective vocabulary instruction as including three components: integration, repetition and meaningful use. First, instruction that relates the new vocabulary terms to the concept needs to occur, stressing the importance of connecting new learning with prior knowledge. In mathematics, this would include conceptual development, not mere definition memorization, which is frequently the form of vocabulary instruction utilized. Repetition, the second feature, refers to the need to provide sufficient practice so that the meaning of the new term can be accessed easily. The last feature is meaningful use, which is tied to the level of processing needed to

perform a task. This is the level at which students are engaged in using the word meanings, suggesting that the more complex the activity or application, the higher the level of processing of the vocabulary word. Promoting vocabulary learning, then, focuses on the comprehension of the concept and not on word knowledge alone (Harmon, Hedrick & Wood, 2005). Therefore, concept development is an important consideration in mathematics.

A meta-analysis of effective instructional techniques shows that the most effective strategy for teaching low-performing students and students with learning disabilities combines components of direct instruction (teacher-directed with student engagement) with components of strategy instruction (teaching ways to learn such as memorization techniques and study skills) (Swanson, 1999). In other words, teachers should teach students how to remember as well as what to remember. These goals can be accomplished using a variety of direct instruction strategies, but by far the most powerful have been the keyword method, the pegword method, and letter strategies; i.e., mnemonics (Mastropieri and Scruggs, 1998).

Mnemonics

Elaboration has emerged as an important component in academic success and current research shows that high achieving students rely more than low achieving ones on elaboration when learning mathematics (Fathi-Ashtiani, Hasani, Nabipoor-Ashrafi, Ejei, & Azadfallah, 2007).

Mnemonic techniques, considered elaboration strategies, facilitate knowledge by assisting in the encoding process. New material is connected then encoded to familiar material through both direct and indirect paths, aiding in the retrieval of the information

at a later time (Levin & Levin, 1990). This process is especially effective when the student has little or no prior knowledge of the material essentially creating new connections for it.

Mnemonics strategies consist of several different yet related strategies, including letter strategies, pegword strategies and keyword strategies. These strategies have been the subject of educational research for the past 30 years, showing positive results with students with disabilities. The focus of the research reported here is the keyword mnemonic strategy, which incorporates components of clear, direct instruction with visual and acoustic cues that aid in connecting, encoding, and retrieving the new information.

Keyword Mnemonics

The keyword mnemonic technique was used in the 1970's by Atkinson to facilitate the learning of foreign language vocabulary (1975). Because of this success, keywords have been utilized and studied in many content areas and across many grade levels. Research studies have consistently demonstrated that the keyword mnemonic strategy has one of the largest effect sizes of any intervention used in special education (Forness, Blum, & Lloyd, 1997). In a meta-analysis of research on mnemonic strategies, the overall effect size was 1.62 (Mastropieri, & Scruggs, 1989), indicating a high level of effectiveness.

As mentioned, keywords have been studied in many content areas and across various grade levels. A review of research by Stahl & Fairbanks (1986) found that keyword methods produced consistently strong effects on measures of definitional and contextual vocabulary knowledge. Mastropieri, Scruggs, & Levin (1985) investigated the

use of keyword mnemonics and found significant results in teaching hardness of minerals to middle school students. In the latter study, seventh grade students with disabilities taught using keyword mnemonics outperformed nondisabled students taught using free study methods. Another study by Mastropieri & Scruggs (1992) utilized keywords with scientific vocabulary and found significance. King-Sears & Sindelar (1992) also found significance in science instruction when using keyword mnemonics with students with disabilities in middle school. Veit, Scruggs, & Mastropieri (1986) investigated the use of keyword mnemonics to teach middle school students with disabilities dinosaur names and facts. Again, the keyword group outperformed the direct instruction group. Mastropieri & Scruggs (1992) examined using keywords for teaching students with disabilities scientific phenomena and achieved significant results. Scruggs & Mastropieri (1992) also investigated using keyword mnemonics with science content, contrasting the keyword method with direct instruction and finding significance in both the instruction as well as student satisfaction.

Other content areas have utilized keyword mnemonics as well. For example, Laufenberg & Scruggs (1987) used keyword mnemonics to successfully increase digit span recall in middle school with students with disabilities. Mastropieri and Scruggs research conducted in 1988 found that keywords promoted greater recall of United States history content in students with disabilities in middle school and included a student satisfaction component. In this study, students using the keyword mnemonic method were more satisfied with the method and with their own learning than were students taught using free study methods. A later study by Mastropieri, Scruggs, Bakken &

Brigham (1992) used keyword mnemonics to teach state capitals to students with disabilities and also found increased student satisfaction.

Mastropieri, Scruggs, & Fulk (1990) also investigated using keyword mnemonics to teach abstract vocabulary with middle school students with disabilities, resulting in higher levels of comprehension. Although most keyword studies have taken place in either a laboratory setting or in the classroom conducted by researchers, Mastropieri, Sweda, & Scruggs (2000) investigated keywords in a classroom setting with instruction conducted by the classroom teacher with all African-American fourth graders. The keyword method proved significantly better, with the researchers noting the importance of sufficient repetition and extensive up-front practice with this level of student.

Sharkin, Morh, & Glover (1983) investigated the impact of keyword mnemonics on the retention of obscure and moderately obscure words, finding that the effect of the strategy was stronger with the more obscure words. This study also discovered that keywords need not be acoustically similar, allowing future research to include words with less-than-perfect acoustical matches. Levin, McCormick, Miller, Berry, & Pressley (1982) used keyword mnemonics to teach new vocabulary words to fourth grade students with disabilities with results from using keyword mnemonics for vocabulary instruction superior to contextual vocabulary instruction. Terrill, Scruggs, & Mastropieri (2004) taught SAT vocabulary words to high school students with disabilities, resulting in significantly higher vocabulary recall in the keyword condition than the free study condition. Wyra, Lawson, & Hungi (2007) used keyword mnemonics with middle school students and found the method remains useful for the acquisition of foreign language vocabulary with the proper training. Uberti, Scruggs, & Mastropieri (2003) utilized

keywords with third graders in the classroom and again found the students with disabilities outperformed students without disabilities who were taught using another method.

Not all keyword research has received significant results, however. Although Pressley (1987) and Rosenheck, Levin, & Levin (1989) successfully used keyword mnemonics with university students, other research studies did not find significance with this population. For example, Campos, Gonzalez, & Amor (2003) used both undergraduate students and secondary students, finding no effects. They also stated that the method was difficult to use in a classroom setting.

In addition, Carney and Levin (1998) report questionable results of using keyword mnemonics on long-term retention of the learned information (Thomas & Wang, 1996; Wang & Thomas, 1995; Wang, Thomas, Inzana, & Primicerio, 1993; Wang, Thomas, & Oulette, 1992). However, the length of delay between tests varied greatly in these studies. For example, Wang and Thomas (1995) tested for retention after only two days, during which the control group demonstrated higher results. Carney and Levin (1998) found that after both two- and five-day delayed tests, there were no differences between the two groups. However, Carney and Levin (1998) concluded that mnemonic participants had the same or higher rates of retention than did free study college students. Again, these non-significant studies were all conducted with college students, who may have developed other elaborative techniques.

Another keyword mnemonic concern surfaced in a study by Johnson, Adams, & Bruning (1985) where the authors concluded that keyword mnemonics were effective with concrete terms but ineffective with abstract vocabulary words. Pressley and Levin

(1985) suspected methodological problems in the study, suggesting future research. A follow-up study conducted by Mastropieri, Scruggs, & Fulk (1990) did find significance using keyword mnemonics with abstract vocabulary and even found higher levels of comprehension for the keyword group. This abstract term issue is of special importance to this research study in mathematics vocabulary.

In summary, keyword research has been conducted in many content areas, settings, group sizes, from the third grade up, including (a) foreign language vocabulary (Mastropieri et al., 1985), (b) science content (Mastropieri, Scruggs, & Graetz, 2003), (c) names and order of U.S. Presidents (Mastropieri, Scruggs, & Whedon, 1997), and (d) name of states and capitals (Mastropieri, Scruggs, Bakken, & Brigham, 1992). Other than a few studies on university students, these studies have consistently demonstrated that keyword mnemonics not only improve the learning of specific vocabulary terms but improves comprehension as well (Mastropieri, Scruggs, McLoone, & Levin, 1985; McLoone, Scruggs, Mastropieri, & Zucker, 1986).

As an elaboration strategy, keyword mnemonics relies on associative mnemonic techniques referred to as the three Rs: recoding, relating, and retrieving (Levin, 1983). The new, unfamiliar information is recoded into something familiar and concrete. These concrete substitutes are then represented by a picture, which forms a retrieval mechanism in the learner. In other words, students are taught the definitions of new vocabulary terminology by linking an acoustically similar word with the new word to be learned and then using a picture of this similar sounding word as a retrieval cue to connect to the essential information (Atkinson, 1975; Kavale & Forness, 1999; Mastropieri & Scruggs, 1989).

The first step in developing keyword mnemonics is to identify the target vocabulary, after which a keyword for each is selected. This keyword should be familiar to the student and should sound like the new vocabulary word being taught. It is also important that this keyword be easily visualized. For example, Mastropieri and Scruggs (2007) suggest using straw for the Italian word strada (which means road) because they sound similar and because straw is easy to illustrate. Next, a picture of the keyword is depicted with the meaning of the new term. In the example of strada, the picture could be straw on a road.

It is important to remember mnemonic strategies are encoding and retrieval strategies. The fact that students perform better on comprehension assessments when using mnemonics merely attests to the effectiveness of the strategy in helping students remember more information. The basic understanding and concept development of the terms must still be facilitated by the teacher, although research has shown that mnemonic strategies do not inhibit this comprehension development (Mastropieri, McLoone, Levin, & Morrison, 1987; Mastropieri, Scruggs & Fulk, 1990). It is also important to remember that two elements critical to this instruction are sufficient repetition and the use of practice-application activities (Mastropieri, Sweda, & Scruggs, 2000).

Affective Components of Mathematics Success

Studies show that affective factors such as motivation and attitude do impact student achievement (Cote & Levine, 2000; Singh, Granville & Dika, 2002). Analyses of TIMSS data, including interest surveys, suggests that most United States mathematics curricula need to place greater emphasis on attitudes towards learning mathematics since they are salient predictors of academic performance (Reynolds & Walbert, 1992). The

National Math Panel also acknowledged that anxiety about mathematics performance is correlated to low test scores. Therefore, it is important to use interventions that significantly reduce anxiety while still improving test scores (National Math Panel, 2007).

Self-efficacy is related to a positive attitude toward mathematics. Defined as self-judgment of a domain-specific ability to perform a task successfully (Bandura, 1977), it is a predictor of both mathematics and science achievement as well as avoidance (Reynolds & Walbert, 1992). Regardless of the method of instruction, students are likely to exert effort according to the effects anticipated, regulated to a large extent by the importance attached to mathematics, the enjoyment of the material, and the motivation to succeed (Tapia & Marsh, 2004).

Keyword mnemonic research has been shown to be effective in increasing mathematics comprehension. In addition, students indicate a preference toward learning using keyword mnemonics than with other methods (Scruggs & Mastropieri, 2000; Terrill, Scruggs, & Mastropieri, 2004). As a result, this strategy could facilitate positive attitudes toward mathematics and reduced anxiety, thereby positively affecting future mathematics achievement and perseverance.

Since vocabulary understanding has been identified as a major factor in mathematics comprehension and since the keyword mnemonic strategy is one of the most effective interventions for developing this understanding, this strategy is a logical choice for mathematics vocabulary instruction. However, an intensive internet, ancestral, and hand search found no research studies investigating the use of keywords for the purpose of mathematics vocabulary instruction to date. Therefore, this project examined the use of

the keyword mnemonic strategy for mathematics vocabulary instruction on both vocabulary mastery as well as overall mathematics achievement. The study also examined whether the use of the keyword mnemonic strategy in mathematics vocabulary increased students' self-efficacy and positive attitudes toward mathematics.

CHAPTER THREE

RESEARCH DESIGN AND PROCEDURES

The purpose of this study was to investigate the effectiveness of the keyword mnemonic strategy for mathematics vocabulary instruction. After defining the literature base and research questions, this chapter continues with five other sections, including (a) Purpose and Research Questions, (b) Participants, (c) Setting, (d) Research Design, (e) Measures and Data Collection, and (f) Procedures.

Purpose and Research Questions

Vocabulary understanding is an important component of comprehension in reading as well as other content areas, including mathematics (Adams, 2003; Capraro & Joffrion, 2006; Miller, 1993). However, teachers often do not emphasize vocabulary in their daily instruction, expecting students to derive vocabulary meaning from the context of the lesson. Low-performing students who do not learn well from contextual cues need clear, explicit instruction, especially in foundational content (Baker, Gersten, & Lee, 2002; Harmon & Hedrick, 2005; Vacca & Vacca, 1996).

Since vocabulary is a major component of mathematical comprehension and low-performing students typically struggle in this area, it is imperative teachers use effective strategies for vocabulary instruction. The keyword mnemonic strategy is one especially effective instructional strategy for vocabulary instruction in many content areas, including science and social studies (Mastropieri & Scruggs, 1992; Mastropieri, Scruggs, Bakken, & Brigham, 1992); however, there is little research on the use of the keyword mnemonic strategy in mathematics vocabulary instruction. The purpose of this study is to

explore the use of the keyword mnemonics strategy in mathematics vocabulary instruction.

The specific research questions that guided the study were:

- Is there a significant difference between scores on vocabulary assessments for third grade students taught mathematics vocabulary by direct instruction without keyword mnemonics and those taught by direct instruction with keyword mnemonics?
- Is there a significant difference between mathematics achievement measures for third grade students taught mathematics vocabulary by direct instruction without keyword mnemonics and those taught by direct instruction with keyword mnemonics?
- Is there a significant difference on student attitudes toward mathematics between third grade students taught mathematics vocabulary by direct instruction without keyword mnemonics and those taught by direct instruction with keyword mnemonics?

Participants

In early December of 2007, principals of 17 elementary schools in the southeastern United States were contacted about participating in a research study investigating effective mathematics vocabulary instruction. Thirteen schools expressed interest in the project. The researcher met with the interested principals, mathematics coaches, and/or teachers to present more information about the project; 11 schools subsequently agreed to participate.

Participating Schools

Participants included 771 third-grade students in 42 classrooms from 11 elementary schools across three rural southeastern school districts. The participating three districts ranged in size from 10,411 to 16,608 students. The free/reduced lunch ratios ranged from 42% to 60% of the student population (See Table 3.1).

Table 3.1

Demographics of Participating Districts

District	Total Teachers	Total Students	Free/Reduced Lunch Status
1	1,063	12,000	60%
2	900	10,411	52%
3	1,122	16,608	42%

The student populations of these 11 participating schools ranged from 287 to 901 enrolled students, including a school with 81% African-American students, one with 23% Hispanic students, and one school with 98% Caucasian students. The free/reduced lunch percentages ranged from 25% to 83% of the school populations (See Table 3.2).

Table 3.2

Demographics of Participating Schools

District	School	Number of Teachers	Number of Students	Free/Red. Lunch	African-American	Hispanic	Cauc.	Other
1	1-2	30	365	83%	66%	3%	31%	0
1	1-1	24	485	72%	81%	2%	17%	0
2	2-1	27	684	72%	4%	23%	71%	2%
2	2-3	17	371	73%	50%	4%	44%	2%
2	2-2	15	454	69%	36%	3%	59%	2%
2	2-6	16	487	66%	5%	2%	93%	0
3	3-1	37	901	58%	7%	1%	91%	1%
2	2-4	12	287	54%	1%	1%	98%	0
2	2-5	20	472	40%	2%	8%	89%	1%
3	3-3	19	510	39%	1%	1%	98%	0
3	3-2	24	674	25%	21%	1%	72%	6%

Participating Teachers

Of the original 42 teachers, four dropped out of the project due to time concerns.

In addition, the data from five other teachers were not included in the final analyses

because of failure to administer all measures or because of inaccuracy in the

administration of the measures. Of these nine losses, two were treatment group classes, the remaining seven were contrast group classes. The final analysis, thus, included 33 participating teachers. Of these, 31 were females and one was male; all teachers but one were Caucasian. Two teachers were National Board Certified, and 32 were Highly Qualified. Years of teaching experience ranged from one year to 34 years; the mean being 11.7 years, the median nine years, and the mode one year of teaching experience (n=5).

Participating Students

The participants consisted of 207 matched pairs of third grade students (n=414) for the pre-test/post-test/follow-up measure. The student participant population consisted of 55% male and 53% free/reduced lunch status. Table 3.3 reports the complete demographics.

Table 3.3

Demographics of Participating Students (n = 395)

Gender

55% Male (n = 217)

45% Female (n = 178)

Ethnicity

75% Caucasian (n = 296)

15% African-American (n = 60)

7% Hispanic (n = 28)

3 % Other (n = 11)

Lunch Status

53% Free/Reduced (n = 210)

47% Regular Price (n = 185)

English Proficiency

95% Proficient (n = 375)

4% Not proficient (n = 20)

Disabilities

83% Not identified (n = 322)

17% Identified disability (n=65)

23% Speech (n = 15)

63% Learning Disabilities (n = 41)

14% Other (n = 11)

0.7% Emotional Disorders (n = 3)

0.2% Hearing Impaired (n = 1)

Table 3.3, Continued

Demographics of Participating Students (n = 395)

0.2%	Orthopedic Handicap (n = 1)
0.7%	Other Health Impairment (n = 3)
0.7%	Mental Retardation (n = 3)

All three of the participating districts administer the Measures of Academic Progress (MAP) benchmarks tests three times per year. According to the *Technical Manual for the NWEA Measures of Academic Progress and Achievement Level Tests* (NWEA, 2003), the reliability for MAP third grade measures is .84. NWEA provides cut scores aligned with South Carolina state assessment ability levels for instructional use in grouping students. Teachers across the state use these scores to group as follows: Below Basic (<22nd percentile, score of <193), Basic (22nd-70th percentile, scores 193-207), Proficient (71st-90th percentile, scores 208-216) and Advanced (91+ percentile, scores >216).

Though only 17% of the students had identified disabilities (n=65), participating students in general were low-performing, as indicated by district MAP scores. These scores indicate that approximately 76% of the participating students have performance levels in the two lowest categories of Basic or Below Basic, indicating minimal or less than minimal achievement. See Table 3.4 for the breakdown of these percentages compared to statewide percentages for each ability level.

Table 3.4

South Carolina Mathematics Performance Levels and Percentages of Research

Participants in Each Category Compared to Statewide Percentages

Below Basic (1)	Basic (2)	Proficient (3)	Advanced (4)
37% of participants	38% of participants	14% of participants	7% of participants
19% statewide	46% statewide	23% statewide	12% statewide

Setting

Thirty-one of the participating classrooms were general education classrooms and two were special education. All instruction took place in the mathematics classroom of the students and by the students’ mathematics teacher. Ten schools grouped heterogeneously for mathematics, one school (n = 6 participating teachers) used MAP Total Mathematics cut scores to divide the students into the four ability levels.

Research Design

A mixed model multi-strand research design was employed to examine the effectiveness of the keyword mnemonic instructional strategy. The quantitative data analysis used a quasi-experimental within-subjects matched pairs design to control for differences between the groups. Each participating third grade teacher was matched to a comparable peer teacher. These matches were based on years of experience and Highly Qualified status, thereby strengthening the design by minimizing differences between teachers. The students within these matched classrooms were then randomly matched according to pretest scores ($\alpha = 0.94$) to control for prior knowledge. A paired samples t

test found no significant difference between the two groups on the pretest, $t(204)=0.143$, $p = 0.887$.

Measures and Data Collection

As this research is a mixed model multi-strand research study, both quantitative and qualitative measures were used, as can be seen in Table 3.5 below. The researcher scored all vocabulary assessments and writing prompts, and transcribed and analyzed the student interviews. Research assistants helped enter Curriculum-Based Measurement (CBM) data and survey data. CBM data was scored in a computer program.

Table 3.5

Assessment Instruments

Quantitative Measures	Qualitative Measures
Vocabulary pre/post/follow up assessment	Writing prompt responses
Curriculum-Based Measurement probes	Focal student interviews
Pre- and post-study student surveys	
Post-study teacher surveys	

Quantitative Assessments

Vocabulary Assessment

To assess student growth in vocabulary understanding, students completed the researcher-developed vocabulary assessment. Repeated measures ANOVA, a within-groups analysis, was used to determine if there were significant differences between the two groups across the pre-, post-, and follow-up tests.

The main researcher developed the vocabulary assessment with assistance from a faculty member having expertise in educational psychology. Different sections of the assessment evaluated different levels of vocabulary understanding. Since there is no one accepted model of vocabulary development, this research used a model developed by Stahl (1986) which identifies four levels of word knowledge: (a) little to no knowledge, (b) associative processing, (c) comprehension processing and (d) generation processing. In the lowest level of understanding, little to no knowledge, the student does not remembering hearing the word before or cannot remember what it means. In the second level, associative processing, the student can link the word to a synonym, a definition, or a specific context. In the third level, comprehension processing, the student can use the word in context, can fill in a blank or group similar words. In the highest level, generation processing, the student can use the word in expressive vocabulary and in multiple contexts. These four levels delineate the stages students move through as they assimilate a new vocabulary term into their knowledge base. The highest level is obviously the goal since knowledge at this level indicates a solid understanding of the term.

The sections of the assessment were organized from the highest level of knowledge (generation processing) to the lowest (associative processing). A short distracting puzzle activity was provided between sections to help minimize carry-over knowledge from previous. In the first section of the assessment, generation processing was assessed by having the students illustrate each of the selected terms. In the second section, the students' comprehension processing was assessed by having them produce the correct term as represented in an illustration. In the third section, associative processing was assessed by having students match selected vocabulary words to the correct definition. Three single application problems at the end required them to use their understanding of the definitions to solve problems. A total of 50 assessment items covered these three levels of vocabulary understanding. See Appendix H for a copy of these assessment.

The assessment was piloted with 64 fourth grade students from one of the participating schools. This was done to check reliability and to ascertain if the questions were written on an appropriate level for third grade. The reliability of this pilot administration was .93 (α) which a high level of reliability. No items were removed after the pilot.

During the study, the teachers read aloud this assessment to the students and did not impose a time limit. Items were scored by assigning one point for each correct answer. Cronbach's alpha (α) for the pre-test measure was .94. Twenty-seven undergraduate students in a university mathematics education class received training on the instrument and the scoring process. The students then scored 25% of the protocols (n=336). The Kappa of this scoring was acceptable at .72.

Curriculum-Based Measurement Probes

Curriculum-Based Measurement (CBM) is a method of measuring student rates of progress over time. For the purpose of this research, CBM probes from Monitoring Basic Skills Progress™ (MBSP) were used to monitor student progress in mathematics. The reliability for MBSP™ fourth grade probes is reported in the MBSP™ technical manual as 0.94. Student growth, as indicated by the Curriculum-Based Measurement probes, was analyzed using ANOVA to determine any differences between the slopes of each group.

Although the students in this study were in the third grade, fourth grade MBSP™ probes were selected because the content included in those was better aligned with the South Carolina third grade mathematics standards than was the content included in the third grade probes. For example, most of the selected terms were geometry terms but geometry terms were only included in the fourth grade probes, not in the third grade probes. In fact, only three skills appeared in the fourth grade probes that are not included in the South Carolina third grade mathematics standards: (a) long division, (b) decimals to hundredths, and (c) line graphs. The full comparison chart can be seen in Appendix F. Other content covered in the probes was aligned with South Carolina third grade standards. Students were told they could skip problems that were unfamiliar to them.

Attitudes Toward Mathematics Inventory

Since studies show that such factors as motivation and attitude impact student achievement (Cote & Levine, 2000; Singh, Granville & Dika, 2002), a widely used mathematics attitude survey, *The Attitudes Toward Mathematics Inventory* (ATMI), was used as a pre-project survey and post-project survey. The ATMI is a 40-item survey

assessing students' self-confidence, value, motivation and enjoyment as related to mathematics. The students answered using a five-point Likert scale (1 strongly disagree, 2 disagree, 3 neither agree nor disagree, 4 agree, and 5 strongly agree). The reliability and validity of this instrument is recorded as 0.96 (Tapia & Marsh, 2004).

This survey is validated only down to fifth grade level. Therefore, a group of participating teachers met with the researcher to modify the survey to make it appropriate for third graders. As a result, nine items regarding high school mathematics courses were removed, and some of the remaining wording was simplified for the younger students. The survey items were read aloud to avoid reading confounds. See Appendix G for a copy of the survey.

Qualitative Assessments

Qualitative analysis can be either exploratory or explanatory. The design in the research presented here was a concurrent mixed model multi-strand study, meaning both sets of data were collected at the same time. In this study, the qualitative data was originally used to support the quantitative data, exemplifying an explanatory purpose, but was then used to investigate other possible reasons, suggesting an exploratory focus (Frechtling & Sharp, 1997).

Writing Prompts

Quantitative data can assess statistically significant changes in student achievement from pre-test to post-test. However, qualitative assessments contribute rich supporting data that reflect levels of understanding and its progression. In this study, participating teachers read one writing prompt to their students each week. These researcher-composed prompts consisted of answering a question about a vocabulary term

and then explaining the answer. Illustrations were required on two of the five prompts. The five writing prompts can be found in Appendix I. The writing prompts were then scored by the researcher as described in Table 3.6. Chi-Square analyses were conducted on them to determine differences between the groups.

Table 3.6

Scoring Rubric for Writing Prompts

Code	Meaning
0	No response
1	Answered "I don't know"
2	All of answer Incorrect
3	Definition only; definition partially correct
4	Definition only; definition correct
5	Definition and picture; definition correct, picture incorrect
6	Definition and picture; definition incorrect, picture correct
7	Definition and picture; all correct
8	Definition and picture; all correct, elaboration or example included
9	Picture only

Interviews

The researcher and three research assistants conducted student interviews at the end of the project. The six researcher-developed questions were intended to capture the

students' thinking processes while solving problems involving various vocabulary terms. The two initial questions pertained to attitudes toward mathematics, and the subsequent four were vocabulary application questions involving the selected vocabulary terms. Students from each school were selected to represent low, middle, and high performers from both the contrast and treatment groups. The interviewers were unaware as to the levels or group membership of the students. The 64 interviews were audio-taped, then transcribed and analyzed by the researcher. The interview questions are available in Appendix J.

Teacher Survey

Research shows that an important component of implementing effective teaching strategies is the teachers' belief that the strategy benefits students (Gersten, Brengelman, & Unok, 1996). Teachers completed a researcher-developed teacher survey at the end of the project to capture feedback about their assigned method of instruction as well as comments or suggestions. A copy of this survey is available in Appendix K.

Procedures

Materials Development

Selecting Vocabulary Terms

In mid-December each participating teacher received an email further explaining the project and requesting assistance in choosing the target vocabulary terms. The teachers were asked to choose problematic words from units taught either before or during the project time. The initial suggestions were combined and mailed out again, this time with a rating scale. Teachers rated the difficulty level of each word on a scale from 1-5: (1) not a big problem, (2) a small problem, (3) sometimes a problem, (4) usually a

problem, and (5) a major difficulty. They also rated the words according to their impact on test success: (1) no impact on test success, (2) minimal impact on test success, (3) some impact on test success, (4) big impact on test success, (5) a major impact on test success. The scores from each of these categories were averaged and then both averages were added together to form a composite score. See Table 3.7 for the initial vocabulary list.

Table 3.7

Initial Vocabulary Word List

Vocabulary Term	Composite Score
Height	3.17
Equal	4.00
Cone	4.33
Dozen	4.67
Y-axis	4.67
Even	4.83
Odd	5.00
Axis	5.17
Circle graph	5.33
Cube	5.50
X-axis	5.50
Categorical data	5.83
Tally chart	5.83

Table 3.7, Continued

Initial Vocabulary Word List

Vocabulary Term	Composite Score
Cylinder	6.00
Greater than	6.00
Translation	6.00
Less than	6.17
Acute angle	6.50
Pyramid	6.50
Commutative property	6.67
Distributive property	6.67
Hexagon	6.67
Reflection	6.67
Sphere	6.67
Octagon	6.67
Width	6.67
Length	6.83
Obtuse angle	6.83
Ordinal numbers	6.83
Rhombus	6.83
Line graph	7.00
Pentagon	7.00
Associative property	7.17

Table 3.7, Continued

Initial Vocabulary Word List

Vocabulary Term	Composite Score
Right angle	7.50
Vertex	7.67
Vertical	7.67
Symmetry	7.83
Horizontal	7.83
Ordered pair	8.00
Area	8.17
Numerator	8.17
Rotation	8.17
Parallel	8.17
Denominator	8.33
Mode	8.33
Perimeter	8.33
Diameter	8.50
Mean	8.50
Median	8.50
Perpendicular	8.67
Radius	8.83

The total score for each word was calculated and the words rank-ordered. The teachers then received another email asking for their final input. Since most of the top scoring words on the final list were geometry terms, some terms were removed because they did not fit into this category. Several phrases were also removed because of the difficulty in representing these terms in a single keyword picture. The final selection list of 20 vocabulary terms was emailed to the teachers: (a) acute angle, (b) obtuse angle, (c) parallel, (d) perpendicular, (e) diameter, (f) radius, (g) mode, (h) hexagon, (i) polygon, (j) pentagon, (k) quadrilateral, (l) symmetry, (m) vertical, (n) horizontal, (o) perimeter, (p) area, (q) vertex, (r) congruent, (s) numerator, and (t) denominator. The presentation rate was one new word per lesson, a total of 20 items for the study, which is similar to the one employed by other research implementation studies (Mastropieri, Sweda, Scruggs, 2000).

Keyword Mnemonics Development

Once the final vocabulary words were selected the researcher developed the keyword mnemonics. For each vocabulary term selected, the researcher chose an acoustically similar word that could be easily represented using pictures taken from a popular clip art package. The researcher then developed keyword mnemonics for each of these vocabulary terms, using the methods shown from Mastropieri and Scruggs (2004):

For each targeted vocabulary term, an acoustically similar alternative, or keyword was chosen. These keywords were familiar to the students and easily portrayed by a picture. For example, for acute angle, a cute angel was chosen (See Figure 3.1). A picture was then created of a cute angel to link this keyword with the definition of acute angle, an angle measuring less than 90 degrees, as seen in Figure 3.1 below.

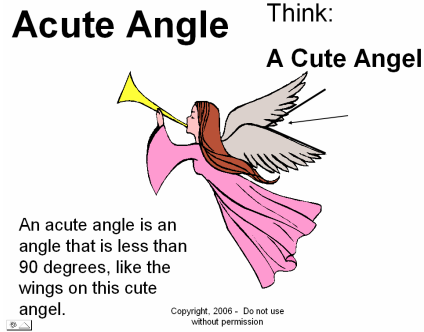


Figure 3.1

Sample Keyword Mnemonic for Acute Angle

The keywords were printed on separate pages along with the target term, the picture, and the definition. Instructional scripts for the keyword mnemonics were written for each term, modeled after keyword research conducted by Mastropieri and Scruggs (1986). At the end of the pre-test week, the treatment group explained the keyword strategy to their students and worked through the strategy using a practice word. In this study, *bugsha* was chosen as the practice keyword term because it is often used in keyword research as the practice item. *Bugsha*, a relatively unknown slang term for money, is easily pictured with an acoustically similar keyword, *bug*, with the meaning clearly depicted with a picture of a bug crawling on money. The teachers were taught how to instruct the students in the use of the keyword mnemonic strategy as outlined by Mastropieri and Scruggs (2004). Using the practice keyword, the students were taught the retrieval process by first being instructed to think of the word they were learning, *bugsha*. They were to think back to the keyword, which is *bug* and to remember what else was in the picture, the money in this instance. This process retrieves the definition of money. Appendix E includes the instructional scripts and keyword mnemonics.

Word Cards

The scripts for the word cards were patterned after the same keyword research, which used direct instruction and word cards in place of the keyword pictures (Mastropieri & Scruggs, 2004). The scripts were timed to make sure both groups received the same amount of instructional time for each term. Appendix D includes the contrast instructional scripts and word cards.

Training

After the first of the year, all participating teachers attended a training session at their schools. This session, which lasted approximately 45 minute, took place either during their planning period or after school hours. All teachers received the same information on the importance of mathematics vocabulary in relation to mathematical understanding along with a packet of all project materials. The teachers received an explanation of the project materials along with emphasis on the importance of following the directions explicitly. Also included was a detailed project schedule to ensure all teachers presented the words and assessments on the same days as well as information indicating each teacher's group assignment, contrast or treatment. The treatment group reviewed their materials while the contrast group received an explanation and demonstration of the direct instruction scripts and word cards. Teachers in the contrast group returned to their classrooms while the teachers in the treatment group received an explanation and demonstration of the keyword mnemonic pictures and instructional scripts. This step concluded the training session.

Instructional Sequence

The teachers administered the pre-test at the first of the week after the completion of all the training sessions. During this pre-test week, the teachers administered three CBM probes to establish the baseline as well as the attitudinal surveys. The teachers also read one writing prompt to the students as a practice prompt, which was not scored. Treatment group teachers presented the keyword mnemonic strategy to their students using the practice term.

The week after the pre-test week was the first one of the instructional sequence. The teachers presented each of the 20 words to their students in the manner assigned, one per day over 20 consecutive school days. The teachers then reviewed the words following a prescribed rotation to provide adequate reinforcement of the words and definitions. The sequence of presentation and review was the same for both groups. The scripts were timed to make sure both groups received the same amount of instructional time on each term. The researcher sent an email every day reminding the teachers of the words to introduce and the words to review for that day. The rotation and instructional schedule can be found in Appendix B.

Each day after vocabulary instruction, the teachers filled out and signed a fidelity treatment form indicating that they had followed exactly the script for the presentation and review of the words. The researcher and research assistants conducted 52 random observations to verify that the teachers were following the scripts. All teachers were observed at least once. According to the signed fidelity sheets as well as the observations conducted, all teachers adhered to the instructional directions. Copies of this form are included in Appendix C.

Mathematics Vocabulary Instruction

At the end of each week, the teachers gave a CBM probe to their students and read one writing prompt. After presenting and reviewing the selected terms for 20 consecutive school days, teachers removed the word cards or keyword pictures from the walls and stopped both the instruction and review of the terms. During this post-test week the students took the vocabulary post-test, responded to the final writing prompt, took the final CBM probe, and completed the post-test survey. The teachers filled out the teacher survey. The researcher and the research assistants conducted student interviews during post-test week as well. After an interim of two weeks, the students took the vocabulary assessment again as a follow-up measure. Teachers were asked to refrain using the materials until after this last measure was administered. All materials were collected at this time.

CHAPTER 4

RESULTS

This study investigated the effects of direct instruction with keyword mnemonics on mathematics vocabulary instruction. Chapter four presents the data findings, including (a) Research Questions, (b) Summary of Quantitative Findings, (c) Discussion of Findings, (d) Summary of Qualitative Analysis and (e) Discussion of Findings.

Research Questions

To answer the questions guiding this research comparing the scores on mathematics vocabulary assessments, mathematics achievement measures and attitudes toward mathematics, the researcher matched the participating 33 third grade teachers with similar peers and randomly assigned one of each pair to the contrast group and the other to the treatment group. The contrast group used direct instruction to teach 20 mathematics vocabulary words over a 20-lesson sequence. The treatment group used direct instruction with embedded keyword mnemonics to teach these same 20 mathematics vocabulary words over the same 20-lesson sequence. Students were matched across comparable classrooms (based on teacher experience and Highly Qualified status) according to pre-test scores, forming 207 pairs of matched students. Scripts were provided for both groups. Treatment integrity measures showed that teachers in both groups followed the procedures for instruction.

Summary of Quantitative Analysis

To test for significant differences between groups on the vocabulary assessment question, a repeated measures analysis of variance was performed on two levels of instruction (direct instruction versus mnemonic instruction) and across three measures

(pre-test, post-test, and follow-up). The students in the treatment classes outperformed the students in the contrast classes as measured on the vocabulary assessment, $F(1, 206) = 13.196, p = .000$, although both groups did show significant improvement.

To test for significant differences between groups on the mathematics achievement question, a repeated measures analysis of variance was performed on two levels of instruction (direct instruction versus mnemonic instruction) and across nine measures (the nine CBM probes). There was no significant difference between the students taught by the direct instruction and the students who were taught by direct instruction with keyword mnemonics on mathematics achievement as measured by the slopes of the progress monitoring probes $F(1, 405) = 4.639, p = .32$.

A t-test was performed on the sums of the attitude survey answers to determine if there were significant differences between the contrast and treatment groups. On the post-test, there was no significant difference between the groups on attitudes toward mathematics, $t(40) = .99, p = .921$.

Discussion of Findings

Quantitative Analyses

Vocabulary Assessment

A 40-item test ($\alpha = .92$) required students to both recognize and produce answers to questions on the selected vocabulary terms. Each student took three assessments-- a pre-test, a post-test, and a follow-up test. One point was awarded for each correct response. A two by three repeated measures two-way analysis of variance was conducted to determine whether instructional group assignment made a significant difference in the

test scores. The mean on the follow-up assessment was 30.53 for the contrast group and 33.65 for the treatment group. Table 4.1 provides the descriptives.

Table 4.1

Descriptives of Results of the Three Vocabulary Assessments

Group	Test	Mean	Std. Deviation	N
Contrast	Pre-test	17.77	9.84	207
Treatment	Pre-test	17.72	9.69	207
Contrast	Post-test	29.22	11.29	207
Treatment	Post-test	31.65	11.77	207
Contrast	Follow-up	30.53	11.36	207
Treatment	Follow-up	33.65	11.56	207

Results of the analysis indicated a main effect of group membership (contrast or treatment), $F(1, 206) = 13.196, p = .000$. In addition, there was a main effect for the measures as well $F(2, 412) = 658.651, p = .000$ and an interaction effect between the group membership and the measures, $F(2, 412) = 10.950, p = .000$. These findings indicated that the two instructional groups performed significantly differently across the three pre-, post-, and follow-up measures. The Cohen's d was .27, which is considered a

small effect size (Cohen, 1988). The statistical power was calculated as .69 at $\alpha = .05$.

Table 4.2 provides the complete results.

Table 4.2

Summary of Repeated Measures ANOVA on Vocabulary Assessment

Source	Type 3 SS	Df	MS	F	Significance
Group	1028.100	1	1028.100	13.196	.000*
Error (Group)	16049.900	206	77.912		
Test	50878.275	2	25439.138	658.651	.000*
Error (Test)	15912.725	412	38.623		
Group x Test	560.919	2	280.460	10.950	.000*
Error (Group x Test)	10552.081	412	25.612		

*Significant at alpha = .05 level

Mathematics Achievement

Nine Curriculum-Based Measurement (CBM) probes from Monitoring Basic Skills Progress™ tracked student mathematics achievement over time. The fourth grade probes were used because these better aligned with current South Carolina third grade standards. Moreover, most of the vocabulary terms selected were geometry terms, which were only included in the fourth grade probes. A slope of the progress was calculated for

each student using the baseline (the median of the first three probes) along with the other six probes calculated across seven weeks (includes pre-test week and post-test week).

A univariate ANOVA analysis indicated that there was no significant difference between the groups on the slopes of the nine CBM probes, $F(1, 405) = 4.639, p = .32$ as seen in Table 4.3 below.

Table 4.3

Summary of ANOVA for CBM Probes

Source	Sum of Squares	Df	Mean S Square	F	Significance
Between Groups	129.132	1	129.132	4.639	0.320
Within Groups	11274.759	405	27.839		
Total	11403.891	406			

Attitude Surveys

The attitude survey consisted of 40 items covering various components of attitudes concerning mathematics. The students answered using a five-point Likert scale, with lower answers indicating a more negative attitude toward mathematics and higher answers a more positive one. The 12 items worded negatively were transposed in SPSS. The reliability (α) of the pre-survey was .92 and of the post-survey .94. The surveys were analyzed using ANOVA on the sums of items to determine any attitudinal differences between the groups from pre-survey to post-survey.

A paired t-test performed on the totals of the pre- and post-survey indicates no significant differences between the groups on either the pre-survey, $t(42)=.232, p=.817$, or the post-survey $t(40) = .99, p=.921$. The standard deviation of both groups increased as did the means for both groups. Table 4.4 provides the complete results.

Table 4.4

Descriptives of the Results of the Attitude Survey

Group	Measure	Mean	N	Standard Deviation	Std. Error
Contrast	Pre-survey	153.67	43	26.045	3.972
Treatment	Post-survey	152.53	43	23.258	3.547
Contrast	Pre-survey	157.63	41	27.690	4.324
Treatment	Post-survey	157.00	41	27.061	4.226

Follow-up Analyses

Since a follow-up measure was used to assess retention rates over time, its scores are expected to drop. However, the follow-up test scores for all students went up. The main reason was that the project was at the end of the school year, and teachers were reviewing material for the end of the year tests. However, teachers were instructed to remove all materials from the walls before the post-test and not use them again until after the follow-up measure.

To ascertain if the treatment group teachers could have used the materials during this time, a situation which would have skewed the repeated measures results, a one-way

analysis of variance was conducted to see if there were differences between the groups on this increase. There was no significant difference between groups on the score increase for the follow up tests, $F(1, 412) = 1.474, p = .225$. Table 4.5 gives the descriptives for the gains. However, since a gain in the follow-up scores indicates that the test was not measuring retention, subsequent analyses were conducted using the differences between the post-test and pretest.

Table 4.5

Descriptives for Gains on Follow-up Assessment

Group	N	Mean	Std. Deviation
Contrast	207	1.3125	5.74611
Treatment	207	1.9515	4.92852

Students with and without disabilities comparisons. Since there was significance between the groups on the vocabulary assessment, a factorial ANOVA was conducted to identify differences in improvement between students with disabilities and students without disabilities across the two instructional groups. This analysis showed a significant difference between the test scores of students with disabilities and students without disabilities, $F(1,410) = 38.883, p = .000$, but no significant interaction between the instructional groups and the disability identification, $F(1,410) = 1.430, p = .232$. Table 4.6 lists the descriptives.

Table 4.6

Means of Growth from Pre-test to Post-test Comparing Students with Disabilities to Students Without Disabilities

Disability Designation	Descriptive	Treatment Pre-test	Treatment Post-test	Contrast Pre-test	Contrast Post-test
Students With Disabilities	Mean	15.6136	25.5227	15.8864	23.2500
	N	44	44	44	44
	Std. Deviation	11.7814	12.9516	11.8168	11.6142
Students Without Disabilities	Mean	18.2945	33.3006	18.2761	30.8344
	N	163	163	163	163
	Std. Deviation	8.9972	10.9003	9.2083	10.6790
Total	Mean	17.7246	31.6473	17.7681	29.2222
	N	207	207	207	207
	Std. Deviation	9.6872	11.7740	9.8382	11.2922

Student performance level analyses. As mentioned previously, scores from the Measures of Academic Progress (MAP) benchmarks assessments are aligned with South Carolina standards. The Northwest Evaluation Association (NWEA) suggests MAP cut scores on its information website (see <http://www.nwea.org/>) that can be used to divide

students into instructional groups. For the purpose of this analysis, students were coded 1, 2, 3, and 4 to indicate the performance levels based on the MAP cut scores as seen in Table 4.7. A factorial ANOVA was conducted on the differences in growth between pre-test scores and post-test scores for the performance levels between the two instructional groups. The results indicate no significant difference in the interaction between the instructional groups and the performance levels, $F(3,386) = .184, p = .907$.

Table 4.7

Group Designation Based on MAP Scores, Total Mathematics Measure

Group Code	Performance Label	Percentile	Score on MAP Total Mathematics
1	Below Basic	<22nd percentile	<193
2	Basic	22nd-70 th percentile	193-207
3	Proficient	71 st -90 th percentile	208-216
4	Advanced	91+ percentile	>216

Since the groups were uneven, a Hochberg GT-2 posthoc comparison was used to display the marginal means for groups in order to determine homogeneous subsets. This test indicated no significant difference between Groups 3 (Proficient) and 4 (Advanced), $p = .244$. Since the number of students in these groups was small (see Table 4.8), and there was no significant difference between them, Group 4 (Advanced) was collapsed into Group 3 (Proficient), creating a new Group 3 (Proficient/Advanced) (See Table 4.8).

A factorial ANOVA was used to analyze the differences between the three collapsed performance levels across the two instructional groups as seen in Table 4.9.

TABLE 4.8

Between-Subjects Factors of Group Designations

Group	N
Contrast	204
Treatment	197
Level 1	154
Level 2	159
Level 3	58
Level 4	30

Table 4.9

ANOVA Results for Three Performance Levels Across Tests

Source	Type 3 SS	Df	MS	F	Significance
Instructional Group	664.962	1	81243.012	955.124	.000
Performance Levels	1662.934	2	831.467	9.775	.000
Group x Level	80.741	2	40.370	.475	.622
Error(Group x Level	33683.823	396	85.060		

Another Hochberg GT2 post-hoc test, conducted on the three new groups, indicated that on the pre-test, there was no significant difference between Groups 1 and 2 (Below Basic and Basic), $p = 0.144$ (See Table 4.10).

Table 4.10

Pre-test Means for Groups in Homogeneous Subsets

Student	N	Subset 1	Subset 2
Performance			
1	149	14.87	
2	159	17.18	
3	88		24.03
Significance		.144	1.00

c Alpha = .05.

However, on the post-test, another Hochberg analysis indicates that Group 2 (Basic level) students were no longer performing similarly to Group 1 (See Table 4.11). The Basic level students had increased to be significantly different from the Below Basic students in Group 1. This growth was maintained across the follow-up test as well, as shown in Table 4.12.

Table 4.11

Post-test Means for Groups in Homogeneous Subsets

Group Code	N	Subset 1	Subset 2	Subset 3
1	149	24.38		
2	156		31.03	
3	88			40.66
Significance		1.00	1.00	1.00

c Alpha = .05.

Table 4.12

Means for Homogeneous Subsets for Growth Across All Three Tests

Group Code	N	Subset 1	Subset 2	Subset 3
1	149	26.87		
2	156		32.25	
3	88			41.33
Significance		1.00	1.00	1.00

c Alpha = .05.

Levels of vocabulary understanding analysis. A 40-item test ($\alpha = .92$) required students to both recognize and produce answers to questions on the selected vocabulary terms. The vocabulary assessment consisted of three sections focused on three levels of vocabulary understanding: Generation, comprehension, and association. A two by six repeated measures two way analysis of variance was conducted to determine whether instructional group membership made a significant difference in the performance on these levels of understanding. Table 4.13 presents descriptives of the means and standard deviations for each level of vocabulary understanding section. It is interesting that both groups did see large increases on the generation items from pre-test to post-test.

Table 4.13

Descriptives of Growth Across Levels of Vocabulary Understanding

Group	Level of Vocabulary Understanding	Mean		Standard Deviation	
		Pre-test	Post-test	Pre-test	Post test
Contrast	Generation*	7.77	12.17	3.809	6.009
Treatment	Generation*	7.70	12.25	3.950	5.388
Contrast	Comprehension*	6.02	9.39	3.995	5.856
Treatment	Comprehension*	5.80	9.49	3.864	5.435
Contrast	Association**	6.02	4.91	3.995	2.744
Treatment	Association**	5.80	5.12	3.864	3.085

* = 19 items, ** = 8 items

Results of the analysis indicate a main effect for the levels of vocabulary understanding $F(5, 203) = 196.290, p = .000$. However, there was no main effect for group membership (contrast or treatment), $F(1, 203) = .006, p = .939$. There was also no interaction effect between the group membership and the levels, $F(5, 340) = .351, p = .667$. Therefore, the two instructional groups did not perform significantly differently across the three levels of vocabulary understanding, as shown in the results presented in Table 4.14.

Table 4.14

Summary of Repeated Measures ANOVA on Levels of Vocabulary Understanding

Source	Type 3 SS	Df	MS	F	Significance
Group	.216	1	.216	.006	.939
Error (Group)	7499.034	203	36.941		
Levels	3012.729	5	3012.729	196.290	.000*
Error (Levels)	15578.606	203	76.742		
Group x Levels	16.066	5	3.213	.351	.882
Error (Group x Levels)	9304.184	203	45.833		

*Significant at alpha = .05 level

Summary of Qualitative Analysis

The research reported here was a concurrent mixed model multi-strand study, where both quantitative and qualitative data were collected at the same time, with the quantitative data being analyzed first and the qualitative data analyzed later for explanatory purposes (Frechtling & Sharp, 1997). Based on previous research, it was expected that students with disabilities would make significant gains when using the keyword mnemonic method. However, the results of this study found that students with disabilities scored significantly lower than nondisabled students on the vocabulary assessments. Basic level students, on the other hand, increased so as to be significantly

different from the performance level of the below basic students, contradicting past research which has shown that basic level students perform similarly to students with disabilities. While this is important for basic level students, it raises questions about vocabulary instruction for students with disabilities.

Other questions surfaced concerning the misconceptions students had about the vocabulary terms. The qualitative data provided insight into this issue as well. Since there was no significant difference between the groups on the levels of vocabulary understanding, group membership is not reported when examining the misconceptions.

Writing Prompts

Twenty-seven undergraduate students in a university mathematics education class were trained on the instrument and the scoring process, then independently scored 25% of the protocols (n=112). The reliability of the agreement as measured by the kappa was .56, a moderate inter-rater reliability score (Cohen, 1960). The writing prompts were coded as shown in Table 4.15.

Table 4.15

Scoring Rubric for Writing Prompts

Code	Meaning
0	No response
1	Answered "I don't know"
2	All of answer incorrect
3	Definition only; definition partially correct
4	Definition only; definition correct
5	Definition and picture; definition correct, picture incorrect
6	Definition and picture; definition incorrect, picture correct
7	Definition and picture; all correct
8	Definition and picture; all correct, elaboration or example included
9	Picture only

These nominal data were analyzed using Chi-Square to compare expected and actual values for each code. This Chi-Square analysis indicated that on the writing prompts there were no significant differences between the contrast and treatment groups on the expected and actual values for each code, as shown in Table 4.16.

Interviews

Follow-up interviews were conducted at each school after the post-test, these fifty-four interviews of students across all levels being transcribed and analyzed by the researcher.

Table 4.16

Summary of Chi-Square for Writing Prompts

Writing Prompt	X^2	DF	Significance
1. Parallel	7.978	8	$p > .01$
2. Quadrilateral	9.492	8	$p > .01$
3. Horizontal	17.199	8	$p > .01^*$
4. Diameter	10.843	7	$p > .01$
5. Acute angle	7.417	7	$p > .01$

* These are not independent tests, which required the significance to be lowered with each test.

For the question, “Do you like math?” the most common explanation for the answer was “It is hard” or “It is easy.” Table 4.17 presents the percentages in this division of answers. For the question, “Are you good at math?” the most common explanation for the students’ *yes* or *no* answers (see Table 4.18 for percentages) was related to grades. Surprisingly, the students with disabilities typically responded that they

received good grades and, therefore, answered that they were good at mathematics.

However, they often answered the rest of the interview questions incorrectly.

Table 4.17

Interview Question 1a

Do you like math?

Percentage	n	Answer
89%	48	yes
11%	6	no

Table 4.18

Interview Question 1b

Are you good at math?

Percentage	n	Answer
94%	51	yes
6%	3	no

Students were asked to differentiate between diameter and radius and explain their answers. For the answer to the diameter and radius question, 7% (n = 4) referred to “radius is a short word and is the shorter line, diameter is the longer word and is the longer line” and 15% (n = 8) confused diameter with denominator answering, “the number on the bottom of a fraction”. Additionally, 13% (n = 7) students defined diameter correctly but not radius, usually saying that radius was a “dot in the center of a circle”, as reported in Table 4.19.

Table 4.19

Interview Question 2

Tell me what diameter and a radius are. How do you remember these words?

Percentage	n	Answer
31%	17	No answer and could not remember any part of the definition.
19%	10	Answered correctly.

For the next question, students were shown a figure with two boxes that represented a fraction and were asked, “If 4 is the numerator and 7 is the denominator, how would you write that fraction? What would the fraction look like if 2 is the denominator and 5 is the numerator?” For this question, 9% (n = 5) of the students who answered correctly indicated that they guessed on the first one and then answered the same way on the second. “I looked (at the first one) and the 4 was on the top line, so it

goes on top. So the numerator goes on top in the second one” (see Table 4.20 for distribution of answers); 4% (n = 2) of the students answering correctly were confused after the second one, where the numerator was greater than the denominator, saying “that one doesn’t make sense,” or “that one is a pretend fraction.” In answering, 6% (n = 3) of the students answering correctly referred to the keywords, and six referred to other methods, including such elaborations as “d is for down” or “den is in the bottom of your house so denominator is on the bottom.”

Table 4.20

Interview Question 3

“If 4 is the numerator and 7 is the denominator, how would you write that fraction?”

Percentage	n	Answer
80%	43	Put numerator on the top and denominator on the bottom.
17%	9	Answered incorrectly, confusing the two words
4%	2	Did not answer

For the next question, students were shown a figure divided into 8 squares and are asked, “How would you find the area of this figure? How do you know?” All students answered Question 4, indicating they could correctly find the area of a simple figure (see Table 4.21).

Table 4.21

Interview Question 4

Students were shown a figure divided into 8 squares and were asked, “How would you find the area of this figure? How do you know?”

Percentage	n	Answer
100%	54	All students answered this question correctly

Table 4.22

Interview Question 5

The students were shown a picture of a small triangle with a perimeter of 15 marked and a larger triangle with a perimeter of 6 marked. The researcher asked, “Which figure has the greater perimeter?”

Percentage	n	Answer
4%	2	The larger triangle
2%	1	Did not answer
94%	51	The larger numbers

Since this question did not have a correct or incorrect answer, as there were no units given and the illustrations were misleading, the question was meant only to determine how the students understood perimeter. As Table 4.22 shows, the students looked at the numbers given, not the sizes of the figures suggesting the students focused on the calculations, not seeing perimeter as representing the actual size of the figure. Third grade is perhaps too early to focus on identifying units as necessary for interpretation.

Table 4.23

Interview Question 6

Insert $<$, $>$, or $=$ into this sentence: An acute angle _____ an obtuse angle.

Percentage	n	Answer
9%	5	Could not remember
2%	1	Did not remember ever hearing acute and obtuse
2%		Equal
91%	49	Acute is greater than obtuse

For the acute/obtuse question, 11 students answered with the wrong symbol (see Table 4.23). This error seemed to occur because the word *obtuse* was at the end of the sentence, so they read it back as “an obtuse angle is larger than an acute angle” and, therefore, picked the wrong symbol. All students recognized the symbols and knew that the open end pointed toward the larger amount as in the “crocodile mouth” analogy.

Teacher Surveys

Although all 33 teachers completed an end-of-project survey, not all teachers responded to every question. The survey can be found in Appendix K.

Table 4.24

Summary of Teacher Survey Answers

Contrast Group (n = 16)

Treatment Group (n = 17)

Question 1: Did you enjoy teaching math vocabulary using the method you were given?

Contrast Group	Yes	50% (n = 8) reported their students enjoyed and learned from their method.
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No	50% (n = 8) reported that the method was dull and monotonous
----	--

Treatment Group	Yes	89% (n = 15) reported their students enjoyed and learned from their method.
-----------------	-----	---

No	11% (n = 2) said that the words were “silly,” “made no sense,” and “had no meat to them.”
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Question 2: Do you think the method you used helped your students learn the vocabulary words?

All teachers answering this question (n = 15) referred to the previous question or simply rewrote the same answer.

Table 4.24, Continued

Summary of Teacher Survey Answers

Question 3: Would you use the word cards or picture cards (whichever you used for the project) again in your vocabulary instruction? Why or why not?

Contrast	Yes	12% (n = 2)
Group	No	88% (n = 14). The most common comment (n = 10) was “They were dull and boring.”
Treatment	Yes	83% of those answering (n = 14) said yes. The most
Group		common comment was “The students enjoyed them, and it helped them learn the words.”
	No answer	17% (n = 3) did not answer this question

Question 4: Would you like to make any comments about the project or the methods of vocabulary instruction? (36% (n = 12) answered this question.)

83%	(n = 10)	Remarked about the amount of time the assessments took.
17%	(n = 2)	Stated that some of the keyword mnemonics were “silly” and “made no sense.”
8%	(n = 1)	Said the keywords “had no meat to them.”

Table 4.24, Continued

Summary of Teacher Survey Answers

Question 5: Treatment group only

- a. Were there particular pictures your students enjoyed more than others or that you thought were effective? If so, what were they?
- b. Were there particular pictures your students did **not** like or that you thought were ineffective? If so, what were they?

The results from a and b are presented in Table 4.25

- c. What suggestions do you or your students have for changing any of the pictures to make them better?

29% (n = 5) Suggested to change the keyword to “make more sense.”

Table 4.25 shows the tallies for the keywords thought effective by the teachers compared to how many times the students referenced these keyword pictures as they were taking the final assessments. In contrast to this information, Table 4.26 lists the percentages of items correct from pre-test to post-test between the two groups. It is interesting to compare these results with the vocabulary terms determined as effective and ineffective by the teachers. Chapter Five presents more discussion on this issue.

Table 4.25

Comparison of Teacher and Student Agreement of Keyword Mnemonics

Vocabulary Term	Teacher Agreed	Teacher Disagreed	Number of Times Cited By Students on Assessments
Acute angle	5	1	13
Area	1	4	3
Congruent	2	3	14
Denominator	2	5	13
Diameter	3	0	42
Hexagon	3	5	2
Horizontal	4	2	10
Mode	4	2	22
Numerator	2	8	17
Obtuse	1	1	11
Parallel	3	0	22
Pentagon	0	5	9
Perimeter	3	4	15
Perpendicular	0	4	29
Polygon	8	3	8
Quadrilateral	1	4	30
Radius	3	1	28

Table 4.25, Continued

Comparison of Teacher and Student Agreement of Keyword Mnemonics

Vocabulary Term	Teacher Agreed	Teacher Disagreed	Number of Times Cited By Students on Assessments
Symmetry	5	0	11
Vertex	0	3	34
Vertical	4	1	19

Table 4.26

Comparison of Percentage of Items Correct From Pre-test to Post-test Across

Contrast and Treatment Groups

Term	Contrast Pre-test	Treatment Pre-test	Contrast Post-test	Treatment Post-test
Perpendicular	12.22%	13.99%	32.13%	31.89%
Vertex	11.84%	16.58%	25.95%	39.37%
Radius	15.04%	20.20%	41.01%	48.21%
Denominator	19.55%	24.18%	40.38%	48.82%
Quadrilateral	31.77%	28.13%	44.85%	50.00%
Numerator	21.24%	24.46%	42.27%	50.52%
Obtuse	33.46%	33.02%	50.17%	52.89%

Table 4.26, Continued

Comparison of Percentage of Items Correct From Pre-test to Post-test Across

Contrast and Treatment Groups

Term	Contrast Pre-test	Treatment Pre-test	Contrast Post-test	Treatment Post-test
Diameter	17.11%	19.43%	46.39%	53.15%
Vertical	18.92%	24.00%	38.14%	53.37%
Mode	10.90%	10.87%	34.71%	53.81%
Hexagon	52.13%	57.61%	57.73%	54.07%
Horizontal	18.05%	26.09%	38.49%	58.14%
Pentagon	43.11%	42.75%	62.66%	58.27%
Perimeter	39.22%	44.93%	53.61%	61.15%
Area	30.45%	41.17%	58.93%	68.50%
Congruent	38.72%	51.81%	57.04%	69.55%
Acute	45.99%	48.82%	68.16%	74.02%
Symmetry	60.90%	66.71%	73.02%	76.90%
Parallel	55.39%	60.69%	69.87%	77.08%
Polygon	71.05%	73.10%	78.69%	81.36%

Discussion of Findings

Since mathematics vocabulary has been shown to be an important component of mathematics comprehension, it is important to determine how to best teach it effectively for all students. The qualitative data obtained here were examined in an attempt to identify the components of vocabulary understanding that, if addressed, could contribute to more effective mathematics vocabulary instruction. Many researchers and educators believe that traditional objective tests may fail to reflect actual student understanding and achievement. However, the current emphasis on accountability has increased the frequency and power of such assessments with regards to curricular and instructional decisions. Critics argue that (a) the tests themselves are sometimes flawed, (b) the tests are a poor measure of anything except a student's test-taking ability, and (c) the tests place too much emphasis on learning isolated facts (Flechtling & Shaw, 1997).

Since the primary goal of assessment should be to improve instruction, authentic performance assessments involving higher order thinking skills should provide the instructor accurate feedback on the student's actual level of understanding. The performance assessment tasks designed for this research were created to provide this deeper understanding of a student's actual performance level. The qualitative analysis for this study was conducted in accordance with Margaret LeCompte's article, "Analyzing Qualitative Data" (2000), her steps being: (a) Tidying up, (b) Finding items, (c) Creating stable sets of items, (d) Creating patterns, and (e) Assembling structures.

The Qualitative Process

Tidying up in this study consisted of transcribing interviews and organizing writing prompts into class sets, removing students who were part of the original study but

not included in the matched pairs. The writing prompts were then coded, using the rubric shown in Chapter Four, in an attempt to find significant differences between the groups. There was no significance found in answers expected and answers received between the groups, and the process moved on to the next qualitative step.

Finding items consisted of the researcher reading and rereading all writing prompts and interviews several times, making notes during the process, attempting to organize the data and identify any items that seemed to warrant more in-depth analysis. Table 4.27 provides an initial summary of these notes.

Table 4.27

The Finding Items Stage in the Qualitative Analysis

Item Code	Construct
Writing Prompts	
A	There are several “I don’t know” answers or “I don’t remember” though students had received instruction on the word presented.
B	Students seem to confuse pairs of terms (vertical and horizontal, for example).
C	Some answered with only pictures though the question required explanation.
D	On several words, the students were able to draw the correct picture but were not able to define the words or defined them incorrectly.
E	Sometimes the definition given appeared to be memorized, not understood
F	Several basic conceptual misunderstandings and errors were found.
G	The entries of several lower-level students were illegible, even in the third grade.

Table 4.27, Continued

Finding Items Stage in the Qualitative Analysis

Item Code	Construct
Interviews	
A	Many lower students consistently answered they did not know or did not remember hearing the terms.
B	Most students responded based on some form of logic, but even then often changed their own rules
C	Most upper-level students had some form of elaboration provided either by the study or their teacher. Some said, “I just know.”
D	The ones who relied on “My teacher told me” gave mostly incorrect answers
E	Most upper-level students answered confidently.
F	Students often confused similar sounding words or had difficulty with words in pairs; i.e., naming confusion.
G	For the question about liking math, calculation was the reason most often cited for their answers.

Table 4.27, Continued

Finding Items Stage in the Qualitative Analysis

Item Code	Construct
H	For the question about being good at math, grades received was the reason most often cited for their answer.
I	Some students from a resource room reported getting good grades but still missed all items or did not answer items.
J	Most students, regardless of self-efficacy, reported that they liked math. “It is fun” was the most common answer.

The next step was to create stable sets of items across these notes. Based on rereading the writing prompts and interview responses, the items were further collapsed (see Table 4.28) and the data were then represented in one table. Varied levels of understanding, conceptual misunderstandings, and naming confusion were evident in both qualitative assessments.

After these stable sets of items were created, the writing prompts and interview responses were again read to identify patterns present. Table 4.20 provides an overview of these patterns, which will be discussed in more detail later.

Table 4.28

Stable Sets of Items Created for Qualitative Assessments

Sets of Items	Notes
Elaborations	Study provided, teacher provided, student generated.
Misconceptions	Conceptual misunderstandings surfaced in incorrect definitions with correct pictures.
Naming confusion	Many students confused terms that were often paired with other terms; vertical and horizontal, for example.
Varied levels of understanding	Some elaborations, some only answered in pictures, some answers illegible.
Confidence levels	Varied and depended on course grades as well as perceived difficulty (calculation ability, etc.)

Table 4.29

Patterns Identified in the Qualitative Data

The Pattern	How Noted
Elaborations	<p>Most students who provided answers used elaborations. Some were teacher given, some were study given, and a few were student generated. Low-performing students often did not use elaborations or used them inaccurately. Higher performing students sometimes generated their own but still tended to use those provided to them.</p>
Conceptual misunderstandings	<p>Many misconceptions were evident across the two assessments. Students produced accurate drawings but provided inaccurate definitions. Students often confused pairs of words, like vertical and horizontal, and even diameter and denominator. This confusion was not as common in students who used elaborations.</p>

Table 4.29, Continued

Patterns Identified in the Qualitative Data

The Pattern	How Noted
Varied levels of understanding	Various levels of understanding were represented, from little to no knowledge, to expressive generation. Typically, low-performing students did not answer or answered hesitantly and higher performing students answered correctly, as would be expected.
Confidence levels	Confidence was often expressed in terms of course grades and in perceived difficulty. Even low-performing students often replied they were good in math because they “got all A’s.” However, they often could not answer any of the interview questions correctly. Most students reported enjoying mathematics, even if they did not feel they were good at it. Calculation was often cited as something they did not enjoy in mathematics.

Clearly emerging from this analysis was the fact that it was difficult to separate elaborations from misconceptions or from levels of understanding. Another factor that emerged as an important part in the overall level of understanding was the students’ tendency to confuse terms often coupled with other terms, for example, diameter and

radius, numerator and denominator, acute and obtuse, horizontal and vertical, and parallel and perpendicular. This will be called naming confusion. The interview data showed that successful students almost always used elaborations to avoid this confusion. In a few cases of upper-level students, the students had evidently become proficient enough with the terms to bypass the need for an elaboration. Very low-performing students often were not able to answer the questions, rarely producing elaborations. This supports research pointing to lack of memory strategies as one factor contributing to low performance (Mastropieri, Sweda, & Scruggs, 2000).

Since elaborations are connections made with the vocabulary term, or name, the wrong conceptual information is activated if a student retrieves the wrong term. This error does not mean the student has no basic conceptual understanding but that the incorrect information was retrieved. Perhaps no elaboration was used or the elaboration chosen was not effective, not presented clearly, not practiced to mastery, or not used correctly. Naming confusion appears to be strongly connected with level of understanding as well, or at least in the determination of the level of understanding. The connections between these components of understanding are represented in Figure 4.1.

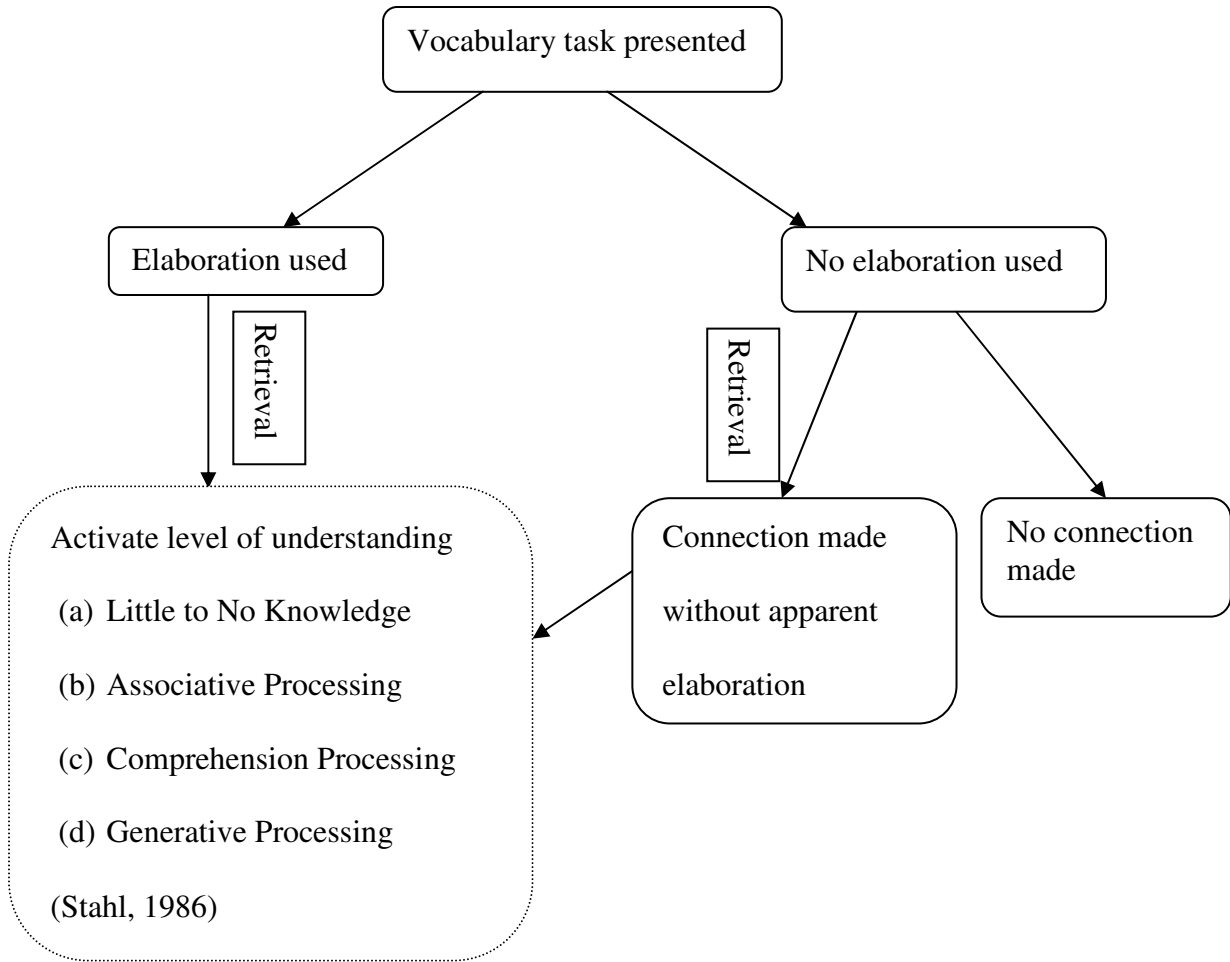
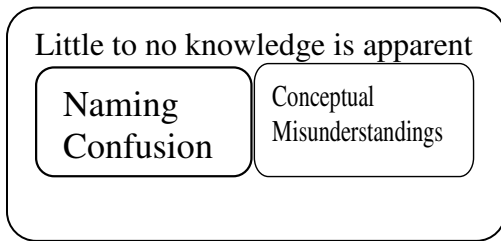


Figure 4.1
Representation of Vocabulary Task Processing

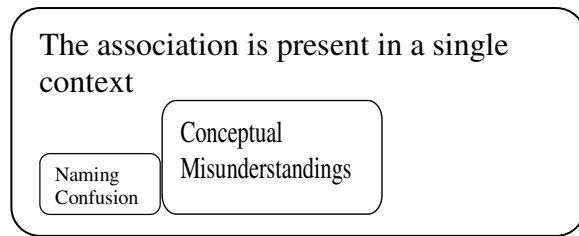
The level of understanding retrieved appears to be affected by naming confusion and conceptual misunderstandings, as seen in Figure 4.2. These components appear in differing proportions, but in the upper-level of vocabulary understanding, confounds are eliminated or minimized. The results here support Vacca and Vacca (1996) who found that “Without appropriate vocabulary instruction, children experience learning

interference with concepts for which they have background knowledge that appears unrelated to mathematics” (p. 140).

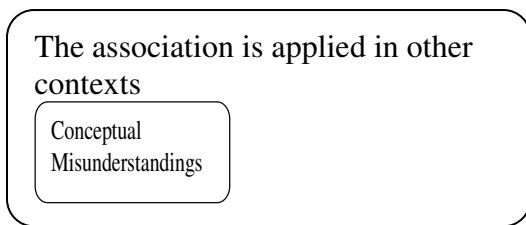
(a) Little to No Knowledge



(b) Associative Processing



(c) Comprehension Processing



(d) Generative Processing

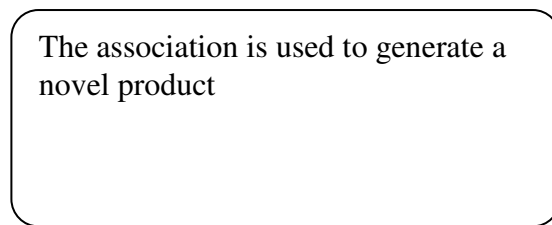


Figure 4.2

Representations of Confounds in Various Levels of Vocabulary Understanding

While the quantitative data obtained here showed that keyword mnemonics increased mastery of the selected keyword vocabulary terms, the qualitative data offer a more in-depth look at student levels of understanding, illustrating the fact that keywords, like other elaboration techniques, can retrieve only the information encoded, whether accurate or inaccurate. This analysis offers an explanation for the smaller gains in students with disabilities as they exhibited many instances of naming confusion as well as numerous conceptual misunderstandings.

CHAPTER FIVE

CONCLUSIONS

Chapter Five discusses the conclusions indicated by the data analyses presented in Chapter Four. Chapter Five includes these sections, (a) Purpose and Methods, (b) Data Analyses, (c) Summary and Conclusions.

Purpose and Methods

The purpose of this study was to ascertain the effects of direct instruction with keyword mnemonics in mathematics vocabulary instruction. The participants in this mixed model multi-strand, quasi-experimental research study were 414 third grade students from 31 general education classes and two special education classes. The researcher matched the participating 33 teachers with similar peers and randomly assigned one of each pair to the contrast group and the other to the treatment group. Students in these classrooms were matched across comparable classrooms according to pretest scores into 207 pairs of matched students.

The contrast group teachers used direct instruction to teach 20 mathematics vocabulary words over a 20-lesson sequence. The treatment group teachers used direct instruction with keyword mnemonics to teach these 20 mathematics vocabulary words over the same 20-lesson sequence. Similar scripts were provided for both groups. According to treatment fidelity self-report forms, 100% of the teachers followed the scripts during the instructions.

Research assistants conducted fifty-three observations. Each of the 33 participating teachers was observed once with some of the teachers in the closest schools being observed more than that. Of the 53 external observations, 13% of the teachers

($n = 7$) varied from the scripts. Six of these teachers were in the contrast group with one in the treatment group. The contrast teachers varied their instruction by adding pictures on the board to the word cards when discussing the definitions. During a review of several of the words, the treatment teacher reviewed one of the terms without showing the keyword picture, an omission that appeared to be an oversight. Assuming that these seven teachers deviated on all 20 lessons, the treatment fidelity percentage is lowered to 80%. However, since the variations were in contrast classrooms, removing these elaborations would have only served to strengthen the results, not inflate the significance.

Data Analysis

A repeated measures analysis of variance was utilized to test for significance between the two instructional groups on the pre-test, post-test and follow-up test scores. The specific research question addressed by this analysis was:

- Is there significant difference between scores on vocabulary assessments for third grade students taught mathematics vocabulary by direct instruction without keyword mnemonics and those taught by direct instruction with keyword mnemonics?

Yes, the students who participated in the keyword mnemonic classes outperformed the students in the direct instruction classes, as measured on the vocabulary assessment, on both the post-test and the follow-up test, although both groups did show significant improvements over the pre-test. Therefore, the answer to research question one is there is a significant difference between the two groups on the vocabulary assessment.

An analysis of variance was conducted to test for significance between the two instructional groups on mathematics achievement, as measured by the Curriculum-Based Measurement (CBM) probes. The specific research question addressed by this analysis was:

- Is there significant difference between mathematics achievement measures for third grade students taught mathematics vocabulary by direct instruction without keyword mnemonics and those taught by direct instruction with keyword mnemonics?

No, there was no significance between the groups on the slope of the CBM probes, meaning the answer to research question number two is there is no significant difference between the two groups.

A t-test was performed on the sums of the totals of the Mathematics Attitudes Inventory to test for significance between the two instructional groups' attitudes toward mathematics. The specific research question addressed by this analysis was:

- Is there significant difference on student attitudes toward mathematics between third grade students taught mathematics vocabulary by direct instruction without keyword mnemonics and those taught by direct instruction with keyword mnemonics?

No, there was no significance between the groups on the difference in attitudes toward mathematics on either the pre-test or the post-test, meaning the answer to research question number three is there was no significant difference between the two groups.

Quantitative Analyses

Vocabulary Assessment

In this investigation, keyword mnemonic instruction was found to provide statistically significant gains in vocabulary understanding, as measured by the pre-, post-, and follow-up tests. This finding supports previous research on vocabulary instruction which indicated that using the keyword mnemonic strategy for vocabulary instruction is effective across various content areas and grade levels (Levin, 1993; Mastropieri, & Scruggs, 1992; Rosenheck, Levin, & Levin, 1989; Scruggs & Mastropieri, 1991). This study adds to the previous research base with its conclusion that direct instruction with the keyword mnemonic strategy is more effective for mathematics vocabulary instruction with third grade students than is direct instruction without the keyword mnemonic.

However, unlike previous research, indicating that the keyword mnemonic method greatly benefited students with disabilities (Scruggs & Mastropieri, 1991), this research did not show a significant increase for these students. Several factors could have contributed to this. The lack of significance could be due to the short duration of the project. It is possible that requiring mastery of 20 vocabulary words in 20 days did not allow the time or the number of repetitions necessary for these students. Another factor could be that in this research, students were required to demonstrate vocabulary knowledge levels above the associative processing stage as had been the requirement of much of the keyword research in the past, (Mastropieri, Scruggs, & Levin, 1985; Mastropieri, Sweda, & Scruggs, 2000; Terrill, Scruggs, & Mastropieri, 2004;) and as is often the goal in classrooms. This research assessed all four levels of vocabulary understanding from the generation processing level to the associative processing level.

Also a possible factor is that much of the previous research was conducted using science or social studies terminology (Levin, 1993; Mastropieri, & Scruggs, 1992; Rosenheck, Levin, and Levin, 1989; Scruggs & Mastropieri, 1991) which may be more concrete than mathematics terminology. Although a study by Mastropieri, Scruggs, & Fulk (1990) examining the keyword mnemonic strategy with abstract words found significance, the study took place one-on-one with students in a resource room with an immediate post-test. Many other studies on keyword mnemonics with students with disabilities also took place in resource rooms or in one-on-one situations (Condus, Marshall, & Miller, 1986; Mastropieri, McLoone, Levin, & Morrison, 1987; Mastropieri, Scruggs, Fulk, 1990; Mastropieri, Scruggs, & Levin, 1985; Sharkin, Mohr, & Glover, 1983). Since the current research took place in general education classrooms for the most part and was not one-on-one, it is possible that attention span played a part, as well as student engagement level. In addition, these students could have had more confounding conceptual misunderstandings than other students, preventing accurate encoding of the terms.

It was apparent during some observations that teachers did not always ensure that the low-performing students were engaged in the instructional activity. At times these students, who tended to be seated farther away from the teacher, were observed drawing, playing with something in their desks, or being otherwise disengaged from the instruction. As mentioned previously, student engagement is key to effective instruction. Other components of effective instruction that could be used in a classroom with low-performing students are to (a) enhance meaningfulness, (b) minimize interference, (c)

promote active manipulation, and (d) increase the amount of practice (Mastropieri & Scruggs, 1998).

One unexpected finding of this research is that students identified as low-performing benefited significantly from the keyword mnemonic strategy. As mentioned previously, a study by Kaznowski (2004) found few significant differences in school performance between low-performing students who did not qualify for special education and slow learners who did qualify for special education. In this study, although the gains of the Basic level students were not significantly better than those of the other performance levels, these students performed statistically similarly to the Below Basic group at the beginning of the study, but were performing significantly differently than the Below Basic students by the end of the study. This is an important finding because this low-performing group could have included students at risk of being identified with disabilities in the future. At the very least, these students will likely be minimally successful in mathematics throughout their education career. Given these findings, it is important to identify various effective strategies for reaching this population in order for them to be successful in mathematics in higher grades.

Mathematics Achievement

There was no significance difference between the groups on mathematics achievement as measured by the Curriculum-Based Measurement (CBM) probes. Several factors could have contributed to these results. One likely reason the vocabulary assessment showed a significant difference is its mastery aspect. The vocabulary assessment tested the exact vocabulary terms taught, the results indicating there was a significant difference in the performance between the groups on this assessment.

However, CBM, by its nature, is a global achievement indicator, assessing all skills to be learned by the student across the entire year (Deno, 1985), meaning there were many skills besides vocabulary represented on each probe. The intent of administering these probes was to track overall student achievement and how it is affected by vocabulary understanding. Perhaps the short duration of the intervention (only 20 days), over a limited amount of material (only geometry terms) did not provide time to affect overall mathematics achievement as represented by this global measure.

CBM is a global measure intended for use as a formative assessment. Its strength lies in its feedback to the teachers for the purpose of adjusting instruction (Whinnery & Stecker, 1992). However, because teachers using feedback might have skewed the results, they did not receive any results during the course of this study. One common teacher comment at the end of the study concerned time spent on assessments. Without feedback from any assessments, it was probably difficult for the teachers to value the time spent for administration and to encourage students to do their best. The students, then, would not have been motivated when taking the probes. Past CBM research has indicated that student motivation to do well tends to increase when the student sees the task as beneficial or helpful (Fuchs, Fuchs, Hamlett, & Ferguson, 1992).

Mathematics Attitude Survey

There was also no significant difference between groups on attitudes as measured by the mathematics attitude survey. Since the project only lasted one month, it is unlikely major changes in attitudes would have taken place this quickly, especially since neither the students nor teachers received any feedback on progress. The qualitative data also points to the fact that many student answers concerning attitudes toward mathematics

were based on grades received and calculation ability. It is possible that the students do not have a realistic view of their own abilities at this level and attempts to gauge their attitudes, or an increase in it, is difficult at this stage. This hypothesis is further indicated by the responses of students with learning disabilities who based their positive attitudes on their high grades in resource room but who were still unable to answer any of the interview problems. However, due to the positive comments teachers reported regarding student enjoyment of keyword mnemonics, this student attitude issue remains an important component to consider in future keyword research.

Qualitative Analysis

Analysis of the qualitative data indicated that level of performance is determined by the knowledge possessed but is tempered by the degree of naming confusion and conceptual misunderstandings involved. These components appear to exist in differing proportions and decrease toward higher levels of understanding. Since keyword mnemonics, or any elaboration technique, retrieve whatever information is encoded with the retrieval cue, it is imperative that the information stored is accurate and complete. It appears that the students with disabilities possessed significant naming confusion as well as conceptual misunderstanding, possibly a reason their scores were not significantly higher, as had been the case in other research. Perhaps the low-performing students who did exhibit significant gains had a better knowledge foundation and just needed an elaborative technique to overcome name confusion. Specific examples of these components from the data are presented here. Since there was no significant difference between the interaction of levels of vocabulary understanding and group membership, as stated earlier, group membership is not reported on the examples presented.

Writing Prompts

The writing prompts provided data on apparent levels of understanding and some on name confusion. Elaborations were not directly provided in this assessment though some could be inferred. For example, across the writing prompts, students with disabilities from the treatment group often correctly represented the keyword mnemonic, but did not completely answer the question, as shown in Figure 5.1. The student in this figure did capture the essence of vertical but was apparently not able to express the understanding in words. It does appear that the student had a correct basic understanding and that the mnemonic assisted in retrieval. However, the appropriate language was not available, making it difficult to assess the level of understanding. This student might have an understanding of the concept, but that would be difficult to capture on an objective assessment.

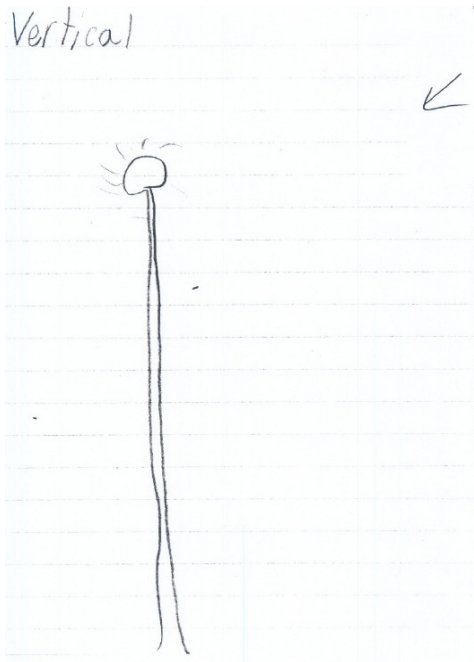


Figure 5.1

A Student with Disabilities Responds to “What Does Vertical Mean?”

Note: This is a representation of the keyword for vertical, which was very tall pole (See Appendix E for a complete set of the keywords used in the research).

Some students produced relatively accurate representations, but the explanations indicated a conceptual misunderstanding, as was the case in Figure 5.2 where the student incorrectly defined vertical. The word congruent apparently confuses the student, as well as the arrow signs drawn to represent lines.

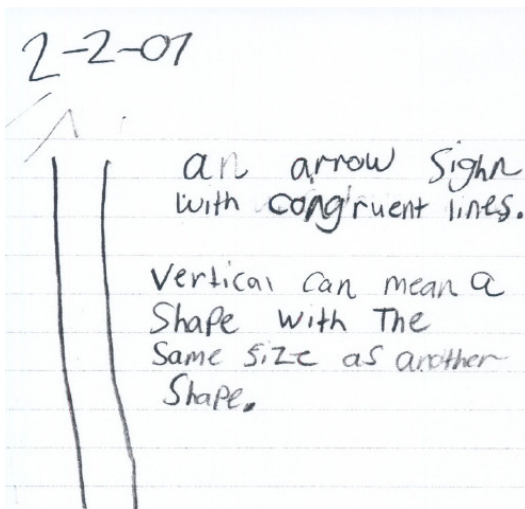


Figure 5.2

An Average Student Responds to “What Does Vertical Mean?”

Often students understood terms, such as the depiction of vertical in Figure 5.3, at a basic level and could illustrate that knowledge. The student might even be able to make associations on an objective assessment that would appear correct. However, more discussion would appear warranted with this student to make sure exactly what going up and down means.

Sometimes students confused similar words, exhibiting name confusion. The student in Figure 5.4 confused vertical with vertex, making it impossible to tell if the student understands vertical.

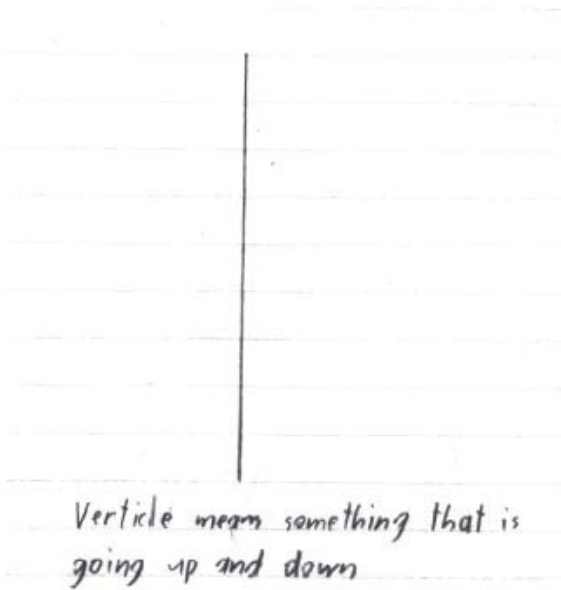


Figure 5.3

A Low-performing Student Responds to “What Does Vertical Mean?”

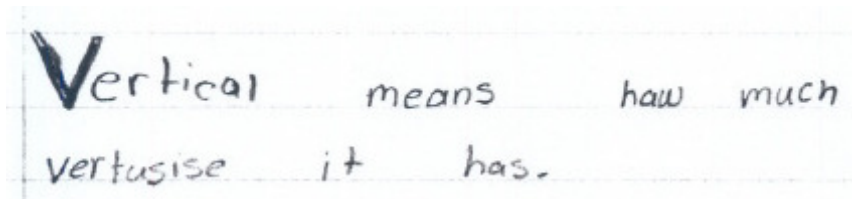


Figure 5.4

An Average Student Responds to “What Does Vertical Mean?”

Higher performing students could accurately represent the terms, such as vertical in Figure 5.5, and sometimes offered a practical application of the term along with a nonexample. This is an example of the highest level of understanding, generative association.

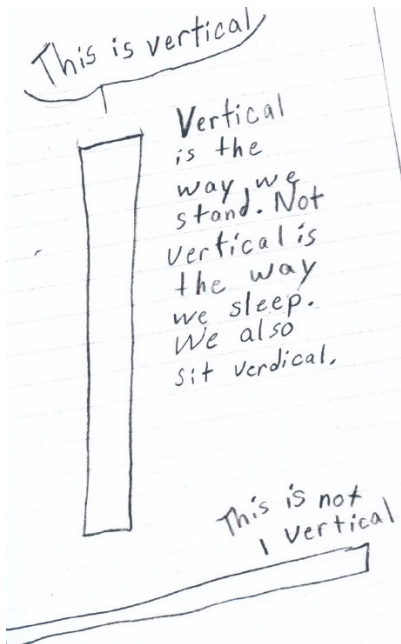


Figure 5.5

A High-performing Student Responds to “What Does Vertical Mean?”

Parallel

The next writing prompt was, “How would you explain parallel to a friend?” A finding from this prompt was that while all students drew the two parallel lines as they are typically drawn, several deduced from this that parallel lines were the same length, indicating that the students do not correctly understand the concept of a line. The student

in Figure 5.6 uses a typical drawing of parallel lines and appears to have basic conceptual knowledge at either an associative processing or comprehension processing level.

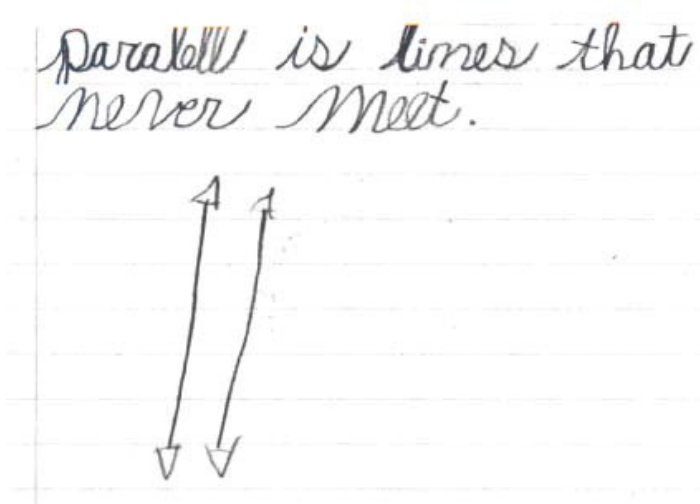


Figure 5.6

An Average Student Responds to “How Would You Explain Parallel to a Friend?”

Higher level students often demonstrated more complete conceptual understanding, as expected. The student in Figure 5.7 offers an explanation plus an illustration and adds a nonexample as well. When the student is introduced to three dimensional concepts later, the understanding will expand to include the lines being the same distance apart.

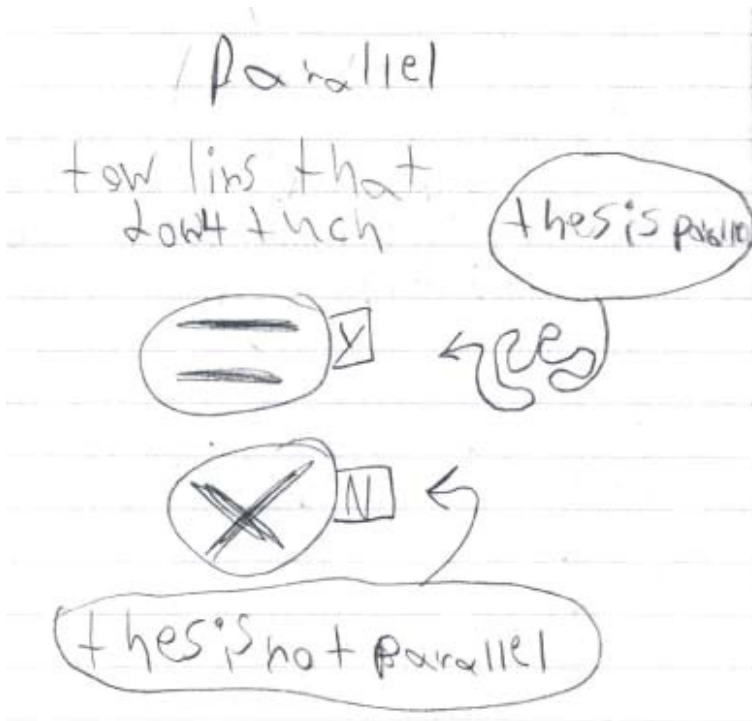


Figure 5.7

An Upper-level Student Responds to “How Would You Explain Parallel to a Friend?”

The student in Figure 5.8, again perhaps because of the way parallel lines are typically drawn, states that parallel lines are the same length. This student does appear to have the basic concept that parallel lines never touch, so the misunderstanding that about line length may not be difficult to address. There is no visual representation here, but none was required to answer the question.

During the interviews, low-performing students often refused to answer. However, the writing prompts appeared to be less intimidating and could capture that low-performing students often did not understand the terms at all, such as in Figure 5.9.

parallel is when
two lines never touch
each other and are the
same length and also
can be any distance
apart.

Figure 5.8

An Average Student Responds to “How Would You Explain Parallel to a Friend?”

parallel is something
strate, and flat.


A hand-drawn diagram of a parallelogram on lined paper. The shape is a quadrilateral with two vertical sides and two slanted sides that are parallel to each other. The top and bottom sides are also parallel to each other.

Figure 5.9

A Low-performing Student Responds to “How Would You Explain Parallel to a Friend?”

Several students had obviously been taught that parallel was in relation to the ground, as seen in Figure 5.10. One student reported that “parallel is something that hovers over the ground.” Some of these pictures indicated that the teacher had used a table or desk as her visual aid, and several students drew tables to illustrate parallel. However, the relationship aspect of parallel was lost in these examples. This is another example of the need to carefully choose visual aids and elaborations.

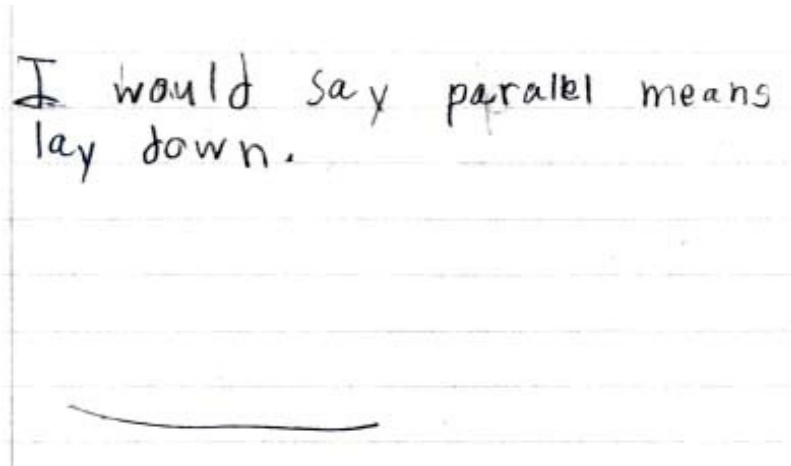


Figure 5.10

An Average Student Responds to “How Would You Explain Parallel to a Friend?”

Quadrilateral

The second writing prompt was, “Draw a quadrilateral. Tell how you know it is a quadrilateral.” Most students, even low-performing ones, answered this correctly although several drew and described a square. It is difficult to ascertain if the students understood that a square is a specific form of quadrilateral. Figure 5.11 is from a student who would have benefited from using an elaboration to remember which polygon is a

quadrilateral. The student obviously confused quadrilateral with pentagon, another vocabulary term selected.

The illustration in Figure 5.12 shows basic understanding and the expected definition, but it is unclear that the student recognizes that quadrilaterals do not all have right angles and equal sides.

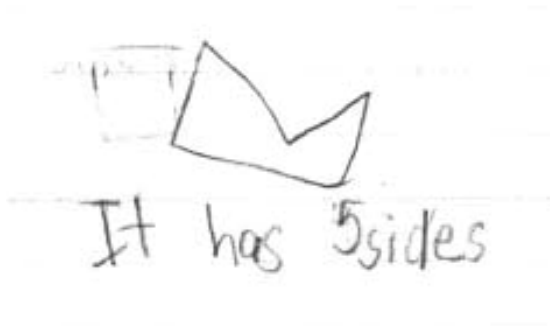


Figure 5.11

An Average Student Responds to “Draw a Quadrilateral. Tell How You Know It Is a Quadrilateral.”

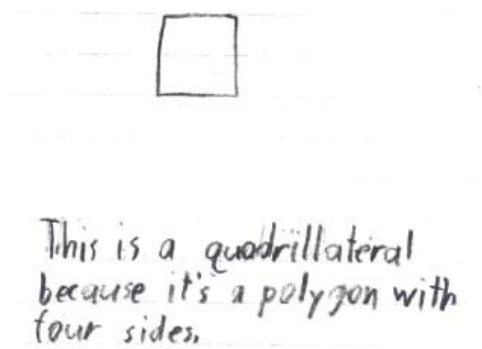


Figure 5.12

An Upper-level Student Responds to “Draw a Quadrilateral. Tell How You Know It Is a Quadrilateral.”

Figure 5.13 represents an upper-level student who was one of the only students demonstrating an understanding that all quadrilaterals do not have right angles and equal length sides.

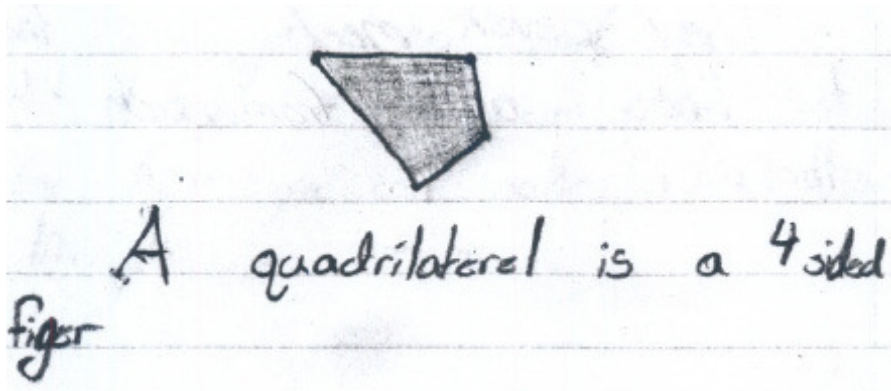


Figure 5.13

An Upper-level Student Responds to “Draw a Quadrilateral. Tell How You Know it is a Quadrilateral.”

Horizontal to Vertical

The third writing prompt was “If you had something that was horizontal, how would you make it vertical?” Surprisingly, the students were quite creative in response to this question, with most students offering a correct solution. Some drew objects surrounded by arrows indicating how to rotate the object to make it vertical. Figures 5.14 and 5.15 show realistic applications from upper-level students.

if you were laing in
bed you could sand
up.

Figure 5.14

An Upper-level Student Responds to “If You Had Something That Was Horizontal, How Would You Make It Vertical?”

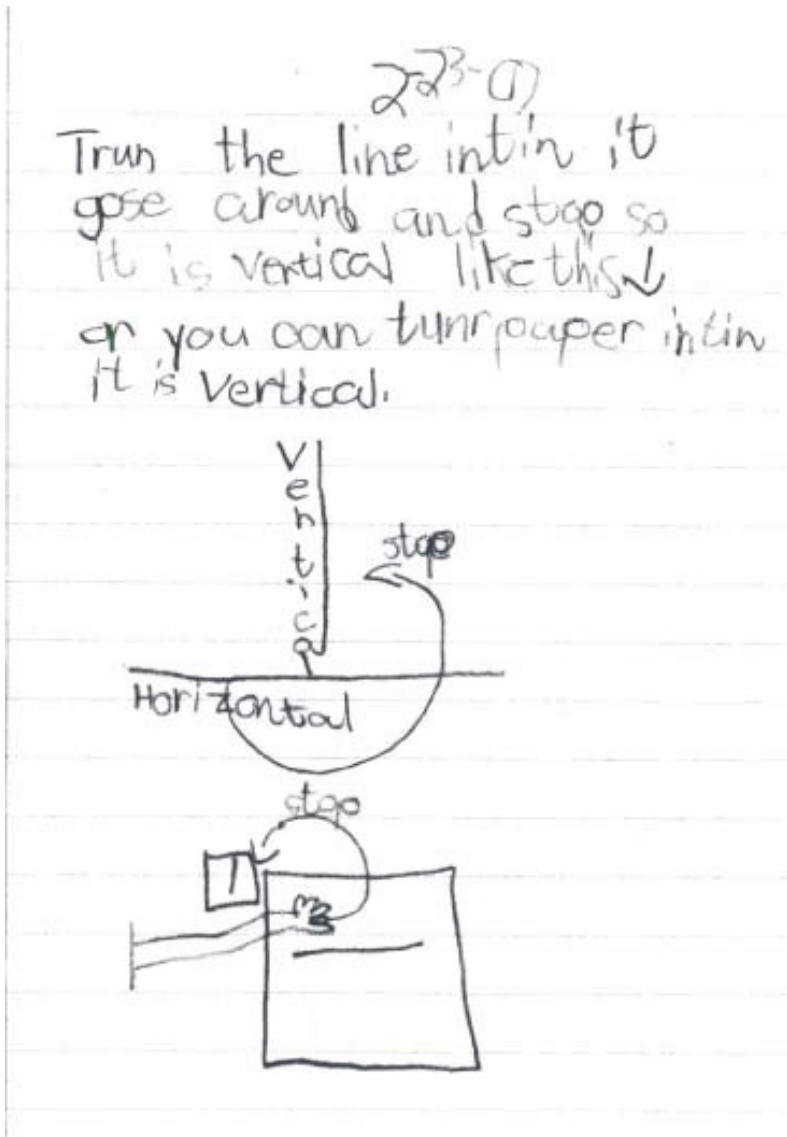


Figure 5.15

An Upper-level Student Responds to “If You Had Something That Was Horizontal, How Would You Make It Vertical?”

In contrast, low-performing students often indicated that they did not understand how to solve this problem. In Figure 5.16, the student offered a flip (reflection) as a solution; however, a flip creates a mirror image, not a rotation. It is unclear which part the student does not understand because there is no indication of the meanings of horizontal and vertical.

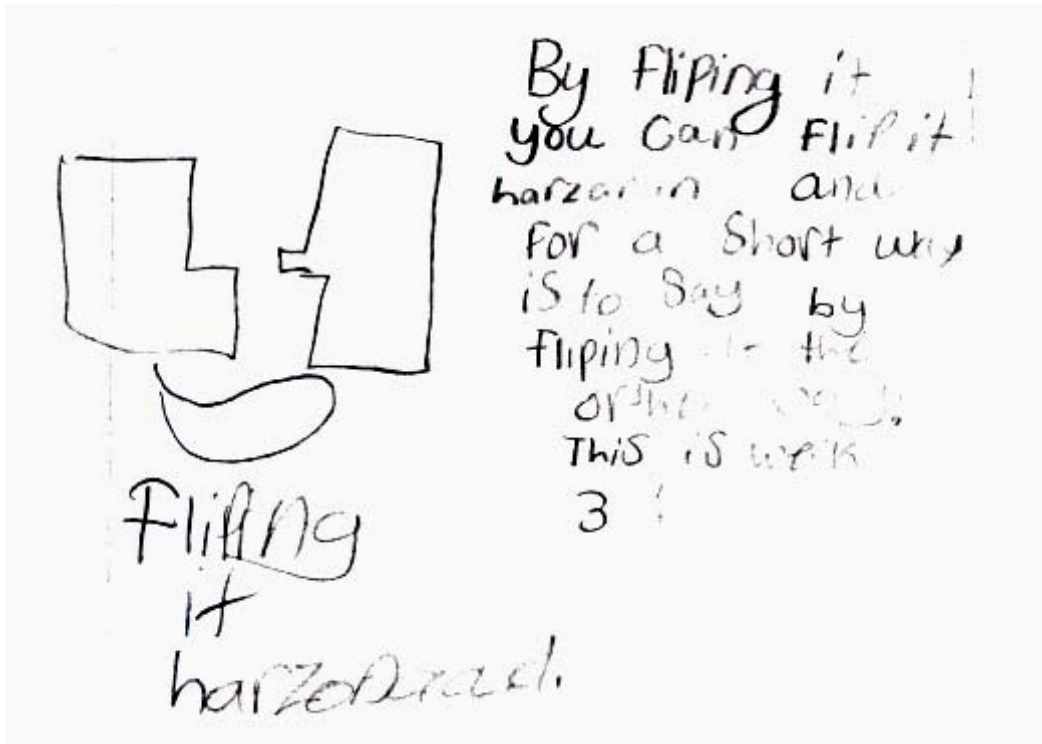


Figure 5.16

A Low-performing Student Responds to “If You Had Something That Was Horizontal, How Would You Make It Vertical?”

Students who missed this prompt typically confused horizontal and vertical. A few of the treatment group students related relationship this to the keywords, saying, for example, “If the very tall pole was on the ground, you could stand it up and make it vertical” or “The horse running is horizontal but you could stand him up on his nose and

make him vertical.” (The keyword for horizontal was horse running with a picture of a horse stretched out and running. The keyword for vertical was very tall pole with a picture of a very tall pole. Appendix E gives a complete listing of the keyword mnemonics used in the research.) In Figure 5.17, a student with disabilities indicates horizontal and vertical correctly by referencing the keyword for vertical, very tall pole. The student may have had difficulty expressing this idea in words, but appears to understand the concepts.

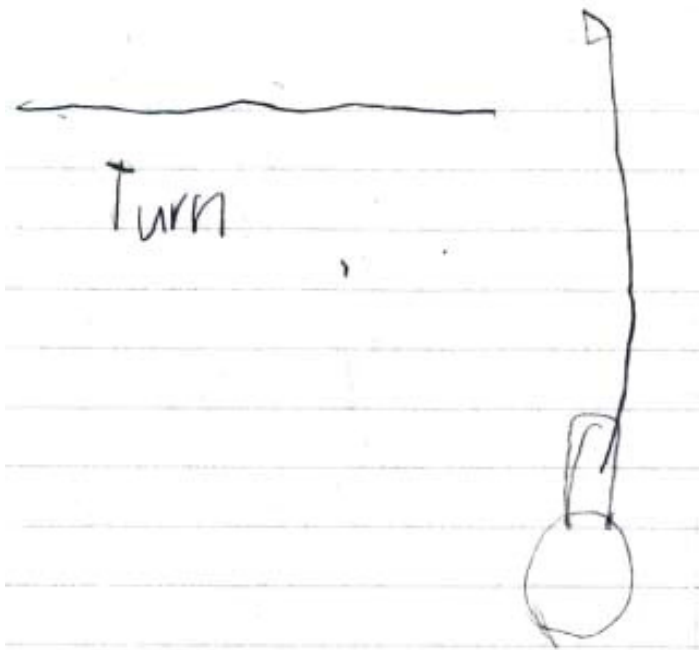


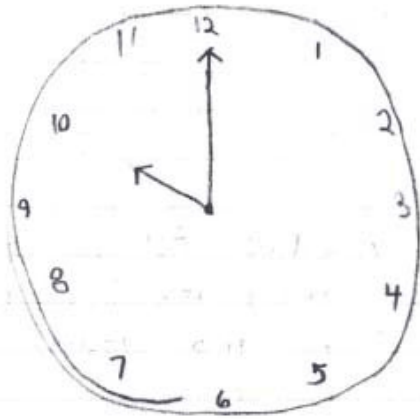
Figure 5.17

A Student with Learning Disabilities Responds to “If You Had Something That Was Horizontal, How Would You Make It Vertical?”

Diameter

The next writing prompt was “Draw a round clock. Show the diameter and tell how you know.” This prompt was the most problematic and had the most diverse range of answers, both correct and incorrect. Some students apparently had conceptual misunderstandings that interfered with their answers to this question. In Figure 5.18, the student was obviously using prior knowledge of a dime to help determine the meaning of diameter. It is unclear why, after regular instruction plus the instruction from this study, this particular elaboration continued to confound conceptual development.

The upper-level student in Figure 5.19 did understand the basic idea of a line across, but had the conceptual misunderstanding that a line across any shape was referred to as a diameter.



I know this is a "diameter"
because "di" means ten so "diameter"
means ten o'clock.

Figure 5.18

A Low-performing Student Responds to "Draw a Round Clock. Show the Diameter and Tell How You Know."

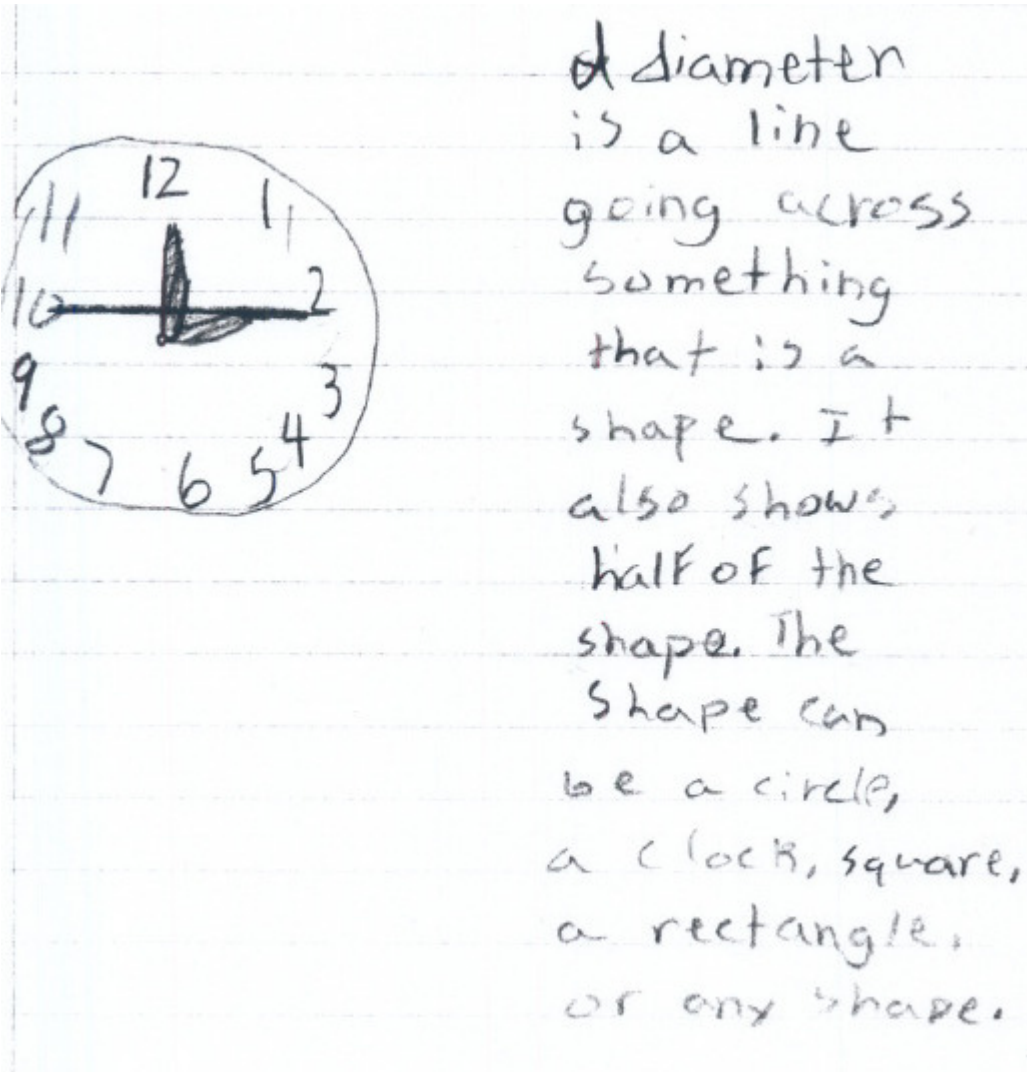


Figure 5.19

An Upper-level Student Responds to “Draw a Round Clock. Show the Diameter and Tell How You Know.”

Several students, like the one in Figure 5.20, stated that the diameter was always either vertical or horizontal, which was probably dependent on the representations they had seen. Teachers should always be aware of these types of conceptual misunderstandings in order to address them.

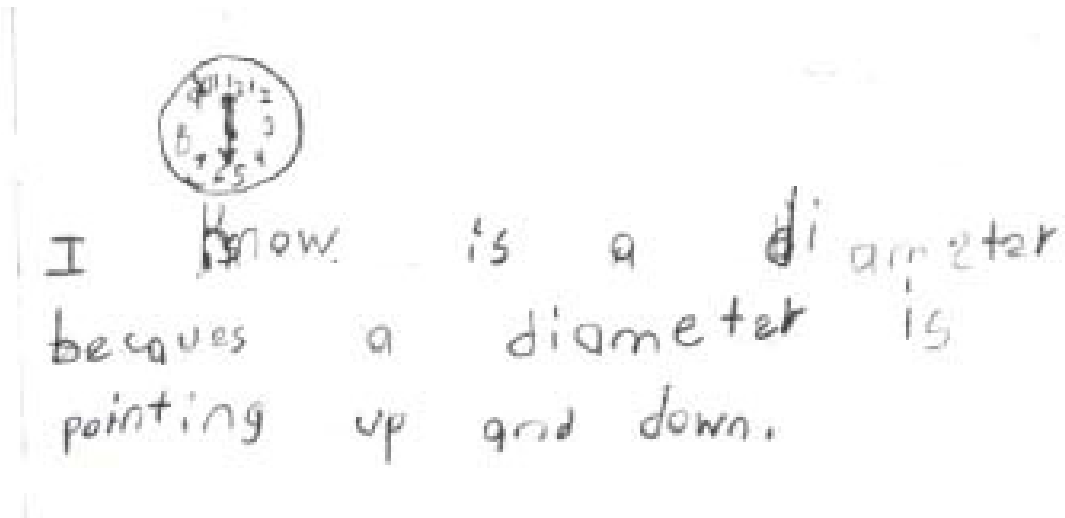


Figure 5.20

An Average-Performing Student Responds to “Draw a Round Clock. Show the Diameter and Tell How You Know.”

Many students represented either the diameter or radius as a point in the middle of a circle, as did the student in Figure 5.21. That misconception may have been due to the teacher’s emphasis on the fact that diameter goes through the middle of the circle and that the radius originates at the middle point.

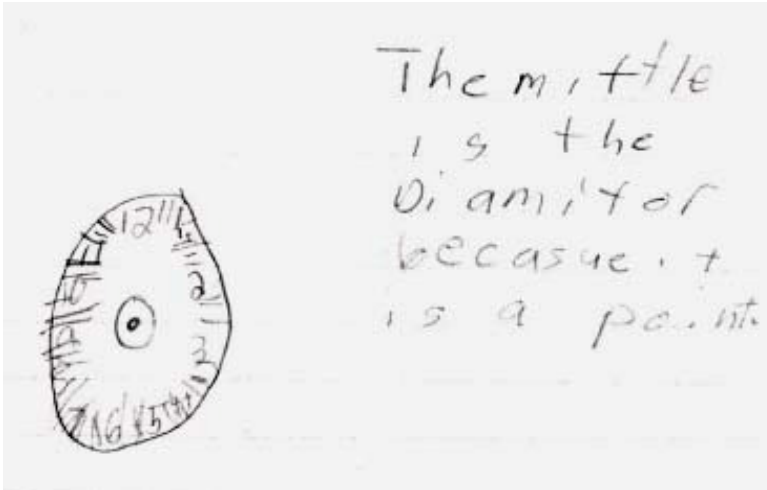


Figure 5.21

A Low-performing Student Responds to “Draw a Round Clock. Show the Diameter and Tell How You Know.”

The upper-level student in Figure 5.22 illustrated and worded the definition well. In addition, some upper-level students mentioned that the diameter was a way of measuring across a circle, providing the teacher with a clear indication that the student had a clear conceptual understanding. However, it did not appear that most teachers made this point to their students.

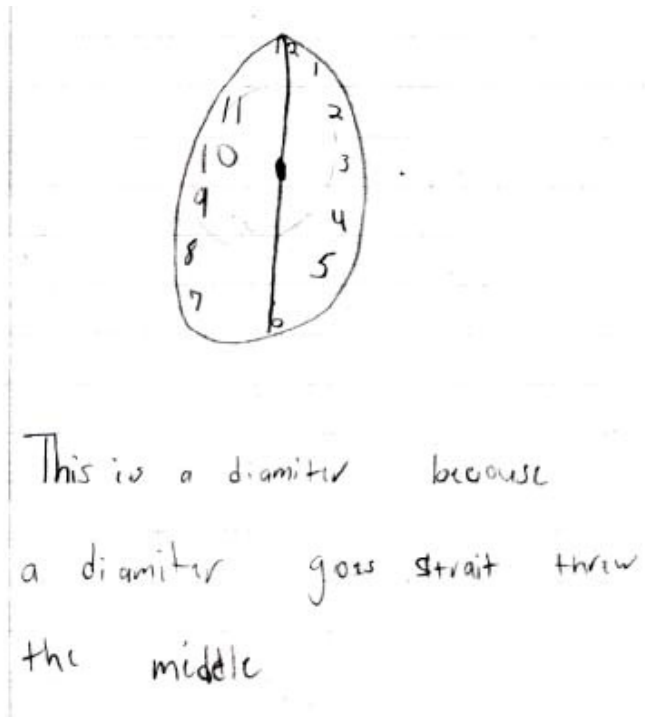


Figure 5.22

An Upper-level Student Responds to “Draw a Round Clock. Show the Diameter and Tell How You Know.”

As Figure 5.23 shows, a student with disabilities had such difficulty representing the clock that the actual question was never answered. It is impossible to determine from this response whether the student understands diameter or not because the task itself was a confound. This issue should be considered when writing assessments.

Figure 5.24 shows a student with disabilities who correctly illustrated the term but did not know how to express it. It is difficult to know if the student understands the concept or not, but the representation was correct.



Figure 5.23

A Student with Disabilities Responds to “Draw a Round Clock. Show the Diameter and Tell How You Know.”

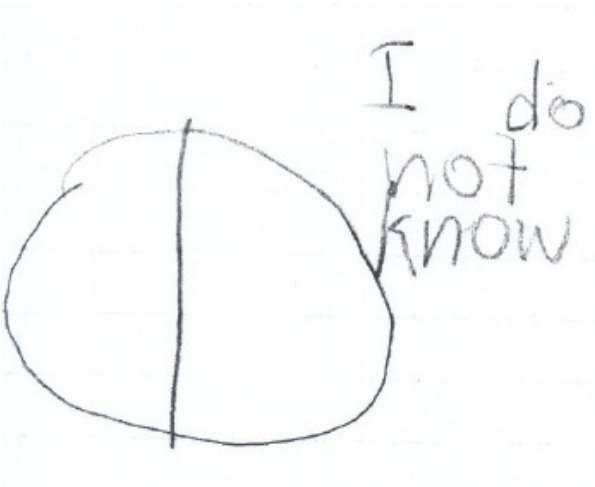


Figure 5.24

A Student with Disabilities Responds to “Draw a Round Clock. Show the Diameter and Tell How You Know.”

Figure 5.25 is from an upper-level student who understands there is more than one way to draw a diameter. This illustrates full conceptual development for this term.



Figure 5.25

An Upper-level Student Responds to “Draw a Round Clock. Show the Diameter and Tell How You Know.”

Acute Angle

For the writing prompt “What is an acute angle? Tell how you know,” almost all students drew the correct, typical picture for this prompt, but the explanations varied. The student in Figure 5.26 correctly depicted an acute angle, but it is difficult to tell from the definition whether the concept is fully understood. The use of the term small in this definition may be an indication of a conceptual misunderstanding, as illustrated by the average student in Figure 5.27. Many students used the term small angle when describing acute angle. Teachers often use this description to help students differentiate between acute and obtuse, which is then referred to as the big angle. This student illustrates the

conceptual misunderstanding that often occurs in this circumstance. The student stated that an acute angle is, literally, small, i.e., “only about an inch and a half long.”

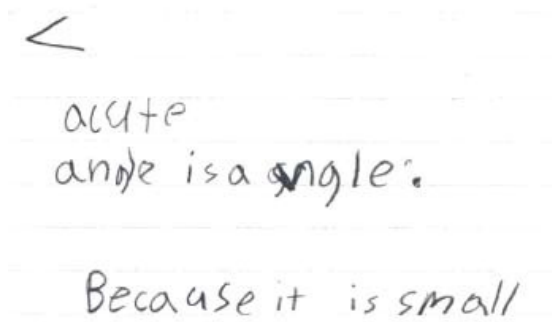


Figure 5.26

An Average Performing Student Responds to “What Is an Acute Angle? Tell How You Know.”

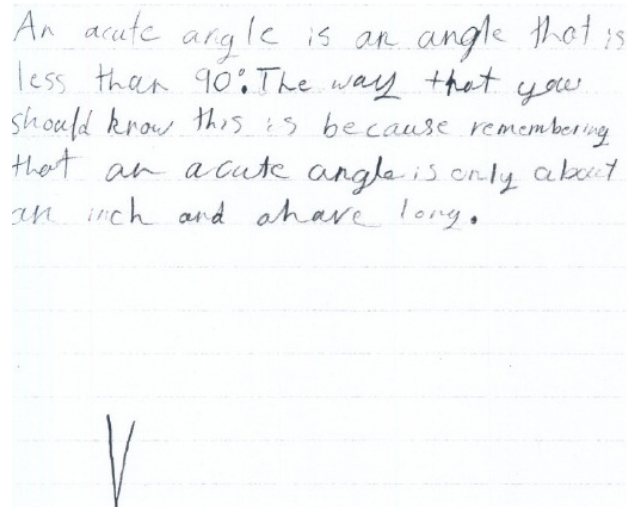


Figure 5.27

An Average Performing Student Responds to “What Is an Acute Angle? Tell How You Know.”

The upper-level student in Figure 5.28 illustrated an acute angle correctly and the definition is accurate except for the fact that the student mistook the percent sign for the degrees sign. Several misunderstandings surfaced concerning degrees, prompting a

question about the appropriateness of this term as a third grade standard. The students can reproduce the definition, but it appears unlikely they understand the total concept, as illustrated by the student in Figure 5.29, a lower-level student apparently confused by the word degrees in the definition of acute. This conceptual misunderstanding is caused by interference from the students' prior knowledge. It did not appear that most teachers explained how the term degrees was used in measuring angles and the students relied on previously learned uses of the term.

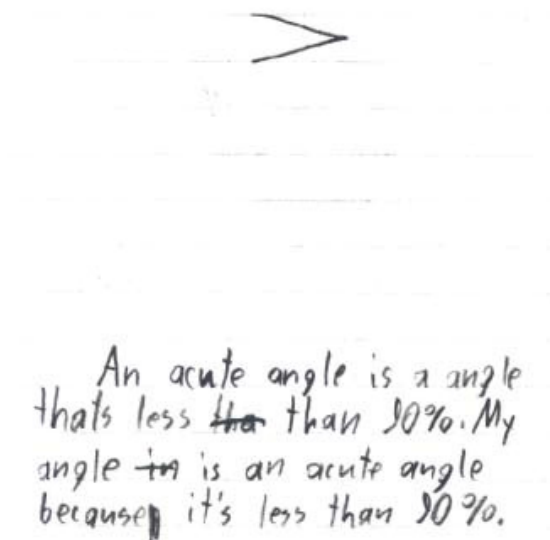


Figure 5.28

An Upper-level Student Responds to “What Is an Acute Angle? Tell How You Know.”

an acute angle is a thumonter
that is less than 90 deagres



Figure 5.29

A Lower Level Student Responds to “What Is an Acute Angle? Tell How You Know.”

Figure 5.30 is from an upper-level student who had a good, basic understanding of the relationships between an acute and a right angle. However, this student, along with many others, over-generalized the right-angle symbol their teacher used. It appeared that many teachers introduced this symbol but may not have clarified its use. The use of nonexamples in this case might help the students understand. This further illustrates a misunderstanding that may interfere with learning in the future.

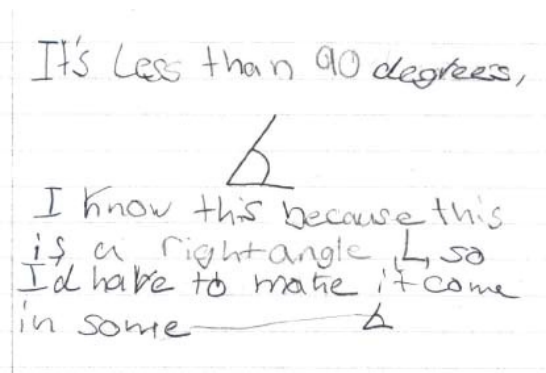


Figure 5.30

An Upper-level Student Responds to “What Is an Acute Angle? Tell How You Know.”

The writing prompts offered much insight into student thinking and a clear view of some of their conceptual misunderstandings, but a more in-depth look is required to explore elaborations the students used to retrieve information. The interviews offered this information.

Interviews

To further explore student thinking processes while solving problems involving the vocabulary words, interviews were conducted at each school after the post-test. These interviews were then transcribed and analyzed. One pattern that emerged from analysis of these transcripts was of elaboration usage. It became apparent from rereading writing prompt responses and the interview transcripts that students vary widely in their use of elaborations and that this difference is directly associated with performance level. Interview questions asked specifically about elaborations, providing more specific information that could only be inferred from the writing prompt responses. This section discusses confidence components, elaborations, and conceptual misunderstandings.

Confidence. There were some interesting, and unexpected, differences between the answers from the various performance levels of the students. For example, the higher performing students answered questions clearly and unhesitatingly. Even though they did not always answer correctly, they did so definitively, suggesting that they trusted themselves to know the right answer.

On the other hand, the basic level students answered more hesitantly and sometimes changed answers if the interviewer hesitated in moving on. This group's gains on the post-test and follow-up test placed them in the same homogeneous subset as the advanced/proficient students. However, during the interviews, which were given the week after the post-test was administered, they were still hesitant as they answered, doubting their own understanding and often making decisions based on questionable strategies. The below basic students often did not answer at all. Sometimes said they remembered hearing the words but could not remember the meanings. These students seemed intimidated by the questions on the interviews although they had produced answers for the writing prompts.

Another interesting confidence factor was that most students answered "Are you good at math?" with a positive response. The most common reason for saying yes was "I get good grades." This was the response even from the students with disabilities who were unable to answer any of the questions correctly. It appears that the inflated grades given for working off-grade level give these students a false sense of security. This situation may have been a factor in the lack of significance in the survey responses. Perhaps lower level students do not have a clear assessment of what they actually know and what they do not know. For example, Question Three was "Tell me what a diameter

and a radius are. How do you remember these words?" The 17 students who gave no answer and could not remember any part of the definition were all below basic students.

This student with disabilities could not answer the radius question.

What are radius and diameter?

Student 1: *radius?*

Researcher: Yes, can you tell me what radius and diameter are?

Student 1: *radius?*

This student never answered so the interviewer moved on.

Following are several examples of basic level students answering the diameter/radius question.

Student 2: *A diameter is the bottom number of a fraction and radius, well, I forgot.*

Student 3: *No, I don't remember*

Researcher: What do they have to do with?

Student 3: *I think the diameter is the middle of the circle and the radius is the dot.*

Student 4: *I remember that the diameter only goes to the center and radius goes all the way through.*

Student 5: *diameter is – you have a circle.....*

Researcher: Do you remember anything else?

Student 5: *Um.....*

Researcher (after waiting several seconds): No?

Student 5: Shakes head

Researcher: How about radius?

Student 5: Shakes head

Researcher: No?

Student 6: *Diameter is on bottom and numerator is on top.*

Student 7: *Radius doesn't go all the way around. I think it only goes half-way.*

In contrast, here is an example from an advanced/proficient student answering the diameter/radius question.

Student 8: *Diameter is straight through the middle of the circle and radius is to the edge.*

Two advanced/proficient level students answer in this manner.

Student 9: *I remember hearing them but don't remember. I think the radius goes from the middle of the circle to the outside and the diameter goes all the way across.*

Student 10: *The Clemson thing says diamond ring and the line goes all the way across.*

These students had received regular instruction from their teachers in the geometry units and 20 days of targeted strategies aimed at teaching these vocabulary terms. However, many still did not know the meanings of these basic mathematical vocabulary terms. (Diamond Ring was the keyword mnemonic used for diameter. Appendix E gives a complete list of the keyword mnemonics used.)

Elaborations. Elaborations come in many forms-- keyword mnemonics, for example-- and are used to assist in retrieval of information by providing a way to differentiate between words thereby avoiding naming confusion. Students often indicated they used elaborations when answering correctly. Some of these elaborations were provided by the keywords, some were provided by the teachers, and some upper-level students generated their own.

Naming confusion was often a problem with terms occurring in pairs, such as numerator and denominator. Question four asked, "If 4 is the numerator and 7 is the denominator, how would you write that fraction? What would the fraction look like if 2 is the denominator and 5 is the numerator?"

Forty-three of the 54 students answered correctly by putting the numerator on the top and the denominator on the bottom. Nine students answered incorrectly, confusing the two words, and two students did not answer. Two of the students answering correctly were confused by the second question, where the numerator was greater than the denominator, saying "that one doesn't make sense," and "that one is a pretend fraction."

These answers indicate that the students do not understand how a fraction can represent more than one whole.

This is a representative basic level student answer.

Student 10: *Put the 7 on the bottom and the 4 on the top?*

Researcher: Why?

Student 10: *Because the 7 is bigger than the 4.*

The follow-up question asked how to make a fraction where 5 is the numerator and 2 is the denominator. Here is how this same student, Student 10, answered.

Student 11: *In the next one, put the 5 on the top and the 2 on the bottom.*

Researcher: Why did you do that?

Student 11: *I looked at the first one and numerator was on top so I put it on top again.*

Another basic level student responded to the same follow-up fraction question like this:

Student 12: *I looked (at the first one) and the 4 was on the top line so it goes on top. So the numerator goes on top in the second one.*

This is from a below basic level student at another school:

Student 13: *Put 4 right here (points on top) and 7 right here (points to the bottom box) because 4 comes first.*

Researcher: What about this next problem where 5 is the numerator and 2 is the denominator?

Student 13: *2 goes on the bottom and 5 goes on the top – because numerator was on top in the first one.*

In contrast, here is the answer from an advanced/proficient student on the same question:

Student 14: *4 is on top and 7 is on bottom.*

Researcher: So what about this one where 5 is the numerator and 2 is the denominator?

Student 14: *5 is on top and 2 goes on bottom.*

Researcher: How did you remember what numerator was?

Student 14: *On the denominator, d is down so denominator goes on bottom.*

These examples show that lower performing students often make decision using incorrect strategies, such as making an arbitrary decision and then referring back to that decision to answer another question. Higher level students use memory strategies that they create, or that were given to them, to answer the questions.

Other higher level students answered with various strategies such as “the u in numerator is for up so it goes up” and “the den in the house is at the bottom so

denominator goes on the bottom,” and two from the treatment group answered with the keyword, “I remember that terminator goes on the bottom.”

The next question, Question Four, presented a square divided into eight squares and asked, “How would you find the area of this figure? How do you know?” All students answered this question correctly by saying “8,” responding that to get the answer they just “counted the boxes.”

Question Five presented the students with a picture of a small triangle having a perimeter of 15 marked and a larger triangle having a perimeter of 6 marked. Although there were no units marked, the intent of this question was not to trick the students but to determine their basic understanding of perimeter. There was no right or wrong answer to this one, and all answers were accepted as correct. However, when the researcher asked, “Which figure has the greater perimeter?” all but three students answered that Triangle B, the smaller triangle, had the greater perimeter because of the numbers. A common answer was “15 is bigger than 6.”

Three students looked at the pictures instead of the numbers, answering that Triangle A had the greater perimeter. One student did not answer and did not seem to know what to do. This question seemed to reinforce that the students do not have a solid understanding of perimeter at this point in their education and had not considered the impact of the lack of units. It is perhaps too early in their experiences to expect third graders to understand this concept

The last question, Question Six, asked the students to “insert $<$, $>$, or $=$ into this sentence: ‘An acute angle _____ an obtuse angle.’” Five students could not remember whether acute angles or obtuse angles were less than 90 degrees, and one

student did not remember ever hearing the words *acute* and *obtuse*. Although 49 of the students answered correctly that an acute angle is smaller than an obtuse angle, 11 answered with the wrong symbol (i.e., $<$, $>$ or $=$). This error seemed to occur because the word *obtuse* was at the end of the sentence, so they read it back as “an obtuse angle is larger than an acute angle” and, therefore, picked the wrong symbol. All students recognized the symbols and knew that the open end pointed toward the larger amount, as in the “crocodile mouth” analogy, although when asked which symbol was which, most students did not know.

A basic level student responded with this answer to the last question about acute angles and obtuse angles:

Student 15: *I remember the words but I'm trying to remember which one is which. I think obtuse is greater than.*

This student exemplifies the overall finding concerning the difference in the confidence level between higher and lower performing students. Higher level students were confident in their answers, while lower level students answer hesitantly and students with disabilities often would not reply at all, even when they had only two answers from which to choose.

Teacher Survey

The post-project teacher survey provided information from the teachers about the project and the two instructional methods. The contrast teachers were split evenly when responding to the question, “Did you enjoy teaching math vocabulary using the method

you were given?” However, 89% of the 17 treatment group teachers responded positively. The two treatment group teachers who did not respond positively commented that “the words were silly,” “the words made no sense,” and “the words had no meat to them.” These comments indicated that these teachers did not understand that the keyword mnemonics were for the purpose of encoding and retrieval, not conceptual development. Additional training seems warranted in these cases.

In addition, each group was asked, “Would you use the word cards or picture cards (whichever you used for the project) again in your vocabulary instruction? Why or why not?” Of the contrast group, 88% said that the direct instruction was “dull and boring.” These teachers seemed conscious of what the students enjoyed and did not think direct instruction was enjoyable for them. However, it was not clear if the teachers thought it was “dull and boring” or if the students did. One contrast group teacher remarked that the direct instruction helped her students remember and she believed that was the important part, even if the method was not particularly enjoyable. These responses reflect the reputation that direct instruction has among teachers as being “dull and boring.” However, 83% of the treatment group teachers responded positively that they would use the keyword mnemonics again. More than half said, “The students enjoyed them and it helped them learn the words.”

The treatment group teachers then rated the keywords based on how effective they were in helping their students remember the vocabulary words. Interestingly, several of the words deemed ineffective by the teachers were cited numerous times on both the post-test and follow-up test by the students. For example, the keyword for mode was listed twice as being ineffective and only four times as being effective. However, the

keyword for mode was cited by the students 22 times on the post- and follow-up tests. This difference could be because the students were remembering this specific keyword while trying to recall the meaning of the words. The questions on mode were correct on only 11% of the questions for the pre-test but were correct on 54% of the questions at the post-test for the treatment group. The contrast group also got the mode items correct 11% of the time on the pre-test but only 34% of the time on the post-test.

Another example, vertex, was listed on the teachers' ranking three times as ineffective and on none as being effective. This was also criticized on the surveys as well as during observations conducted by the research assistants. However, it was cited 34 times by the students across the post-tests and follow-up tests. Even though the answers were not always clear enough to be counted correct, the keyword was obviously cited as the students tried to recall the meaning of the word. This result may reflect the fact that the students did not quite understand the concept of vertex but were recalling the keyword mnemonic while attempting to remember the definition. Again, the keyword mnemonic is not meant to explain the concept, only to trigger encoding and retrieval of the definition. Conceptual development must be done clearly and directly by instruction from the teacher. In addition, studies have shown that keywords are more effective when there is no interference from prior knowledge (Mastropieri, Scruggs, & Fulk, 1990). The results of this study seems to support those findings.

Quadrilateral and perpendicular were other examples that the teachers did not see as effective but that were highly cited by the students on the tests. Specifically, quadrilateral was a favorite among the students but not the teachers. The keyword was "card table and the picture showed two students playing cards at a card table. The

students duplicated this picture on 30 of the tests, and got 50% of the quadrilateral items correct on the post-tests, an increase over the 28% correct on the pre-tests.

Though not chosen as effective by the teachers, horizontal and vertical were two of the more effective keyword mnemonics and were cited numerous times by the students. It appears likely that remembering one of these would contribute to remembering the other one. These two terms were cited collectively 29 times across the tests. The students got the horizontal and vertical items correct on the pretest 26% and 24% of the time, respectively, but on the post-test, the items were correct 58% and 54% of the time, respectively. The terms horizontal and vertical are not often used by teachers in favor of the hotdog and hamburger descriptions which is often used in elementary school classroom instruction (i.e., “turn your paper hotdog style” for horizontal, or “turn it hamburger style”, for vertical). It would appear that an effective way to remember these two words, as demonstrated by these keyword mnemonics, would be of great use in early elementary classrooms.

Interestingly, the keyword for polygon was considered effective by many of the teachers but was only represented on 8 of the tests. This result could be because students answered 73% of the polygon items correctly on the pre-test and 81% correctly on the post-test. In other words, the students did not need a retrieval cue for this term because they already knew it. This conclusion supports research showing that students tend to depend on mnemonics more when the material is unfamiliar (Mastropieri, Scruggs, & Fulk, 1990).

In general, the words chosen as effective by the teachers typically were very close acoustically to the vocabulary term and helped portray the concept in a concrete form.

Diameter, for example, was a favorite for both teachers and students. The keyword mnemonic showed a “diamond ring” with a line all the way across the ring part. This illustrates the concept while still being acoustically similar to the original term. Some of the keywords were not effective. Hexagon, for example, was a difficult word to render acoustically and was represented, with some frustration by the researcher, as a big dragon holding a hexagon with a six on the side. The keyword was chosen by the teachers as ineffective and was cited only twice by students on the test. The correct answers for the hexagon terms went from 57% on the pre-test to 54% on the post-test, a decrease for the treatment group, while the direct instruction group went from 52% correct to 58%, an increase. Surprisingly, this finding seems to say that in the absence of strong keyword choices, direct instruction alone would be a more effective choice.

Overall, the teacher surveys supported what research on keyword mnemonics has found: many educators are reluctant to use mnemonics because it appears to use artificial learning that appears superficial, not requiring the learner to think about the meaning of the connection (Pressley, 1995). This belief is probably at the root of the teachers’ comments that the keyword mnemonics “having no meat to them.” However, in the light of the effectiveness of the keyword strategy as shown in this research, especially with minimally competent students, teachers would be well advised to focus on the conceptual development in their instruction and use keyword mnemonics for retrieval purposes. The strategy seem especially strong when differentiating between two terms with related meanings where the terms are often transposed (i.e., parallel and perpendicular, vertical and horizontal, acute angle and obtuse angles).

Limitations

Threats to External Validity

There were two possible threats to external validity. The first is that because of limited resources, the teachers did not receive compensation for their participation, perhaps contributing factor to the attrition rate. The second limitation is that all participants are from three school districts in the southeastern United States. Although unlikely, it is possible that studies of different populations would find different results.

Threats to Internal Validity

There are two possible threats to internal validity. The first is that instructional materials were all developed by the researcher. The pictures and keywords were carefully selected following recommendations from expert keyword researchers; however, the selection and creation was somewhat arbitrary. Materials employing different keywords or pictures may produce different results. The second limitation relates to the gains from post-test to follow-up test because teachers continued to review the vocabulary terms in preparation for year-end testing.

Implications for Future Research

It appears that keyword mnemonics could play an important role in mathematics vocabulary instruction, especially for lower-level students. It is important, then, that this research be replicated for other mathematics vocabulary words and in other grades to identify words that can clearly be depicted with keywords and that aid students in remembering confusing terminology.

More research is also needed with students with disabilities to determine effective ways to develop basic mathematical understanding. Based on the results of this study as well as on previous research, it is apparent that there are basic conceptual misunderstandings that cannot be addressed simply by the implementation of retrieval techniques. The students in this study received regular classroom instruction on concepts but still had numerous misunderstandings about them. These misunderstandings must be addressed with direct, clear instruction at a basic level before these students can advance to be successful in mathematics.

Overall, teachers need to understand the consequences of partial explanations and of unclear analogies and elaboration techniques with low-performing students, but especially with students with disabilities. As mentioned previously, studies show that teachers rarely plan vocabulary instruction ahead of time, assuming the students will learn the terms incidentally. This research shows clearly that lower level students and students with disabilities are unsure of definitions or have conceptual misunderstandings that interfere with complete knowledge of vocabulary terms. Teachers in foundational years must teach students the concepts clearly and must teach retrieval techniques to address name confusion. More research in this area is warranted.

More research is also needed concerning effective and not effective keywords per grade level. It could be that younger students, such as these third graders, need more acoustically similar representations. Investigations into the factors that make a keyword effective or ineffective would be of interest, as well as how the abstractness of the term affects effectiveness.

Another area needing attention concerns levels of vocabulary understanding. This research demonstrated that both groups increased significantly from pre-test to post-test in the top level of knowledge, generative. This growth occurred even though many of the students had received instruction on the geometry unit before this study began. More research on explicit instruction of mathematics vocabulary terminology is warranted in order to prevent many of the conceptual misunderstandings that students demonstrated in the qualitative assessments.

Conclusions

Mathematics vocabulary is a significant factor in mathematics comprehension. Students often have trouble remembering the definitions of difficult mathematics terms, causing them to miss problems that are dependent upon those terms. Keyword mnemonics was shown by this research to be an effective way to teach mathematics vocabulary words to third grade students. Therefore, it is important that teachers receive training in this strategy and that administrators place emphasis on using such strategies to enable students, especially minimally competent ones, to learn important mathematical vocabulary terms accurately and effectively.

The keyword strategy is a memory strategy, not a concept development technique. As shown in these examples, keyword mnemonics retrieve the vocabulary term at whatever level of conceptual understanding the student has at that time, accurate or inaccurate. Research has been done in reading that stresses the importance of teaching conceptual development along with the definition. However, more research in this area is warranted with mathematical concepts. Also, more research is needed about the interplay of name confusion and conceptual misunderstandings and their role in students' levels of

understanding. This information is critical to assist teachers in effective mathematics vocabulary instruction.

APPENDICES

Appendix A

Vocabulary Definitions

VOCABULARY DEFINITIONS

Acute Angle - An angle with a measure greater than 0 degrees and less than 90 degrees.

Area: A measure of the surface inside a closed boundary. The formula for the area of a rectangle is $A = l * w$ where A represents the area, l the length, and w the width. The formula may also be expressed as $A = b * h$, where b represents the length of the base and h the height of the rectangle.

Congruent: Figures with the same shape and size are congruent.

Denominator: The number of equal parts into which a whole (or ONE or unit) is divided. In the fraction a/b , b is the denominator.

Diameter: A line segment that passes through the center of a circle (or sphere) and has endpoints on the circle (or sphere); also, the length of such a line segment. The diameter of a circle is twice its **radius**.

Height: The measure of how tall something is from the base to the apex.

Hexagon: A polygon with six sides.

Horizontal: Positioned in a left-right orientation; parallel to the horizon line.

Mode: The value or values that occur most often in a set of data.

Numerator: In a whole divided into a number of equal parts, the number of equal parts being considered. In the fraction a/b , a is the numerator.

Obtuse Angle: An angle with a measure greater than 90 degrees and less than 180 degrees.

Parallel: Lines (segments, rays) that are the same distance apart and never meet.

Pentagon: A polygon with five sides.

Perimeter: The distance around a two-dimensional shape. A formula for the perimeter of a rectangle is $P = 2 * (l + w)$, where l represents the length and w the width of the rectangle.

Perpendicular: Two rays, lines, line segments, or other figures that form right angles are said to be perpendicular to each other. The symbol \perp indicates perpendicular figures.

VOCABULARY DEFINITIONS, continued

Polygon: A closed figure with any number of straight sides.

Quadrilateral: A polygon with 4 sides.

Radius: A line segment from the center of a circle (or sphere) to any point on the circle (or sphere); also, the length of such a line segment.

Symmetry: Having the same size and shape across a dividing line or around a point.

Vertex: The point at which the rays of an angle, two sides of a polygon, or the edges of a polyhedron meet.

Vertical: Positioned in an up-down orientation; perpendicular to the horizon.

Appendix B

Research Schedules

Research Timeline

Jan 29-Feb 2 – Pretest Week

- Give Vocabulary Quiz pretest
- Give 3 CBM probes – Monday, Wednesday and Thursday
- Give practice keyword on Friday
- Give practice written response on Friday

For the next 5 weeks.....

Feb 5 – 9,

Feb 12-16,

Feb 20-23,

Feb 26-Mar 2, and

Mar 5 – 9 Give the CBM probe for that week
Give the written response for that week
Monday – Friday

Present one new keyword everyday according to the schedule, until
all have been presented

Review the previously learned ones according to the schedule

Fill out the Self-report log every day

****Notify Sharon when you have completed all 20 words

Mar 13-16 Post-test week

- Give Vocabulary Quiz post-test
- Give final CBM probe
- Give final written response
- Sharon will schedule interviews

WEEKLY SCHEDULE FOR RESEARCH

Week 1 (February 5-9)

*****I will deliver the pretests on Monday. On Monday morning, please send all completed CBMs and surveys to the office in a folder with your name on it and I'll pick them all up when I am there. Thanks!**

Monday Any remaining **CBM probes** not yet completed (6 min.)
Practice/Pretest Week **writing response** (on *Vertical*)
(3-5minutes)

Tuesday **Pretest Vocabulary Quiz (Read aloud)**
(Exp Group only) Introduce and practice the keyword
strategy (Bugsha)

Wednesday(Redo the practice with Bugsha, experimental group only)
Introduce **Vertical**
Start filling out the Treatment Fidelity Checklists

Thursday **Horizontal**

Friday **Symmetry**
Review Vertical

CBM Probe – Test 4

Writing Prompt Number 1

(Due to the fact that we just got started, we'll do the
CBMs on Friday this time. They will be on Thursdays
after this)

Don't forget to fill out a Treatment Fidelity Checklist every day.

Do you need anything from me?

WEEKLY SCHEDULE FOR RESEARCH

Week 2 (February 12-16)

Monday	Parallel Review Horizontal Make up any missed probes and writings from Friday
Tuesday	Perpendicular Review Vertical and Symmetry
Wednesday	Polygon Review Horizontal and Parallel
Thursday	Quadrilateral Review Perpendicular, Vertical, and Symmetry CBM Probe – Test 5 Writing Prompt Number 2
Friday	Out of School

Don't forget to fill out a Treatment Fidelity Checklist every day.

Enjoy your day off!

WEEKLY SCHEDULE FOR RESEARCH

Week 3 ***(February 19-23)***

Monday (This is the inclement weather makeup day)
Hexagon
Review Polygon, Horizontal, and Parallel

Tuesday **Pentagon**
Review Quadrilateral, Perpendicular, Vertical, and
Symmetry

Wednesday **Perimeter**
Review Hexagon, Polygon, Horizontal and Parallel

Thursday **Congruent**
Review Pentagon, Quadrilateral, Perpendicular, Vertical,
and Symmetry

CBM Probe – Test 6
Writing Prompt Number 3

Friday **Vertex**
Review Perimeter, Hexagon, Polygon, Horizontal and
Parallel

Makeups for probes or writing prompts

Don't forget to fill out a Treatment Fidelity Checklist every day.

Almost done!

WEEKLY SCHEDULE FOR RESEARCH

Week 4 (February 26-March 2)

Monday **Acute Angle**
Review Congruent, Pentagon, Quadrilateral,
Perpendicular, Vertical and Symmetry

Tuesday **Obtuse Angle**
Review Vertex, Perimeter, Hexagon, Polygon,
Horizontal, and Parallel

Wednesday **Area**
Review Acute Angle, Congruent, Pentagon,
Quadrilateral, Perpendicular, Vertical and
Symmetry

Thursday **Diameter**
Review Obtuse Angle, Vertex, Perimeter, Hexagon,
Polygon, Horizontal, and Parallel

CBM Probe – Test 7
Writing Prompt Number 4

Friday **Radius**
Review Area, Acute Angle, Congruent, Pentagon,
Quadrilateral, Perpendicular, Vertical and
Symmetry

Makeups for probes or writing prompts

Don't forget to fill out a Treatment Fidelity Checklist every day.
Need anything?

WEEKLY SCHEDULE FOR RESEARCH

Week 5

(March 5-9)

Monday

Denominator

Review Diameter, Obtuse Angle, Vertex, Perimeter, Hexagon, Polygon, Horizontal, and Parallel

Tuesday

Numerator

Review Radius, Area, Acute Angle, Congruent, Pentagon, Quadrilateral, Perpendicular, Vertical and Symmetry

Wednesday

Mode

Review Denominator, Diameter, Obtuse Angle, Vertex, Perimeter, Hexagon, Polygon, Horizontal, and Parallel; also review Numerator from yesterday

Thursday

**CBM Probe – Test 8
Writing Prompt Number 5**

Friday

Vocabulary Post Test

March 7

Post test Survey

Don't forget to fill out a Treatment Fidelity Checklist every day.

Retention Check

March 12-16

Friday, 3/16 **CBM Probe post-test – Test 9**

Final Vocabulary Post test Quiz

THANK YOU!!!

Appendix C

Treatment Fidelity Checklists

**Treatment Fidelity Checklist
Treatment Teachers**

Name _____ Date _____

1. Before beginning the lesson, please review the script for each word being introduced or reviewed.

After the lesson, answer this question: I followed the script exactly as it was written
_____ Y or N

If N, please explain the deviation:

2. List the Vocabulary word(s) covered today and code each as I (introduced) or R (reviewed).

Only list those words included on the focal vocabulary list.

Note: List only those which were specifically introduced or specifically reviewed; not the vocabulary words covered incidentally within the lesson

Vocabulary word	Codes: I (introduced) or R (reviewed)	Method: T (assigned treatment method), or O (other, please specify)	Time spent:
1			
2			
3			
4			
5			

Please remember not to discuss the research or your assigned treatment method with other teachers in order to protect the results from being contaminated.

Please sign here to show that you understand this and have followed the directions:

**Treatment Fidelity Checklist
Contrast Teachers**

Name _____ Date _____

1. Before beginning the lesson, please review the script for each word being introduced or reviewed.

After the lesson, answer this question: I followed the script exactly as it was written
_____ Y or N

If N, please explain the deviation:

2. List the Vocabulary word(s) covered today and code each as I (introduced) or R (reviewed).

Only list those words included on the focal vocabulary list.

Note: List only those which were specifically introduced or specifically reviewed; not the vocabulary words covered incidentally within the lesson

Vocabulary word	Codes: I (introduced) or R (reviewed)	Method: T (assigned treatment method), or O (other, please specify)	Time: Please write start and end times
1			
2			
3			
4			
5			

Please remember not to discuss the research or your assigned treatment method with other teachers in order to protect the results from being contaminated.

Please sign here to show that you understand this and have followed this:

Appendix D

Contrast Scripts and Word Cards

CONTRAST SCRIPTS

In this order:

Week 1

Vertical
Horizontal
Symmetry

Week 2

Parallel
Perpendicular
Polygon
Quadrilateral

Week 3

Hexagon
Pentagon
Perimeter
Congruent
Vertex

Week 4

Acute Angle
Obtuse Angle
Area
Diameter
Radius

Week 5

Denominator
Numerator
Mode

Script for Contrast ACUTE ANGLE

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is **Acute Angle** which is an angle that is less than 90 degrees.

SAY:

Now look at this word card. It says **Acute Angle**

Acute Angle is an angle that is less than 90 degrees.

SAY

This is an acute angle.

You can remember that an acute angle is a small angle by thinking of a cute baby – it is small. An acute angle is a small angle that is less than 90 degrees – less than a right angle.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Look at the card. It says **Acute Angle**.

Remember, an acute angle is an angle that is less than 90 degrees. Now let's review.

SAY

Now look at the word card. It says **Acute Angle**

Acute Angle means an angle that is less than 90 degrees.

What does the card say? (let students answer "Acute Angle")

What is an acute angle? (let students answer "an angle that is less than 90 degrees")

(Post the word card in the room where students can see it)

Script for Contrast CONGRUENT

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.
Today's word is ***Congruent*** which is figures that are the same size and same shape but may be turned differently.

SAY:

Now look at this word card. It says ***Congruent***

Congruent means figures that are the same size and same shape but may be turned differently.

SAY

This is ***congruent***.

You can remember that congruent means figures that are the same size and shape by thinking of making a sandwich. The two pieces of bread are the same size and same shape, but may be turned differently when you are making a sandwich.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Look at the card. It says ***Congruent***.

Remember, congruent means figures that are the same size and same shape but may be turned differently. Now let's review.

SAY

Now look at the word card. It says ***Congruent***

Congruent means figures that are the same size and same shape but may be turned differently.

What does the card say? (let students answer "Congruent")

What is congruent? (let students answer "figures that are the same size and same shape but may be turned differently")

(Post the word card in the room where students can see it)

Script for Contrast AREA

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is **Area** which is how many square units are in a figure.

SAY:

Now look at this word card. It says **Area**

Area is how many square units are in a figure.

SAY

This is an area.

You can remember that an area is what covers something – how much is inside a figure, like how many squares would cover your desk.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Look at the card. It says **Area**.

Remember, an area is how many square units are in a figure. Now let's review.

SAY

Now look at the word card. It says **Area**

Area means how many square units are in a figure.

What does the card say? (let students answer "Area")

What is an area? (let students answer "how many square units are in a figure")

(Post the word card in the room where students can see it)

Script for Contrast DENOMINATOR

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.
Today's word is ***Denominator*** which is the number on the bottom of a fraction that tells how many parts the whole thing is divided into

SAY:

Now look at this word card. It says ***Denominator***

Denominator is the number on the bottom of a fraction that tells how many parts the whole thing is divided into

SAY

This is the word **denominator**.

You can remember that denominator means the number on the bottom of a fraction that tells how many parts the whole thing is divided into by thinking of a fraction like $\frac{1}{4}$. The 4 on the bottom tells how many pieces something is divided into. It is the denominator. (Point to a fraction showing $\frac{1}{4}$ or write it on the board)

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says ***Denominator***.

Remember, denominator means the number on the bottom of a fraction that tells how many parts the whole thing is divided into. Now let's review.

SAY

Now look at the word card. It says ***Denominator***

Denominator means the number on the bottom of a fraction that tells how many parts the whole thing is divided into.

What does the card say? (let students answer "Denominator")

What is denominator? (let students answer the number on the bottom of a fraction that tells how many parts the whole thing is divided into")
(Post the word card in the room where students can see it)

Script for Contrast DIAMETER

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is ***Diameter*** which is a line segment that goes through the center of a circle from one side of the circle to the other

SAY:

Now look at this word card. It says ***Diameter***

Diameter means a line segment that goes through the center of a circle from one side of the circle to the other

SAY

This is the word **diameter**.

You can remember that diameter means a line segment that goes through the center of a circle from one side of the circle to the other by thinking about drawing a line all the way across a circle to see how big it is across. This is the diameter.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says ***Diameter***.

Remember, diameter means a line segment that goes through the center of a circle from one side of the circle to the other. Now let's review.

SAY

Now look at the word card. It says ***Diameter***

Diameter means a line segment that goes through the center of a circle from one side of the circle to the other.

What does the card say? (let students answer "Diameter")

What is diameter? (let students answer "a line segment that goes through the center of a circle from one side of the circle to the other")
(Post the word card in the room where students can see it)

Script for Contrast HEXAGON

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is **Hexagon** which is a polygon that has 6 sides

SAY:

Now look at this word card. It says **Hexagon**

Hexagon means a polygon that has 6 sides

SAY

This is the word **hexagon**.

You can remember that hexagon is a polygon that has 6 sides by thinking about this shape (DRAW A HEXAGON ON THE BOARD). It has 6 sides. That is a hexagon.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says **Hexagon**.

Remember, hexagon means a polygon that has 6 sides. Now let's review.

SAY

Now look at the word card. It says **Hexagon**

Hexagon means a polygon that has 6 sides.

What does the card say? (let students answer "Hexagon")

What is hexagon? (let students answer "a polygon that has 6 sides")

(Post the word card in the room where students can see it)

Script for Contrast HORIZONTAL

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is ***Horizontal*** which is when something is parallel to the ground

SAY:

Now look at this word card. It says ***Horizontal***

Horizontal means when something is parallel to the ground

SAY

This is the word **horizontal**.

You can remember that horizontal is when something is parallel to the ground by thinking of laying down. If you are laying down, you are stretched out and parallel to the ground. You are horizontal when you are laying down.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says ***Horizontal***.

Remember, horizontal means when something is parallel to the ground. Now let's review.

SAY

Now look at the word card. It says ***Horizontal***

Horizontal means when something is parallel to the ground.

What does the card say? (let students answer "Horizontal")

What is horizontal? (let students answer "when something is parallel to the ground")

(Post the word card in the room where students can see it)

Script for Contrast MODE

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is **Mode** which is the number in a set of data that is listed the most times

SAY:

Now look at this word card. It says **Mode**

Mode means the number in a set of data that is listed the most times

SAY

This is the word **mode**.

You can remember that mode is the number in a set of data that is listed the most times by thinking of a list of numbers. There may be all different numbers in the list, but the one that is listed the most is the mode.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says **Mode**.

Remember, mode means the number in a set of data that is listed the most times. Now let's review.

SAY

Now look at the word card. It says **Mode**

Mode means the number in a set of data that is listed the most times.

What does the card say? (let students answer "Mode")

What is mode? (let students answer "the number in a set of data that is listed the most times")

(Post the word card in the room where students can see it)

Script for Contrast NUMERATOR

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.
Today's word is **Numerator** which is the number on the top of a fraction that tells how many parts you are looking at

SAY:

Now look at this word card. It says **Numerator**

Numerator is the number on the top of a fraction that tells how many parts you are looking at

SAY

This is the word **numerator**.

You can remember that numerator means the number on the top of a fraction that tells how many parts you are looking at by thinking of a fraction like $\frac{1}{4}$. The 1 on the top tells how many pieces of something you are looking at. It is the numerator. (Point to a fraction showing $\frac{1}{4}$ or write it on the board)

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says **Numerator**.

Remember, numerator means the number on the top of a fraction that tells how many parts you are looking at. Now let's review.

SAY

Now look at the word card. It says **Numerator**

Numerator means the number on the top of a fraction that tells how many parts you are looking at.

What does the card say? (let students answer "Numerator")

What is numerator? (let students answer "the number on the top of a fraction that tells how many parts you are looking at.")
(Post the word card in the room where students can see it)

Script for Contrast OBTUSE ANGLE

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is ***Obtuse angle*** which is an angle that is greater than 90 degrees

SAY:

Now look at this word card. It says ***Obtuse angle***

Obtuse angle means an angle that is greater than 90 degrees

SAY

This is the word **obtuse angle**.

You can remember that obtuse angle is an angle that is greater than 90 degrees or greater than a right angle by thinking about sitting in a reclining chair – a recliner. When you lay back in a recliner you are all stretched out and your body makes a big angle. That is an obtuse angle.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says ***Obtuse angle***.

Remember, obtuse angle means an angle that is greater than 90 degrees. Now let's review.

SAY

Now look at the word card. It says ***Obtuse angle***

Obtuse angle means an angle that is greater than 90 degrees.

What does the card say? (let students answer "Obtuse angle")

What is obtuse angle? (let students answer "an angle that is greater than 90 degrees")

(Post the word card in the room where students can see it)

Script for Contrast PARALLEL

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.
Today's word is ***Parallel*** which is when lines are the same distance apart and will never meet

SAY:

Now look at this word card. It says ***Parallel***
Parallel is when lines are the same distance apart and will never meet

SAY

This is the word **parallel**.

You can remember that parallel means when lines are the same distance apart and will never meet by thinking of the two l's in parallel (point to them on the word card). They are straight beside each other and even if I made them very long, they would never touch.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says ***Parallel***.

Remember, parallel means when lines are the same distance apart and will never meet. Now let's review.

SAY

Now look at the word card. It says ***Parallel***

Parallel means when lines are the same distance apart and will never meet

.

What does the card say? (let students answer "Parallel")

What is parallel? (let students answer "lines that are the same distance apart and will never meet")

(Post the word card in the room where students can see it)

Script for Contrast PENTAGON

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is ***Pentagon*** which is a polygon that has 5 sides

SAY:

Now look at this word card. It says ***Pentagon***

Pentagon means a polygon that has 5 sides

SAY

This is the word **pentagon**.

You can remember that pentagon is a polygon that has 5 sides or greater than a right angle by thinking about home plate at a baseball game. It has 5 sides. That is a pentagon.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says ***Pentagon***.

Remember, pentagon means a polygon that has 5 sides. Now let's review.

SAY

Now look at the word card. It says ***Pentagon***

Pentagon means a polygon that has 5 sides.

What does the card say? (let students answer "Pentagon")

What is pentagon? (let students answer "a polygon that has 5 sides")

(Post the word card in the room where students can see it)

Script for Contrast PERIMETER

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is ***Perimeter*** which is the total distance around the sides of a figure

SAY:

Now look at this word card. It says ***Perimeter***

Perimeter means the total distance around the sides of a figure

SAY

This is the word **perimeter**.

You can remember that perimeter means the total distance around the sides of a figure by thinking about your desk. You can measure each side around your desk and add those numbers up. That is the total distance around the sides and that is the perimeter of your desk.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Look at the card. It says ***Perimeter***.

Remember, perimeter means the total distance around the sides of a figure. Now let's review.

SAY

Now look at the word card. It says ***Perimeter***

Perimeter means the total distance around the sides of a figure.

What does the card say? (let students answer "Perimeter")

What is perimeter? (let students answer "the total distance around the sides of a figure")

(Post the word card in the room where students can see it)

Script for Contrast POLYGON

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is ***Polygon*** which is a straight-sided, closed figure

SAY:

Now look at this word card. It says ***Polygon***

Polygon means a straight-sided, closed figure

SAY

This is the word **polygon**.

You can remember that polygon is a straight-sided, closed figure by thinking of any kind of figure that has straight sides. Some have 3 sides, some have 4 sides, some have 10 sides. Polygons have different numbers of sides, but they are straight-sided closed figures.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says ***Polygon***.

Remember, polygon means a straight-sided, closed figure. Now let's review.

SAY

Now look at the word card. It says ***Polygon***

Polygon means a straight-sided, closed figure.

What does the card say? (let students answer "Polygon")

What is polygon? (let students answer "a straight-sided, closed figure")

(Post the word card in the room where students can see it)

Script for Contrast RADIUS

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is **Radius** which is a line segment that goes from the center of a circle to the outside

SAY:

Now look at this word card. It says **Radius**

Radius means a line segment that goes from the center of a circle to the outside

SAY

This is the word **radius**.

You can remember that radius means a line segment that goes from the center of a circle to the outside by thinking about a clock. (Point to a clock) The clock is a circle. The hands go from the center to the outside of the circle. That is a radius.

Now look back at the card. It says **Radius**.

Remember, radius means a line segment that goes from the center of a circle to the outside. Now let's review.

SAY

Now look at the word card. It says **Radius**

Radius means a line segment that goes from the center of a circle to the outside.

What does the card say? (let students answer "Radius")

What is radius? (let students answer "a line segment that goes from the center of a circle to the outside")

(Post the word card in the room where students can see it)

Script for Contrast SYMMETRY

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.
Today's word is **Symmetry** which is when something looks the same on both sides.

SAY:

Now look at this word card. It says **Symmetry**
Symmetry is when something looks the same on both sides.

SAY

This is the word **symmetry**.

You can remember that symmetry means when something looks the same on both sides by thinking of putting paint on one half of a sheet of paper and then folding it. If you opened it, it would look the same on both sides. You could draw a line down the middle and fold it and it would be exactly the same on both sides.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says **Symmetry**.

Remember, symmetry means when something looks the same on both sides.
Now let's review.

SAY

Now look at the word card. It says **Symmetry**

Symmetry means when something looks the same on both sides.

.

What does the card say? (let students answer "Symmetry")

What is symmetry? (let students answer "when something looks the same on both sides.")

(Post the word card in the room where students can see it)

Script for Contrast VERTEX

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is **Vertex** which is where lines or line segments come together to make an angle

SAY:

Now look at this word card. It says **Vertex**

Vertex means where lines or line segments come together to make an angle

SAY

This is the word **vertex**.

You can remember that vertex is where lines or line segments come together to make an angle by thinking of an angle. (Hold up two pencils to illustrate an angle) That point where the lines make an angle is called the vertex. If you have more than one angle and more than one vertex, they are called the **vertices**.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says **Vertex**.

Remember, vertex means where lines or line segments come together to make an angle. Now let's review.

SAY

Now look at the word card. It says **Vertex**

Vertex means where lines or line segments come together to make an angle.

What does the card say? (let students answer "Vertex")

What is vertex? (let students answer "where lines or line segments come together to make an angle")

(Post the word card in the room where students can see it)

Script for Contrast VERTICAL

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is **Vertical** which is something straight up and perpendicular to the ground

SAY:

Now look at this word card. It says **Vertical**

Vertical means something straight up and perpendicular to the ground

SAY

This is the word **vertical**.

You can remember that vertical is something straight up and perpendicular to the ground by thinking of standing up. If you stand up nice and tall, you are straight up and perpendicular to the ground. (Have students stand up and be vertical. Ask them to sit back down)

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says **Vertical**.

Remember, vertical means something straight up and perpendicular to the ground. Now let's review.

SAY

Now look at the word card. It says **Vertical**

Vertical means something straight up and perpendicular to the ground.

What does the card say? (let students answer "Vertical")

What is vertical? (let students answer "something straight up and perpendicular to the ground")

(Post the word card in the room where students can see it)

Script for Contrast QUADRILATERAL

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the words or send them home until after the post-testing of the project.

We are going to learn a new math word today.

Today's word is ***Quadrilateral*** which is a polygon that has 4 sides

SAY:

Now look at this word card. It says ***Quadrilateral***

Quadrilateral means a polygon that has 4 sides

SAY

This is the word **quadrilateral**.

You can remember that quadrilateral is a polygon that has 4 sides by thinking about a square (DRAW A QUADRILATERAL ON THE BOARD). It has 4 sides. That is a quadrilateral. Not all quadrilaterals have really straight sides and right angles like a square, but quadrilaterals all have 4 sides.

*(Take about 1 minute and walk around so all students can see the word on the word card.)

Now look back at the card. It says ***Quadrilateral***.

Remember, quadrilateral means a polygon that has 4 sides. Now let's review.

SAY

Now look at the word card. It says ***Quadrilateral***

Quadrilateral means a polygon that has 4 sides.

What does the card say? (let students answer "Quadrilateral")

What is quadrilateral? (let students answer "a polygon that has 4 sides")

(Post the word card in the room where students can see it)

Word Cards for Contrast Teachers

<p>Vertical</p> <p>Vertical is something straight up and perpendicular to the ground.</p>	<p>Horizontal</p> <p>Horizontal means when something is parallel to the ground.</p>	<p>Symmetry</p> <p>Symmetry is when something looks the same on one side as on the other, as if it had been cut in the middle and folded over.</p>	<p>Parallel</p> <p>Parallel lines are lines that are the same distance apart and will never meet</p>
<p>Perpendicular</p> <p>When something is perpendicular, it is at a right angle to something else.</p>	<p>Polygon</p> <p>A polygon is a straight-sided, closed figure</p>	<p>Quadrilateral</p> <p>A quadrilateral is a polygon that has 4 sides</p>	<p>Hexagon</p> <p>A hexagon is a polygon that has 6 sides</p>
<p>Pentagon</p> <p>A pentagon is a polygon that has 5 sides.</p>	<p>Perimeter</p> <p>The perimeter is the total distance around the sides of a figure.</p>	<p>Congruent</p> <p>Congruent figures are the same size and same shape but may be turned differently.</p>	<p>Vertex</p> <p>The vertex is where lines or line segments come together to make an angle.</p> <p>More than one vertex are Vertices</p>
<p>Acute Angle</p> <p>An acute angle is an angle that is less than 90 degrees.</p>	<p>Obtuse Angle</p> <p>An obtuse angle is an angle that is greater than 90 degrees</p>	<p>Area</p> <p>The area is how many square units are in a figure</p>	<p>Diameter</p> <p>The diameter is a line segment that goes through the center of a circle from one side of the circle to the other.</p>
<p>Radius</p> <p>The radius is a line segment that goes from the center of a circle to the outside.</p>	<p>Denominator</p> <p>The denominator is the number on the bottom of a fraction that tells how many parts the whole thing is divided into.</p>	<p>Numerator</p> <p>The numerator is the number on the top of a fraction that tells the number of pieces you are looking at.</p>	<p>Mode</p> <p>The mode is the number in a set of data that is listed the most times.</p>

Appendix E

Treatment Scripts and Keywords

KEYWORD SCRIPTS

In this order:

Week 1

Vertical
Horizontal
Symmetry

Week 2

Parallel
Perpendicular
Polygon
Quadrilateral

Week 3

Hexagon
Pentagon
Perimeter
Congruent
Vertex

Week 4

Acute Angle
Obtuse Angle
Area
Diameter
Radius

Week 5

Denominator
Numerator
Mode

Script for keywords ACUTE ANGLE

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is **Acute Angle** which means an angle that is less than 90 degrees.

Acute Angle sort of sounds like "A cute angel".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of a cute angel

When I ask you the meaning of **Acute Angle**, think first what it sounds like – A cute angel

Then think back to this picture with the a cute angel with an angle on her wings

Think about what was in the picture– a cute angel

** (Point to the a cute angel and the angle in her wings. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that **Acute Angle** means an angle that is less than 90 degrees.

Now let's review.

PUT PICTURE DOWN

SAY

The new word is **Acute Angle**
Acute Angle sort of sounds like a cute angel

The picture of the cute angel shows an angle that is less than 90 degrees.

**Script for keywords
ACUTE ANGLE, page two**

Acute Angle means an angle that is less than 90 degrees

SHOW THE PICTURE

Look again at this picture of the a cute angel

When I ask you the meaning of **Acute Angle**, think what it sounds like – A cute angel

What does **Acute Angle** sound like? (let students respond – “A cute angel”)

Tell me about the wings of the cute angel. (let students respond – “they had an angle that was less than 90 degrees”)

What does **Acute Angle** mean? (let students respond – “an angle that is less than 90 degrees”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Acute Angle" means "A cute angel") say,

"No, *A cute angel* is the keyword to help us retrieve the answer. What was in the picture?

A cute angel. The cute angel that had an angle on her wings

Acute Angle means an angle that is less than 90 degrees

Script for keywords AREA

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is **area** which means how many square units are in a figure.

Area sort of sounds like "fairy".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of a fairy

When I ask you the meaning of **area**, think first what it sounds like – a fairy

Then think back to this picture with the fairy in it

Think about what was in the picture– a fairy in each square showing how many square units are in a figure.

** (Point to the fairies in the picture. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that **area** means how many square units are in a figure

Now let's review.

PUT PICTURE DOWN

SAY

The new word is **area**

Area sort of sounds like fairy

The picture of the fairy showed how many square units are in a figure

Area means how many square units are in a figure

**Script for keywords
AREA, page two**

SHOW THE PICTURE

Look again at this picture of the fairy

When I ask you the meaning of **area** think what it sounds like – fairy

What does **area** sound like? (let students respond – “fairy”)

Tell me about the fairy in the picture – what was it showing? (let students respond – “how many square units are in a figure”)

What does **area** mean? (let students respond – “how many square units are in a figure”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "area" means "fairy") say,

"No, *fairy* is the keyword to help us retrieve the answer. What were the fairies in the squares showing?"

The fairy shows how many square units are in a figure.

Area means how many square units are in a figure."

Script for keywords CONGRUENT

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Congruent*** which means figures that are the same size and same shape but may be turned differently.

Congruent sort of sounds like "Glue it".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of gluing paper pieces that are the same size and same shape but turned differently – Then you Glue It

When I ask you the meaning of ***Congruent***, think first what it sounds like – Glue it

Then think back to this picture saying "Glue it "

Think about what was in the picture– the "Glue it" picture shows paper pieces that are the same size and same shape

** (Point to the "Glue it" picture and the paper pieces. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Congruent*** means when figures are the same size and same shape but may be turned differently.

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Congruent***
Congruent sort of sounds like Glue it

**Script for keywords
CONGRUENT, page two**

The picture saying “Glue it” has paper pieces that are the same size and same shape.

Congruent means when figures are the same size and same shape but may be turned differently

SHOW THE PICTURE

Look again at this picture of Glue it

When I ask you the meaning of ***Congruent***, think what it sounds like – Glue it

What does ***Congruent*** sound like? (let students respond – “Glue it”)

Tell me about the “glue it” picture. (let students respond – “in the “glue it” picture, the paper pieces are the same size and same shape.)

What does ***Congruent*** mean? (let students respond – “when figures are the same size and same shape but may be turned differently”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. “Congruent” means “Glue it”) say,

“No, *Glue it* is the keyword to help us retrieve the answer. What was in the picture?”

Think “Glue it”. The “glue it” picture had paper pieces the same size and same shape.

Congruent means when figures are the same size and same shape but may be turned differently

Script for keywords DENOMINATOR

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Denominator*** which means the number on the bottom of a fraction that tells how many parts the whole thing is divided into.

Denominator sort of sounds like "The Terminator".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of The Terminator

When I ask you the meaning of ***Denominator***, think first what it sounds like – The Terminator

Then think back to this picture with the The Terminator standing on the bottom of a fraction

Think about what was in the picture– The Terminator standing on the bottom of the fraction

** (Point to The Terminator and the fraction line. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Denominator*** means the number on the bottom of a fraction that tells how many parts the whole thing is divided into.

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Denominator***
Denominator sort of sounds like The Terminator

**Script for keywords
DENOMINATOR, page two**

The picture of the Terminator is on the bottom of a fraction and tells how many parts the whole thing is divided into.

Denominator means the number on the bottom of a fraction that tells how many parts the whole thing is divided into

SHOW THE PICTURE

Look again at this picture of The Terminator

When I ask you the meaning of **Denominator**, think what it sounds like – The Terminator

What does **Denominator** sound like? (let students respond – “The Terminator”)

Tell me about where the Terminator is. (let students respond – “The Terminator is on the bottom of the fraction”)

What does **Denominator** mean? (let students respond – “the number on the bottom of a fraction that tells how many parts the whole thing is divided into”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Denominator" means "The Terminator") say,

"No, *The Terminator* is the keyword to help us retrieve the answer. What was in the picture?"

The Terminator is on the bottom of the fraction

Denominator means the number on the bottom of a fraction that tells how many parts the whole thing is divided into

Script for keywords DIAMETER

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Diameter*** which means the line segment that goes through the center of a circle and connects one side of a circle to the other.

Diameter sort of sounds like "diamond ring".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of diamond ring

When I ask you the meaning of ***Diameter***, think first what it sounds like – diamond ring

Then think back to this picture with the diamond ring in it

Think about what was in the picture– diamond ring that showed the line segment that goes through the center of a circle and connects one side of a circle to the other.

** (Point to the diamond ring and the line segment in the picture. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Diameter*** means the line segment that goes through the center of a circle and connects one side of a circle to the other

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Diameter***
Diameter sort of sounds like diamond ring

**Script for keywords
DIAMETER, page two**

The picture of the diamond ring showed the line segment that goes through the center of a circle and connects one side of a circle to the other

Diameter means the line segment that goes through the center of a circle and connects one side of a circle to the other

SHOW THE PICTURE

Look again at this picture of the diamond ring

When I ask you the meaning of **Diameter** think what it sounds like – diamond ring

What does **Diameter** sound like? (let students respond – “diamond ring”)

Tell me about the diamond ring in the picture – what were they showing? (let students respond – “the line segment that goes through the center of a circle and connects one side of a circle to the other”)

What does **Diameter** mean? (let students respond – “the line segment that goes through the center of a circle and connects one side of a circle to the other”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Diameter" means "diamond ring") say,

"No, *diamond ring* is the keyword to help us retrieve the answer. What was the diamond ring showing?"

The diamond ring showed the line segment that goes through the center of a circle and connects one side of a circle to the other.

Diameter means the line segment that goes through the center of a circle and connects one side of a circle to the other."

Script for keywords HEXAGON

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is **Hexagon** which means a polygon that has 6 sides.

Hexagon sort of sounds like "big dragon".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of big dragon

When I ask you the meaning of **Hexagon**, think first what it sounds like – a big dragon

Then think back to this picture with the big dragon

Think about what was in the picture– a big dragon with a polygon that has 6 sides.

** (Point to the Hexagon the big dragon has in the picture. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that **Hexagon** means a polygon that has 6 sides

Now let's review.

PUT PICTURE DOWN

SAY

The new word is **Hexagon**
Hexagon sort of sounds like big dragon

The picture of the big dragon had a polygon that has 6 sides

Hexagon means a polygon that has 6 sides

SHOW THE PICTURE

Look again at this picture of the big dragon

When I ask you the meaning of **Hexagon**, think what it sounds like – big dragon

What does **Hexagon** sound like? (let students respond – “big dragon”)

Tell me about the big dragon in the picture – what did it have? (let students respond – “a polygon that has 6 sides”)

What does **Hexagon** mean? (let students respond – “a polygon that has 6 sides”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Hexagon" means "big dragon") say,

"No, *big dragon* is the keyword to help us retrieve the answer. What did the big dragon have?"

Big dragon had a polygon that has 6 sides.

Hexagon means a polygon that has 6 sides."

Script for keywords HORIZONTAL

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is *horizontal* which means something parallel to the ground.

Horizontal sort of sounds like "horse running".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of a horse running

When I ask you the meaning of *horizontal*, think first what it sounds like – a horse running

Then think back to this picture with the horse running in it

Think about what was in the picture– a horse running stretched out and parallel to the ground.

** (Point to the horse in the picture. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that *horizontal* means stretched out and parallel to the ground

Now let's review.

PUT PICTURE DOWN

SAY

The new word is *horizontal*
Horizontal sort of sounds like horse running

The picture of the horse running was stretched out and parallel to the ground

Horizontal means stretched out and parallel to the ground

SHOW THE PICTURE

Look again at this picture of the horse running

When I ask you the meaning of **horizontal** think what it sounds like – horse running

What does **horizontal** sound like? (let students respond – “horse running”)

Tell me about the horse running in the picture – what was it like? (let students respond – “the stretched out and parallel to the ground”)

What does **horizontal** mean? (let students respond – “stretched out and parallel to the ground”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "horizontal" means "horse running") say,

"No, *horse running* is the keyword to help us retrieve the answer. What was the horse like in the picture with the horse running?"

The horse running is stretched out and parallel to the ground.

Horizontal means stretched out and parallel to the ground.”

Script for keywords MODE

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is **Mode** which means the number in a set of data that is listed the most times.

Mode sort of sounds like "Toad".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of a Toad

When I ask you the meaning of **mode**, think first what it sounds like – Toad

Then think back to this picture with the Toad

Think about what was in the picture– a Toad that has a lot of numbers. This Toad has more 3's than anything else so his mode is 3.

** (Point to the numbers that the Toad has in the picture. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that **mode** means the number in a set of data that is listed the most times

Now let's review.

PUT PICTURE DOWN

SAY

The new word is **mode**
Mode sort of sounds like Toad

The picture of the Toad shows a lot of numbers. The mode is the number in a set of data that is listed the most times.

Mode means the number in a set of data that is listed the most times.

SHOW THE PICTURE

Look again at this picture of the Toad.

When I ask you the meaning of **mode**, think what it sounds like – Toad.

What does **mode** sound like? (let students respond – “Toad”)

Tell me about the Toad in the picture – what did he have? (let students respond – “a lot of 3’s which is his mode”)

What does **mode** mean? (let students respond – “the number in a set of data that is listed the most times”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. “Mode” means “Toad”) say,

“No, *Toad* is the keyword to help us retrieve the answer. What was in the picture?”

Toad had one number in a set of data that is listed the most times – his was a 3.

Mode means the number in a set of data that is listed the most times.

Script for keywords NUMERATOR

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Numerator*** which means the number on the top of a fraction that tells the number of pieces you are looking at.

Numerator sort of sounds like "New Arm and Head".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of New Arm and Head for the Terminator

When I ask you the meaning of ***Numerator***, think first what it sounds like – New Arm and Head

Then think back to this picture with the New Arm and Head on the top of a fraction

Think about what was in the picture– New Arm and Head on the top of the fraction

** (Point to New Arm and Head and the fraction line. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Numerator*** means the number on the top of a fraction that tells the number of pieces you are looking at.

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Numerator***
Numerator sort of sounds like New Arm and Head

The picture of New Arm and Head is on the top of a fraction and tells how many parts the whole thing is divided into.

Numerator means the number on the top of a fraction that tells the number of pieces you are looking at

SHOW THE PICTURE

Look again at this picture of New Arm and Head

When I ask you the meaning of **Numerator**, think what it sounds like – New Arm and Head

What does **Numerator** sound like? (let students respond – “New Arm and Head”)

Tell me about where New Arm and Head is. (let students respond – “New Arm and Head is on the top of the fraction

What does **Numerator** mean? (let students respond – “the number on the top of a fraction that tells the number of pieces you are looking at”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Numerator" means "New Arm and Head") say,

"No, *New Arm and Head* is the keyword to help us retrieve the answer. What was in the picture?

New Arm and Head. The new arm and head pieces on the top of the fraction

Numerator means the number on the top of a fraction that tells the number of pieces you are looking at

Script for keywords OBTUSE ANGLE

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Obtuse angle*** which means an angle that is greater than a right angle.

Obtuse angle sort of sounds like "moose antler".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of moose antlers

When I ask you the meaning of ***Obtuse angle***, think first what it sounds like – moose antlers

Then think back to this picture with the moose antlers in it

Think about what was in the picture– moose antlers that showed an angle that is greater than a right angle.

** (Point to the moose antlers and the angle in the picture. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Obtuse angle*** means an angle that is greater than a right angle

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Obtuse angle***
Obtuse angle sort of sounds like moose antlers

The picture of the moose antlers showed an angle that is greater than a right angle

Obtuse angle means an angle that is greater than a right angle

SHOW THE PICTURE

Look again at this picture of the moose antler

When I ask you the meaning of **Obtuse angle**, think what it sounds like – moose antler

What does **Obtuse angle** sound like? (let students respond – “moose antlers”)

Tell me about the moose antlers in the picture – what were they showing? (let students respond – “an angle that is greater than a right angle”)

What does **Obtuse angle** mean? (let students respond – “an angle that is greater than a right angle”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Obtuse angle" means "moose antlers") say,

"No, *moose antlers* is the keyword to help us retrieve the answer. What were the moose antlers showing?"

The moose antlers showed an angle that is greater than a right angle.

Obtuse angle means an angle that is greater than a right angle."

Script for keywords PARALLEL

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Parallel*** which means lines that are the same distance apart and will never meet.

Parallel sort of sounds like "Pair of rails".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of a pair of fence rails

When I ask you the meaning of ***Parallel***, think first what it sounds like – Pair of rails

Then think back to this picture with the pair of rails on the fence

Think about what was in the picture– a pair of rails on the fence

******(Point to the pair of rails on the fence. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Parallel*** means lines that are the same distance apart and will never meet.

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Parallel***
Parallel sort of sounds like Pair of rails

The picture of the Pair of rails shows that lines that are the same distance apart and will never meet.

Parallel means lines that are the same distance apart and will never meet

SHOW THE PICTURE

Look again at this picture of the Pair of rails

When I ask you the meaning of **Parallel**, think what it sounds like – Pair of rails

What does **Parallel** sound like? (let students respond – “Pair of rails”)

Tell me about the pair of rails on the fence. (let students respond – “they were the same distance apart and will never meet”)

What does **Parallel** mean? (let students respond – “lines that are the same distance apart and will never meet”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Parallel" means "Pair of rails") say,

"No, *Pair of rails* is the keyword to help us retrieve the answer. What was in the picture?"

Pair of rails. The pair of rails was on the fence

Parallel means lines that are the same distance apart and will never meet

Script for keywords PENTAGON

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Pentagon*** which means a polygon that has 5 sides.

Pentagon sort of sounds like "the pen is long".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of a pen that is long

When I ask you the meaning of ***Pentagon***, think first what it sounds like – the pen is long

Then think back to this picture with the long pen in it

Think about what was in the picture– the pen is long and it was drawing a polygon that has 5 sides.

******(Point to the pen that is long the pentagon it was drawing in the picture. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Pentagon*** means a polygon that has 5 sides

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Pentagon***
Pentagon sort of sounds like the pen is long

The picture of the pen that is long showed drawing a polygon that has 5 sides

Pentagon means a polygon that has 5 sides

SHOW THE PICTURE

Look again at this picture of the pen that is long

When I ask you the meaning of **Pentagon**, think what it sounds like – the pen is long

What does **Pentagon** sound like? (let students respond – “the pen is long”)

Tell me about the pen that is long in the picture – what was it drawing? (let students respond – “a polygon that has 5 sides”)

What does **Pentagon** mean? (let students respond – “a polygon that has 5 sides”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Pentagon" means "the pen is long") say,

"No, *the pen is long* is the keyword to help us retrieve the answer. What was the pen that is long showing?"

The pen is long was drawing a polygon that has 5 sides.

Pentagon means a polygon that has 5 sides."

Script for keywords PERPENDICULAR

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Perpendicular*** which means when something is perpendicular, it is standing at a right angle to something else.

Perpendicular sort of sounds like "Purple dictionary".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of a purple dictionary

When I ask you the meaning of ***Perpendicular***, think first what it sounds like – Purple dictionary

Then think back to this picture with the purple dictionary standing on the shelf

Think about what was in the picture– a purple dictionary standing on the shelf

** (Point to the purple dictionary standing straight up on the shelf. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Perpendicular*** means when something is perpendicular, it is standing at a right angle to something else.

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Perpendicular***

Perpendicular sort of sounds like Purple dictionary

The picture of the Purple dictionary shows that when something is perpendicular, it is standing at a right angle to something else.

Perpendicular means when something is perpendicular, it is standing at a right angle to something else

SHOW THE PICTURE

Look again at this picture of the Purple dictionary

When I ask you the meaning of **Perpendicular**, think what it sounds like – Purple dictionary

What does **Perpendicular** sound like? (let students respond – “Purple dictionary”)

Tell me about the purple dictionary standing on the shelf. How was it standing? (let students respond – “straight up and at a right angle”)

What does **Perpendicular** mean? (let students respond – “when something is perpendicular, it is standing at a right angle to something else”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Perpendicular" means "Purple dictionary") say,

"No, *Purple dictionary* is the keyword to help us retrieve the answer. What was in the picture?"

Purple dictionary. The purple dictionary was straight up on a shelf

Perpendicular means when something is perpendicular, it is standing at a right angle to something else

Script for keywords POLYGON

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Polygon*** which means a straight sided closed figure.

Polygon sort of sounds like "Polly wants a cracker".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of Polly – a parrot – that wants a cracker

When I ask you the meaning of ***polygon***, think first what it sounds like – Polly wants a cracker

Then think back to this picture with the parrot and the crackers

Think about what was in the picture– parrot with a lot of crackers that look like straight sided closed figures.

** (Point to the polygons that the Parrot has in the picture. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***polygon*** means any straight sided closed figure

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***polygon***
Polygon sort of sounds like Polly wants a cracker

The picture of the Polly wants a cracker has a lot of crackers which are straight sided closed figures

Polygon means a straight sided closed figure

SHOW THE PICTURE

Look again at this picture of the Polly wants a cracker

When I ask you the meaning of **polygon**, think what it sounds like – Polly wants a cracker

What does **polygon** sound like? (let students respond – “Polly wants a cracker”)

Tell me about the parrot and the crackers in the picture – what did they look like? (let students respond – “a straight sided closed figures”)

What does **polygon** mean? (let students respond – “a straight sided closed figure”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Polygon" means "Polly wants a cracker") say,

"No, *Polly wants a cracker* is the keyword to help us retrieve the answer. What was in the picture?

Polly wants a cracker. The parrot had crackers which were straight sided closed figures.

Polygon means a straight sided closed figure

Script for keywords QUADRILATERAL

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Quadrilateral*** which means a polygon that has 4 sides.

Quadrilateral sort of sounds like "Card table".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of Card table

When I ask you the meaning of ***Quadrilateral***, think first what it sounds like – Card table

Then think back to this picture with the Card table

Think about what was in the picture– a Card table with 4 sides

** (Point to Card table with the 4 sides. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Quadrilateral*** means a polygon that has 4 sides.

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Quadrilateral***
Quadrilateral sort of sounds like Card table

The picture of Card table has 4 sides

Quadrilateral means a polygon that has 4 sides

SHOW THE PICTURE

Look again at this picture of Card table

When I ask you the meaning of ***Quadrilateral***, think what it sounds like – Card table

What does ***Quadrilateral*** sound like? (let students respond – “Card table”)

Tell me about the card table. (let students respond – “the Card table has 4 sides

What does ***Quadrilateral*** mean? (let students respond – “a polygon that has 4 sides”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Quadrilateral" means "Card table") say,

"No, *Card table* is the keyword to help us retrieve the answer. What was in the picture?

Card table. The card table has 4 sides

Quadrilateral means a polygon that has 4 sides

Script for keywords RADIUS

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is **Radius** which means the line segment that goes from the center of a circle to the outside of the circle.

Radius sort of sounds like "radios".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of radios

When I ask you the meaning of **Radius**, think first what it sounds like – radios

Then think back to this picture with the radios in it

Think about what was in the picture– radios that showed the line segment that goes from the center of a circle to the outside of the circle.

** (Point to the radios and the line segment in the picture. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that **Radius** means the line segment that goes from the center of a circle to the outside of the circle

Now let's review.

PUT PICTURE DOWN

SAY

The new word is **Radius**
Radius sort of sounds like radios

The picture of the radius showed the line segment that goes from the center of a circle to the outside of the circle

Radius means the line segment that goes from the center of a circle to the outside of the circle

SHOW THE PICTURE

Look again at this picture of the radius

When I ask you the meaning of **Radius** think what it sounds like – radius

What does **Radius** sound like? (let students respond – “radius”)

Tell me about the radius in the picture – what were they showing? (let students respond – “the line segment that goes from the center of a circle to the outside of the circle”)

What does **Radius** mean? (let students respond – “the line segment that goes from the center of a circle to the outside of the circle”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. “Radius” means “radius”) say,

“No, *radius* is the keyword to help us retrieve the answer. What were the radius showing?”

The radius showed the line segment that goes from the center of a circle to the outside of the circle.

Radius means the line segment that goes from the center of a circle to the outside of the circle.”

Script for keywords SYMMETRY

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is ***Symmetry*** which means when something looks the same on one side as on the other, as if it had been cut in the middle and folded over.

Symmetry sort of sounds like "Twins in a tree".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of Twins in a tree

When I ask you the meaning of ***Symmetry***, think first what it sounds like – Twins in a tree

Then think back to this picture with the Twins in a tree

Think about what was in the picture– Twins in a tree where the two sides of the picture are the same

** (Point to Twins in a tree and the line in the middle. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that ***Symmetry*** means when something looks the same on one side as on the other, as if it had been cut in the middle and folded over.

Now let's review.

PUT PICTURE DOWN

SAY

The new word is ***Symmetry***
Symmetry sort of sounds like Twins in a tree

The picture of Twins in a tree looks the same on both sides

Symmetry means when something looks the same on one side as on the other, as if it had been cut in the middle and folded over

SHOW THE PICTURE

Look again at this picture of Twins in a tree

When I ask you the meaning of **Symmetry**, think what it sounds like – Twins in a tree

What does **Symmetry** sound like? (let students respond – “Twins in a tree”)

Tell me about the twins in a tree. (let students respond – “the Twins in a tree look the same on both sides

What does **Symmetry** mean? (let students respond – “when something looks the same on one side as on the other, as if it had been cut in the middle and folded over”)

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:

When students reply with the keyword instead of an answer, (i.e. "Symmetry" means "Twins in a tree") say,

"No, *Twins in a tree* is the keyword to help us retrieve the answer. What was in the picture?

Twins in a tree. The twins in a tree looked the same on both sides

Symmetry means when something looks the same on one side as on the other, as if it had been cut in the middle and folded over

Script for keywords VERTEX

Read the script word for word. Do not add or take away from the script. Do not use a projector or an Elmo until after the post-testing of the project. Do not give the students copies of the pictures or send the pictures home until after the post-testing of the project.

We are going to use our new method of remembering the meanings of words to learn a new word.

Today's word is **Vertex** which means where lines or line segments come together to make an angle.

Vertex sort of sounds like "Bird's nest".

SHOW THE PICTURE

SAY:

Now look at this picture. It is a picture of a bird's nest

When I ask you the meaning of **vertex**, think first what it sounds like – Bird's nest

Then think back to this picture with the bird's nest in the tree

Think about what was in the picture– a bird's nest in a tree where the branches come together to make an angle

** (Point to the vertex in the branch of the tree. Take about 1 minute and walk around to make sure all students can see the picture).

That helps you remember that **vertex** means where lines or line segments come together to make an angle.

If there are lines coming together to make two angles, those are called **vertices**.

What is it called when lines come together to make two angles? (let students answer "vertices")

Now let's review.

PUT PICTURE DOWN

SAY

The new word is **vertex**

Vertex sort of sounds like Bird's nest

The picture of the Bird's nest branches where lines or line segments come together to make an angle.

Vertex means where lines or line segments come together to make an angle

If there are lines coming together to make two angles, those are called **vertices**.

What is it called when lines come together to make two angles? (let students answer "vertices")

SHOW THE PICTURE

Look again at this picture of the Bird's nest

When I ask you the meaning of **vertex**, think what it sounds like – Bird's nest

What does **vertex** sound like? (let students respond – "Bird's nest")

Tell me about the bird's nest in the tree branches. What did they look like? (let students respond – "they made an angle")

What does **vertex** mean? (let students respond – "where lines or line segments come together to make an angle")

If there are lines coming together to make two angles, those are called **vertices**.

What is it called when lines come together to make two angles? (let students answer "vertices")

Now post the picture on the wall where it is visible to the students.

TROUBLESHOOTING with the keyword method:




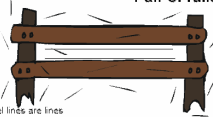

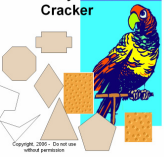


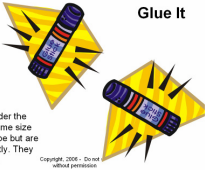





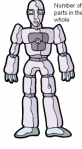


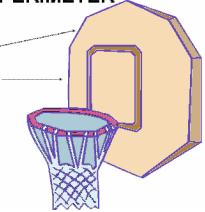
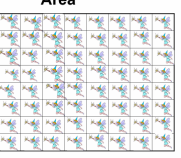

When students reply with the keyword instead of an answer, (i.e. "Vertex" means "Bird's nest") say,

"No, *Bird's nest* is the keyword to help us retrieve the answer. What was in the picture?"

Bird's nest. The bird's nest was in a tree where the branches made an angle

Vertex means where lines or line segments come together to make an angle

Mathematics Vocabulary Instruction

<p>Vertical</p> <p>Think: Very Tall Pole</p>  <p>Vertical is when something is straight up and down and perpendicular to the ground, like this tall pole.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Horizontal</p> <p>Think: Horse running</p>  <p>Horizontal means when something is parallel to the ground, like a horse when running.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Symmetry</p> <p>Think: Twins in a tree</p>  <p>The picture has symmetry because it is the same on one side as on the other, as if it had been cut in the middle and folded over.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Parallel</p> <p>Think: Pair of rails</p>  <p>Parallel lines are lines that are the same distance apart and will never meet, like these fence rails.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>
<p>Perpendicular</p> <p>Think: Purple Dictionary</p>  <p>When two things are perpendicular to each other, they form a right angle where they meet, like the dictionary and the shelf.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Polygon</p> <p>Think: Polly Wants a Cracker</p>  <p>Polygons are straight-sided closed figures, like these crackers.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Quadrilateral</p> <p>Think: Card Table</p>  <p>Other quadrilaterals</p> <p>A quadrilateral is any polygon that has 4 sides, like this card table.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Hexagon</p> <p>Think: Six Dragons</p>  <p>A hexagon is any polygon that has 6 sides.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>
<p>Congruent</p> <p>Think: Glue It</p>  <p>The figures under the glue are the same size and same shape but are turned differently. They are congruent.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Vertex</p> <p>Think: Bird's Nest</p>  <p>The vertex is the point where two lines come together to make an angle, like the two branches in the tree.</p> <p>More than one vertex are called Vertices.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Acute Angle</p> <p>Think: A Cute Angel</p>  <p>An acute angle is an angle that is less than 90 degrees, like the wings on this cute angel.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Obtuse Angle</p> <p>Think: Moose Antlers</p>  <p>An obtuse angle is an angle greater than 90 degrees, like the one on these moose antlers.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>
<p>Diameter</p> <p>Think: Diamond Ring</p>  <p>A diameter is a line segment that goes through the center, all the way across a circle, like the one on this ring.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Radius</p> <p>Think: Radios</p>  <p>A radius is a line segment that goes from the center of a circle to the edge of the circle, like the dial on these radios.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Denominator</p> <p>Number of parts you are looking at</p> <p>Think: Terminator</p>  <p>The denominator is the number on the bottom of a fraction that tells how many parts the whole thing is divided into.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Numerator</p> <p>Think: New arm and head</p>  <p>Number of pieces you are looking at</p> <p>How many pieces in the whole thing</p> <p>The numerator is the number on the top of a fraction that tells the number of pieces you are looking at.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>
<p>Mode</p> <p>Think: Toad</p>  <p>The mode is the number in a set of data that is listed the most times.</p> <p><small>Copyright, 2006 - Do not use without permission</small></p>	<p>Think: PERIMETER</p> <p>The PURPLE RIM.</p> <p>The perimeter is the total distance around the sides.</p> 	<p>Think: Fairy</p> <p>Area is how many square units are in a figure, like the fairy on the board.</p> 	<p>Think: THE PEN IS LONG.</p> <p>Hive stands for 5. A pentagon has 5 sides.</p>  <p>5</p>

Appendix F

Curriculum Based Measurement Skills Aligned by Grade

Mathematics Vocabulary Instruction

CBM Skills in Fourth Grade Probes Coded According to Current South Carolina Standards

Skill	Standard and Grade
geometry terms	3-4
line graphs	4th grade
place value to 100,000	3-2.20
area	3-4
perimeter	3-4.2
minutes/hours	3-5.7
decimals to hundredths	4th grade
<> fractions with like den.	3-2.5
metric weights	3-5.2
number patterns/sequences	3-3.1
coordinate pairs	3-6.2
standard measurements	3-5.2
long division	4th grade
pictographs	3-6.3
denominator/numerator	3-2.5
estimating to nearest ten	3-2.4
bar graphs	3-6.3
estimating to nearest hundred	3-2.4
time to nearest minute	3-5.6

Appendix G

Attitudes Toward Mathematics Inventory: Revised Version

Mathematics Vocabulary Instruction

The Attitudes Toward Mathematics Inventory: Revised Version (ATMI)

A- Strongly Disagree B. – Disagree C. – Neutral D. – Agree E – Strongly Agree

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Math is a very important subject.	A	B	C	D	E
2. I want to develop my math skills	A	B	C	D	E
3. It makes me happy when I solve a math problem.	A	B	C	D	E
4. Math helps develop the mind and teaches us to think	A	B	C	D	E
5. Math is important in everyday life.	A	B	C	D	E
6. Math is one of the most important subjects for people to study.	A	B	C	D	E
7. Math classes would be helpful no matter what I decide to be.	A	B	C	D	E
8. I can think of many ways that I use math outside of school.	A	B	C	D	E
9. Math is one of my most dreaded subjects.	A	B	C	D	E
10. My mind goes blank and I am unable to think clearly when working with math.	A	B	C	D	E
11. Studying math makes me nervous.	A	B	C	D	E
12. Math makes me feel uncomfortable.	A	B	C	D	E
13. I am always stressed in math class.	A	B	C	D	E
14. When I hear the word <i>math</i> , I have a feeling of dislike.	A	B	C	D	E
15. It makes me nervous to even think about having to do a math problem.	A	B	C	D	E

Mathematics Vocabulary Instruction

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
16. Math does not scare me at all.	A	B	C	D	E
17. I have a lot of self-confidence when it comes to math.	A	B	C	D	E
18. I am able to solve math problems without too much trouble.	A	B	C	D	E
19. I expect to do fairly well in any math class.	A	B	C	D	E
20. I am always confused in my math class.	A	B	C	D	E
21. I feel uncertain when attempting math.	A	B	C	D	E
22. I learn math easily.	A	B	C	D	E
23. I am confident that I could learn advanced math.	A	B	C	D	E
24. I have usually enjoyed doing math in school.	A	B	C	D	E
25. Math is dull and boring.	A	B	C	D	E
26. I like to solve new problems in math.	A	B	C	D	E
27. I would prefer to do an assignment in math than to write a paper.	A	B	C	D	E
28. I would like to avoid using math in high school and in college.	A	B	C	D	E
29. I really like math.	A	B	C	D	E
30. I am happier in math class than in any other class.	A	B	C	D	E
31. Math is a very interesting subject.	A	B	C	D	E
32. I am willing to take more math classes than I have to.	A	B	C	D	E

Mathematics Vocabulary Instruction

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
33. I plan to take as much math as I can during my education.	A	B	C	D	E
34. The challenge of math appeals to me.	A	B	C	D	E
35. I think studying math is useful.	A	B	C	D	E
36. I believe that studying math helps me with problem solving in other areas.	A	B	C	D	E
37. I am comfortable saying what my own ideas are for solving a hard problem in math	A	B	C	D	E
38. I am comfortable answering questions in math class.	A	B	C	D	E
39. A strong math background could help me in my job.	A	B	C	D	E
40. I believe I am good at solving math problems.	A	B	C	D	E

Appendix H

Vocabulary Assessment Instrument

NAME _____

Vocabulary Assessment

Section I

In the space provided, draw each of the following:

1. A quadrilateral

2. A pentagon

3. A hexagon

4. An acute angle

5. A polygon

13. A horizontal line

14. The perimeter of a figure

15. A vertex

16. Two shapes that are congruent

17. A numerator

18. The area of a figure

19. Show a set of data where 4 is the mode

20. A denominator

Just for fun..... Write in code!

A=1	G=7	M=13	S=	Y=
B=2	H=	N=	T=	Z=
C=3	I=9	O=15	U=	
D=	J=	P=16	V=	
E=5	K=11	Q=	W	
F=	L=12	R=	X=	

1. Fill in the rest of the numbers for the code.
2. Then use those numbers to write your name.

For example: For the name *ABE*

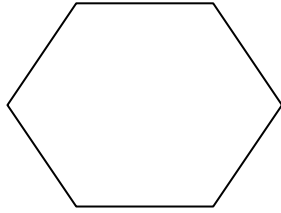
These are the letters used in the name A=1 B=2 E=5
 so the name *ABE* would be written 1, 2, 5

Write your name in the code = _____

Section II

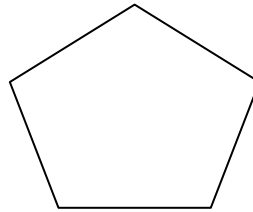
For each of the items, fill in the blank.

1.



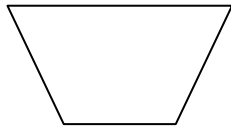
What kind of polygon is this?

2.



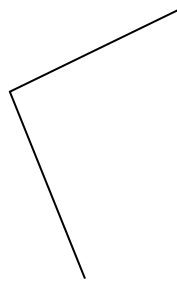
What kind of polygon is this?

3.



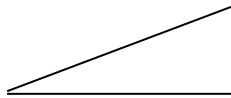
What kind of polygon is this?

4.



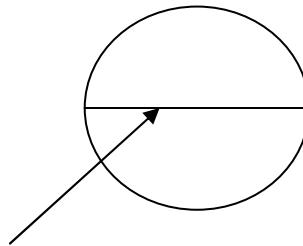
What kind of angle is this?

5.



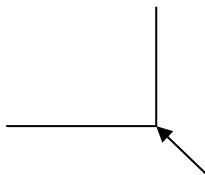
What kind of angle is this? _____

6.



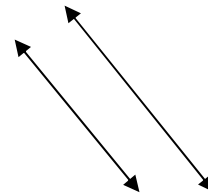
This is a _____ of the circle

7.



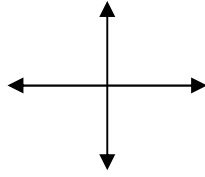
This is the _____ of the angle

8.



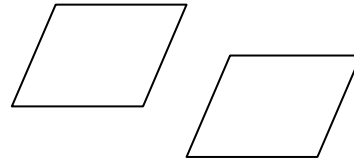
These two lines are _____ to each other

9.



These two lines are _____
to each other

10.



These two shapes are _____
since they are the same size and
same shape

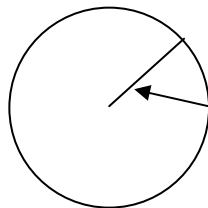
11-12.

$$\frac{3}{5}$$

3 is the _____ in this fraction

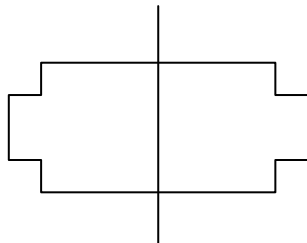
5 is the _____ in this fraction

13.



This is a _____ of the circle

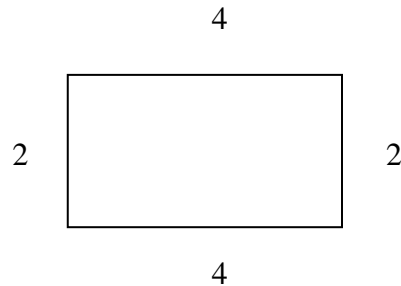
14.



See the line down the middle of this shape?

This shape has _____

15.

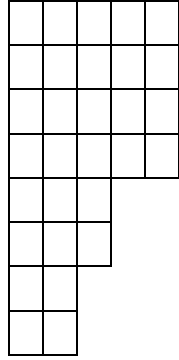


$2 + 4 + 2 + 4$ is how you

find the _____

of this shape.

16.



17.

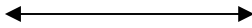


30 is the _____ of this shape

The direction of this line makes it

a _____ line

18.



19.

1, 6, 6, 6, 6, 6, 7, 7, 8, 9, 12, 12, 17

The direction of this line makes

6 is the _____

it a _____ line

of this set of data

Just for fun....

Use the code again

A=1	G=	M=13	S=	Y=
B=	H=8	N=	T=	Z=
C=3	I=	O=15	U=	
D=	J=	P=	V=	
E=5	K=11	Q=17	W	
F=	L=	R=	X=	

Write the answer to this question in code:

What is your favorite thing to do after school? _____

Match each statement in the left column to a word in the right column.
Some words may be used more than once, others may not be used at all.

Shapes

- a. polygon
- b. quadrilateral
- c. perimeter
- d. pentagon
- e. hexagon
- f. symmetry
- g. congruent

Definitions

- _____ 20. A polygon with 6 sides
- _____ 21. A polygon with 5 sides
- _____ 22. The distance around the sides of a figure
- _____ 23. Two figures that are the same size and same shape

Match each statement in the left column to a word in the right column.
Some words may be used more than once, others may not be used at all.

Lines and Angles

- r. vertical
- s. horizontal
- t. diameter
- u. vertex
- v. acute angle
- w. obtuse angle
- x. perpendicular
- y. parallel
- z. radius

Definitions

- _____ 24. An angle smaller than 90 degrees; smaller than a right angle
- _____ 25. Two lines that will never meet.
- _____ 26. A line that points up and down
- _____ 27. A line that goes from the center of a circle to the edge.

28. What is the perimeter of a pentagon if each of its sides is 4 inches long?

29. What is the perimeter of a hexagon if each of its sides is 2 inches long?

30. Draw a quadrilateral with each side 2 inches long.
Show how you would find the area of this quadrilateral.

Appendix I

Writing Prompts

PRACTICE PROMPT

Writing Prompt

Hand out the response journals.

Read this prompt exactly as written to your students.

Allow 5 minutes for them to answer, then take up the journals.

You may help with spelling, but tell the students not to worry with spelling too much.

- * Students who have writing goals listed on their IEP will be allowed to dictate their responses. Please write what they say word for word.

Practice/pretest prompt:

Draw something that is vertical. What does vertical mean?

WEEK 1

Writing Prompt

Hand out the response journals.

Read this prompt exactly as written to your students.

Allow 5 minutes for them to answer, then take up the journals.

You may help with spelling, but tell the students not to worry with spelling too much.

* Students who have writing goals listed on their IEP will be allowed to dictate their responses. Please write what they say word for word.

Week 1:

If you were going to explain *parallel* to a friend, what would you tell them?

WEEK 2

Writing Prompt

Hand out the response journals.

Read this prompt exactly as written to your students.

Allow 5 minutes for them to answer, then take up the journals.

You may help with spelling, but tell the students not to worry with spelling too much.

* Students who have writing goals listed on their IEP will be allowed to dictate their responses. Please write what they say word for word.

Week 2:

Draw a quadrilateral. Write and explain how you know it is a quadrilateral.

WEEK 3

Writing Prompt

Hand out the response journals.

Read this prompt exactly as written to your students.

Allow 5 minutes for them to answer, then take up the journals.

You may help with spelling, but tell the students not to worry with spelling too much.

- * Students who have writing goals listed on their IEP will be allowed to dictate their responses. Please write what they say word for word.

Week 3:

If something is horizontal, how could you make it vertical. How do you know?

WEEK 4

Writing Prompt

Hand out the response journals.

Read this prompt exactly as written to your students.

Allow 5 minutes for them to answer, then take up the journals.

You may help with spelling, but tell the students not to worry with spelling too much.

- * Students who have writing goals listed on their IEP will be allowed to dictate their responses. Please write what they say word for word.

Week 4:

Draw a round clock and show where the diameter is. How do you know this is a diameter?

FINAL

Writing Prompt

Hand out the response journals.

Read this prompt exactly as written to your students.

Allow 5 minutes for them to answer, then take up the journals.

You may help with spelling, but tell the students not to worry with spelling too much.

- * Students who have writing goals listed on their IEP will be allowed to dictate their responses. Please write what they say word for word.

Final/posttest prompt:

Draw an acute angle. Write and explain what an acute angle is. How do you know?

Appendix J

Student Interview Script

STUDENT INTERVIEW SCRIPT

TURN ON RECORDER. Remember to say out loud any gestures that the students make so I will know what they did.

Hi, _____ (student's name).

My name is _____ and I am from Clemson University. Your class has been studying math vocabulary words lately for a project I work on and I would like to ask you a few questions about math.

I'm going to use this tape recorder so I don't have to write down what you say. This is not going to be used for a grade in your classroom and your name won't be used on anything. I just need you to do your best, all right? Let's get started.

1. Do you like math?

Why do you say this?

2. Are you good at math?

Why do you say this?

3. Sometimes math vocabulary words are easy to get mixed up. For example, the words *diameter* and *radius*.

Can you tell me what *diameter* means?

Can you tell me what *radius* means?

Tell me how you remember the difference between *diameter* and *radius*.

4. *Now I want you to tell me how you would work some problems.*

(Give student the first problem page.)

Read the problem to the student. Do not prompt, but if they say, “I don’t know.” try to encourage them to try just a little bit such as, “What would you do first?” or “Can you try just a little of it?”

Try this encouragement for a few minutes, but then move on to the prompt questions at the end of the problem. If still no answer, move on to the next problem. Do not correct them if they are wrong and do not prompt them for ways to remember.

I. Answer this question and explain how you did it:

Write the fraction when:

4 is the numerator and

7 is the denominator

$$\frac{\square}{\square}$$

2 is the denominator and

5 is the numerator

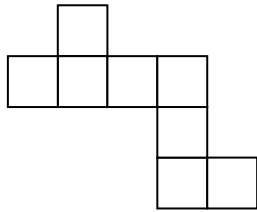
$$\frac{\square}{\square}$$

*****If they did not address this in their explanation, ask:

How did you remember where the numerator was?

How did you remember where the denominator was?

II. Answer this question and explain how you did it:

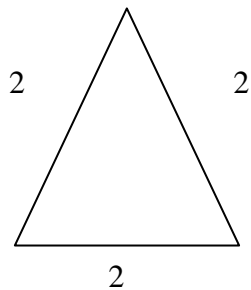


The area = _____ sq. units

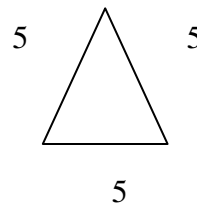
***If they did not address this in their explanation, ask:

How did you know what *area* was?

III. Answer this question about two triangles and explain how you did it:



<p><u>Triangle A</u> Perimeter = 6</p>



<p><u>Triangle B</u> Perimeter = 15</p>
--

Which triangle has the greater perimeter? _____

**If they do not address this during the discussion, ask:

What is a perimeter?

IV. Write $>$, $<$, or $=$ in the blank and tell how you know.

Acute angles _____ Obtuse angles

***If they do not address this during the discussion, ask:

What is an acute angle?

What is an obtuse angle?

Appendix K

Teacher Project Summary Survey

Project Summary

Name _____ Group (Exp or Cont) _____

1. Did you give the posttest on either **Tuesday, March 13** or **Weds, March 14**?
_____ (Y/N) If **no**, when did your class take it? _____

2. **What date** did you give the **final retention** measure (this last one with the survey)?

3. Did you enjoy teaching math vocabulary using the method you were given?
_____(Y/N)
Why or why not?

4. Do you think the method you used helped your students learn the vocabulary words?
_____(Y/N)
Why or why not?

5. Would you use the word cards or picture cards (whichever you used for the project) again in your vocabulary instruction? Why or why not?

6. Would you like to make any comments about the project or the methods of vocabulary instruction? (You can use the back of this paper if you need more room)

****For experimental group teachers only (Please discuss these with your class to answer):**

- a. Were there particular pictures your students enjoyed more than others or that you thought were effective? If so, what were they?

- b. Were there particular pictures your students did **not** like or that you thought were ineffective? If so, what were they?

- c. What suggestions do you or your students have for changing any of the pictures to make them better?

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