THE BENEFITS OF LEARNING MATH VOCABULARY WITH CONTEXT STRATEGIES ALONE VERSUS WITH COMICS AS A VISUAL: A CASE STUDY

Amanda Gilles

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Committee:

Dr. Nancy Fordham

Dr. Cindy Hendricks

Dr. Rachel Reinhart
ABSTRACT

Dr. Nancy Fordham, Advisor

The purpose of this study was to assess and observe which of two instructional methods proved to help students learn math vocabulary better and for a longer period of time. It compared learning math terms using context, or words alone, to using context in addition to visuals, specifically comics. This study was conducted during three separate one-day visits during two periods at a rural Midwestern school in a sixth grade classroom.

Over a three-week period, students were pre-assessed on their knowledge of math content vocabulary, and based on the results, were taught lessons using context strategies alone and context strategies with comics. Post-tests were administered after each set of lessons.

Results indicated that students performed better on the post-tests after learning the vocabulary lessons using context strategies with comics versus context strategies alone. The students’ preference for learning using the context strategies with comics as visuals method was also revealed.
I wish to dedicate this to my Grandma, who has been my rock and my support, being there for me night and day, giving me never-ending support and faith this year and always—even when I didn’t believe in myself. Love, Amanda

I also wish to dedicate this to my professors at BGSU, and my teachers in school, as it was all of you who helped me to keep my dream and passion for teaching alive as I learned from the best.
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CHAPTER I. INTRODUCTION

Vocabulary is an imperative topic in any school subject, as all words have an academic purpose and meaning. According to Reich and Reich (1979), the English language contains morphological regulations that can change verbs into nouns, adverbs, and adjectives, with some words functioning as both nouns and verbs, and being spelled the same way. Furthermore, an online blog found on Classof1, an early pioneer of an online tutoring and homework assistance program, states that the average middle school student should know about 1,500 words, with the accelerated students knowing even more than this (Getta, 2011, *Categories*, para. 1). With the recent push for standardized state tests and “various competitive exams,” a strong and extensive vocabulary is a pertinent representation of academic success and future job qualifications (Getta, 2011, *Categories*, para. 1).

More specifically, this push for vocabulary knowledge on state high-stakes tests is apparent in math, presenting students with complex sentences and problems for them to complete, explain, and solve (Pierce & Fontaine, 2009). Research has also shown that students with limited vocabularies struggle to comprehend text, which leads them to read less, resulting in a weak vocabulary, which then creates difficulty with comprehension (Johnson & Johnson, n.d.). Thus, not only is vocabulary an imperative topic in reading, it bears specific importance in the subject of math.

In teaching vocabulary, teachers have used several different techniques to help students better comprehend and retain unknown words. One popular form of teaching vocabulary is through context, a strategy that allows students to make more informed guesses about the meaning of words in print and to verify these meanings by using the grammatical and semantic clues around the words. Authors often provide meanings for words or clues surrounding these
words; thus, it is essential that students be able to use these clues as they read to gain the most in regard to comprehension (Tierney & Readence, 2005).

However, Howard Gardner found there are a multitude of intelligences (Gardner, 1999); therefore, not all students learn vocabulary in the same way. Thus, using context alone as a form of instruction may not be enough to help students’ vocabularies to develop in depth and quantity. For some students, the addition of visual representations along with the use of context clues may make a difference, specifically, pictures such as those used in comics. It is with these picture associations that students connect to and retain the meaning of the vocabulary, in addition to being able to comprehend and feel more comfortable in how they use the initially unknown terms. The use of comics is seen as more “student-friendly” and helps the students to explain the words in everyday language (Pierce & Fontaine, 2009), in addition to making a visual association with the word. In mathematics, terminology is critical, as comprehension and the use of words build on each term, much as the lessons themselves do. Mathematics textbooks are often written above the indicated grade level, and provide few contextual clues, making comprehension especially challenging for students. Many of the words even have meanings that are different than those used in everyday language, with some words even containing symbols that are not used in the common English alphabet. For example: percent (%), Pi (π), degrees (°), not equal (≠), summation (Σ), Theta (Θ) these symbols are all a part of the math vocabulary, yet they are not found in the Standard English language. Furthermore, students do not always read from left to right and top to bottom in a math text, again making the vocabulary hard to decipher through context strategies alone, thus the benefits of visuals.
As addressed by Beheydt (1987):

Evidence is mounting that the use of visual representations may precipitate the semantization process. Especially with concrete picturable words (e.g., table, house) the picture serves as an associative aid to constructing the conceptual network that is connected with a word. Pictures not only represent reality but they can, through selective presentation of cues, provide a phototypical meaning. (p. 62)

Thus, comics may be an effective strategy in teaching math vocabulary, as they allow students to develop a visual representation of a term through the various illustrations. They represent a quick, concise, and creative way for students to learn new terminology.

Statement of the Problem

Currently, an abundance of research exists on the importance of vocabulary and effective strategies that may be used during instruction in all subject areas, especially math. According to Schell (1982), “Research indicates that math is the most difficult content area material to read, with more concepts per word, per sentence, and per paragraph than any other area” (p. 544). This then leads to students struggling or becoming frustrated when they come across unfamiliar terminology in math, for reasons such as lack of motivation, lack of readiness to read in math, and not understanding the purposes for reading in examples like that of solving word problems. Schell also states these frustrations stem from the differences that exist between Standard English prose and that of math. For example, English uses 26 symbols in its alphabet, but in the subject of math, these 26 symbols plus more are used. With these extra symbols, vocabulary can be seen as being even more difficult, as there is more to decode for meaning. The sentence structures used in English are also constructed differently than those found in math. Thirdly, students do not always read from left to right and top to bottom as they do in English. While the
use of context may help some students, it tends to be a strategy that is more beneficial in introducing words, not teaching or reinforcing them (Tierney & Readence, 2005).

Teaching through context alone is also insufficient when the words surrounding or used to explain a new or unfamiliar word are not familiar or understandable. Students cannot be expected to learn a new word, let alone retain it, when they do not even know what the words surrounding it mean. Additionally, not all contexts are considered helpful to students. According to Beck, McKeown, and McCaslin (1983), “non-directive contexts” is a term that refers to context that can be of little guidance or help in directing students toward deciphering the meaning of an unknown word. Thus, the problem this study addressed was observing and describing the effects of teaching mathematical vocabulary through the use of context and comic illustrations as a form of visual representation in one rural junior high school.

Research Question

This research study focused on the following questions: Is teaching mathematical vocabulary using context clues with visual representations such as comic cartoons more effective than teaching vocabulary through context alone? Also, which method do the students prefer? Thus, the purpose of this investigation was to compare the teaching of mathematical vocabulary through context clues alone with the teaching of mathematical vocabulary through context and the addition of visual representation, specifically comics.

Rationale

This study was implemented in a rural junior high school, but can apply to teachers of any level, particularly those who teach mathematics, as “Mathematics texts contain more concepts per word, per sentence, and per paragraph than any other kind of text” (Barton, Heidema, & Jordan, 2002. p. 24). However, the results of this investigation may provide all
teachers with essential information about vocabulary instruction in other content areas.

Furthermore, using comics as a form of visual representation may also be appealing to teachers of other subjects, as they, too, need to use a plethora of strategies to help students learn and retain content terminology. Students who are challenged readers and who struggle in the area of math may also receive benefits from this study, as it will provide them with a new opportunity to become engaged in mathematical topics, in addition to having a visual reminder of the mathematical word’s definition. For those English as Second Language (ESL) students, comics are also proactive in that they assist these students by helping them to better grasp the English language and to make connections with the terminology (Cunningham, 2009).

Definition of Terms

The following terms will be used throughout this investigation and should be defined to help elucidate concepts that may be misunderstood:

1. Middle School: Typically, this constitutes grades 4-9, with ages consisting of 9 - 14 years. Usually, these schools are in separate buildings or departments from the high school/elementary schools within the same district. This type of school focuses more on serving young adolescents than on the system of the school or the assessments (National Middle School Association, 2010).

2. Comics: narratives told by a sequence of pictures, with the character’s dialogue incorporated into the pictures (Harvey, 1996).

3. Context Clues: Throughout this study, context clues refer to the use of a word’s context (surrounding words) as a strategy to help define unknown or confusing words. For example, readers may cover up the unknown term and define it based
on words around it, or break the word into smaller syllables---prefix, suffix, and root words (Hendricks & Rinsky, 2007).

4. Visual Representation: A picture, drawing, and or graph-like visual that correlates with a word’s definition. In this research study, visual representation specifically refers to the use of comic strips.

5. Quasi-experimental study: a form of experiment in which less control and randomization occurs in the selection and formation of the comparison and control groups. Results produce less validity than a true form of an experiment (Muijs, 2011).

6. Mnemonics: a memory device (written, visual, or cognitive) that helps one to remember something by associating new information with something already known (Burchers, 2007).

7. Morphology: the study of a word’s formation and how it can change in regard to tense, contractions, affixes, and compounds (Crawley & Merritt, 2009).


Limitations

As a quasi-experimental study, this research project had several potential limitations in working with students in a school. These limitations might cause the reproduction of this study to produce different results. One limitation was the sample size of the two classes involved. This particular study involved 37 students per class; however, in future studies, the class sizes
may be larger or smaller due to students moving away, dropping out of the school district, and some declining to participate.

Another limitation in this study was the lack of consistency due to attendance. Some students were not able to complete the entire study due to illness. One student attended for only one portion of the study during which this student learned the lesson with context instruction with comics but was absent for the lesson using only context strategies. This resulted in a change of total students in the study from 37 to 36 for the second set of assessments.

A third limitation in this study was the time of day and year in which the classes were held. Both classes were held in the morning, the two periods before lunch, so some of the students may not have performed well based on their response from a distraction caused by hunger. Furthermore, with this study being conducted in the late winter, state standardized testing was drawing near, which may somehow have indirectly heightened the awareness of the math teacher at this school in regard to teaching vocabulary skills.

A fourth limitation of this study was based on the school involved and its demographics. The junior high school was located in a rural district in a small town in Northwest Ohio. The demographics and socio-economic status of students attending the school, as well as their cognitive characteristics, may differ from those in other sites selected for future studies. Therefore, the results of this study reflect the results of this school and these two classes alone, whereas a reproduction of this study in a site that differs by geography (city or suburban) or class makeup could produce different results.
CHAPTER II. LITERATURE REVIEW

The purpose of this investigation was to explore the effect of using visual representations, specifically comics, in addition to context, in helping students learn mathematical terminology in a sixth grade class at one rural junior high school in Northwestern Ohio. This research study focused on the following questions: Is teaching mathematical vocabulary using context clues with visual representations such as comic cartoons more effective than teaching vocabulary through context alone? Also, which method do the students prefer?

The literature review framing this study and depicted in this chapter first examines the theories and theorists framing the underlying ideologies supporting this research. It then explains the importance and history of vocabulary instruction in the curriculum. Following this, the chapter illustrates the teaching of math vocabulary. Next, the chapter addresses strategies of context and visual representation when teaching mathematics vocabulary. In discussing visual representations, the chapter then places a focus on the use of comics, describing the benefits and studies conducted using this manner of instruction. Finally, this chapter concludes with a brief summarization of the information enclosed in this literature review.

Theoretical Orientation

Years of research among theorists, as well as information found among ideals and instruments, has shown that not only students’ motivation, but their performance and retention of curriculum topics improves when instruction is applicable to a variety of learning styles and the students can form a connection with the material (Miller, 2001). Perhaps one of the most well-known theories that address differences in learning is Howard Gardner’s Theory of Multiple Intelligences (2001). His original theory described seven different types of intelligences every person possesses, noting that each person has strengths and weaknesses within each. The initial
seven intelligences included linguistic, logical-mathematical, spatial, bodily-kinesthetic, musical, interpersonal, and intrapersonal, and more recently, he has added an eighth intelligence, the naturalist. Originally, Gardner defined intelligence as the ability to solve problems and to create products that were valued in one’s society. However, a few years later, he redefined this term to mean “a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture” (pp. 13-14).

The reason for this refinement was to point out that intelligence is not a tangible or visible object; instead, it is a cognitive potential, which depends upon a person’s environment and culture (Gardner, 1993). Thus, if a student is presented with a vocabulary term in context alone, he or she may not be able to fully develop and use his or her logical-mathematical intelligence, as there will be no concrete connection to or comprehension of the term, whereas context and the accompaniment of a visual representation may help the student. Gardner also pointed out that no intelligence was better than another; yet, each could be developed for constructive or destructive use, depending on one’s environment. He also stated, “Now that we know something about teaching styles, learning styles, and individual intelligences, it is simply inexcusable to insist that all students learn the same thing in the same way,” (Gardner, p. 73). Therefore, if schools and teachers engage a multitude of strengths as Gardner suggests, then they will help lead students to succeed in the classroom and beyond (Kornhaber, Fierros, & Veenema, 2004).

Another well-known theorist who promoted educational success and student differentiation was Soviet psychologist, Lev Vygotsky. He is most recognized for his term “Zone of Proximal Development” (ZPD) and for the concept of scaffolding information taught to students. The Zone of Proximal Development “refers to the gap between what a given child can
achieve alone, their 'potential development as determined by independent problem solving, and what they can achieve through problem solving under adult guidance or in collaboration with more capable peers” (Wood & Wood, 1996, p. 5). It is seen as a basis of dialogue between an experienced learner who is the teacher and the novice learner who is the student, in which inner speech or individual learning is developed over time, as the teacher helps the student to add information to his or her schemata, or prior knowledge in which new information is built upon (Frank, Grossi, & Stanfield, 2006). The teacher first supplies a great deal of guidance, support, and modeling, and then slowly provides less and less as the student begins to develop the skill or task on his or her own. According to Riber and Robinson (2004), Vygotsky’s use of ZPD allowed the novice learner to reflect on the dialogue, or lesson, and to then use its distinctions and key points to formulate his or her own thought, or connection to the material.

The term scaffolding recognizes the nature of guidance and assistance from the experienced learner to the novice learner (Wood & Wood, 1996). In some cases, this can refer to the use of pictures, demonstrations, manipulatives, and even relational stories in the classroom to include the students’ interests, in addition to making them cognitively aware of features that may otherwise be overlooked by students (Wood & Wood). Thus, teachers and tutors provide a connection between what students already know in their existing knowledge and what lies as a confusion or unknown in completing a lesson or task. According to Wood and Wood, without the use of scaffolding in the classroom, students may not gain the connection between the content terminology, such as in math or science, and therefore not recognize the relevance of the lesson or task, leading to more confusion and frustration in the future.

A third contributor in recognizing the need for students and their different learning styles was David Kolb (as cited in Freedman & Stumpf, 1980). In his Learning Style Theory, Kolb
theorizes that students learn in a four-stage process consisting of concrete experiences, reflective observations, abstract conceptualizations, and active experimentations. He claims that people are not likely to enter each stage for an equal amount of time and can even be “categorized along two bipolar learning dimensions,” (Freedman & Stumpf, p. 445). This theory continues to be used for further theory building, research, and to provide pedagogical advice to teachers on how to best help address their students’ needs in the classroom.

A learning style model that stems from Kolb’s theory on learning styles and that is used to identify the individuality of students’ learning styles is the Visual, Aural, Read/write, and Kinesthetic (VARK) Learning Styles Inventory created by Neil Fleming in 1987 (Miller, 2001). This instrument lends itself to the different learning style theories developed over the last 30 years, with the most familiar being that of Howard Gardner’s Theory of Multiple Intelligences. This model is different than other learning style centered instruments in that its main purpose is to advise and guide versus diagnose (Miller). This inventory gives teachers an idea of their students’ learning style. According to Drago and Wagner, (2004), “Learning style refers to the differences that exist between individuals in how they best learn” (p. 1), and for many teachers this should be considered a priority. Fleming’s instrument is used to guide and develop students’ learning styles among four psychological elements (visual, aural, reading/writing, and kinesthetic). It also places a focus on the perceptual learning style in the section of reading and writing by examining the use of symbols and text. In other words, the VARK model helps to clarify in understanding how students best perceive and understand the meaning of symbols and text used in reading and writing.

Othman and Amiruddin (2010) explain that while each category adheres to different student needs and allows students to decode information differently; all four categories take in
information in some way for using pictures and visualizations. For example, in the visual
category, students who excel at using pictures, figures, graphs, and models and can often explain
corcepts using these. The students in the aural category have an easier time reading text and
pictures, and as well as being able to write and narrate effortlessly, in addition to having a strong
vocabulary. Students in the reading and writing category are similar, in that they benefit from
taking notes as they condense information into shorter more relatable chunks, often using small
pictures and symbols to coincide with their notes. The fourth category, kinesthetic, also benefits
students and their learning from the use of visuals such as pictures and graphs in that it applies
the concept of touch within the activities, bringing visuals to life through manipulation and
figures (Othman & Amiruddin). Above all in using, the VARK model in the classroom, teachers
can make students’ learning experiences more productive and overall enticing.

Another theory relevant to vocabulary instruction is Schema theory. The term “schema”
was first referenced by Piaget in 1926 (1999, SIL International). According to Cooper and
Sweller (1987), schema is “a construct that allows problem solvers to group problems into
categories in which the problems in each category require similar solutions,” (p. 348). Brewer
and Nakamura (1984), also defined schemata in recognizing that they play a role in linking to
stored knowledge and building onto this with new knowledge gained. They state, “In brief,
[schemata] are higher-order cognitive structures that have been hypothesized to underlie many
aspects of human knowledge and skill. They serve a crucial role in providing an account of how
old knowledge interacts with new knowledge in perception, language, thought, and memory” (p.
120). In their text, Vacca and Vacca define schema as well. They state, “Cognitive scientists
use the technical term schema to describe how people use world or prior knowledge to organize
and store information in their heads” (2005, p. 15). They further the idea of schema by defining
*schema activation* as a strategy in which people “access what they know and match it to the information in a text” (p. 15). In making these connections between prior knowledge and text, Vacca and Vacca state that schema functions in several different ways. One example in making the link between prior knowledge and the text is that students will be able to look for and select the information that is worth their while and purposeful to their reading. Another strategy provided in making connections with prior knowledge and text is organization. Students will be able to strengthen their retention of information if they are able to organize it. Elaboration is a third strategy developed through schema. Again, if students can make a connection with information and what they already know, they interact in a “cognitive process that involves deeper levels of insight, judgment, and evaluation” (Vacca & Vacca, p. 20).

The previous definitions and uses of schema help convey the importance of using schemata in vocabulary development, especially in math. In their study, Fuchs, Fuchs, Finelli, Courey, and Hamlett (2004), found that real-life problem solving in math that incorporated challenging transfer features based upon the Schema-based transfer instruction (SBTI) produced more success among students who drew from problem types and scenarios that they already knew. They noted that children considered the math problems easier to solve when they had something to connect it with. The same would hold true with vocabulary instruction, because students who can make a connection with the word will have a much easier time understanding and retaining it. Furthering this idea, Johnson and Johnson (n.d.), state students will remember words better and their new meanings if they can draw a connection with what they already have in their knowledge.

The actual schema theory itself was developed by R.C. Anderson (1999, SIL International). This theory focuses on how one organizes knowledge into categories or schemata
and, within each of these unique categories, is stored information. According to McVee, Dunsmore and Gavelek (2005), this theory had a huge impact on reading models “particularly in reading comprehension and learning” (p. 537). They found this theory provided teachers with an understanding of how to represent knowledge and help students to categorize it. They provide the example of one having the schema of a “cup” and being able to better understand the concept of other containers, based on this prior knowledge. SIL International corroborates this aspect of prior knowledge, as they state on their library link that “prior knowledge is essential for the comprehension of new information,” and they suggest visual aids and illustrations as some of the ways connections among students can be achieved (1999).

The Ontogeny of Vocabulary as a Result of Reading and Writing

The act of speech, along with the history of writing, has been present for centuries, tracing back to the days of prehistoric men as they left visible evidence of pictures on rocks and in the sand, in what Gibson (1970) calls the “fundamental graphic act” (p. 136). These pictures led to the gradual transition to symbols, which eventually developed into writing. For many students, as infants, their first form of graphic communication consists of various scribbles and markings, which eventually lead to the practice of various line properties forming letters. These letters are then grouped to become words that convey a meaning, and in the English language that equates to about 88,500 distinct words (Nagy & Anderson, 1984). With each word, it is estimated that at least one-to-three related words are learned and conceptualized by a student, depending on the child’s ability to use the surrounding context clues and morphology skills to decipher the related words. Students in the upper middle school levels, grades six through nine, are likely to encounter about 3,000-4,000 new vocabulary words each year, depending on whether they read anywhere from 5,000 to about a million words of text (Nagy & Anderson).
Pertinence of Vocabulary Instruction in Education

As a basic implication of their study on word frequency, Nagy and Anderson (1984) believed that with the intensity and quantity of vocabulary students encounter on a day-to-day basis in reading, any instruction to decipher terminology must incorporate some method of increasing students’ abilities to learn words, especially on their own. According to McKeown (1993), looking up words in a dictionary or learning words based on rote memorization may be effective to some degree, but this is only short term and “superficial at best,” with students forgetting the words soon after the lesson or unit. This practice of creating a list, looking up the words in a dictionary, or in today’s society, on the internet on various web sites, and then using it in a sentence is the most popular form of vocabulary instruction in many classrooms (McKeown).

Countering this typical style of vocabulary instruction, some believe students should use the terminology in the subject area, and that repetitive defining and use of the word in a sentence should not be a focus. For example, in math, when students use the terms correctly, this delivers the message that they understand not only the term’s morphology, or basic structure, but also the importance of word choice, as it helps students to convey directly what they are thinking in relation to the topic or problem (Graeber, Valli, & Jones Newton, 2011). Furthermore, Johnson and Johnson (n.d.), state that students remember words better and for longer periods of time when they construct meanings and associate them with what already exists in their schemata, or prior knowledge. Typically, this process occurs when students rewrite definitions, identify examples and non-examples of a term, and create scenarios or stories in which the term is used, i.e., comics and graphic novels. They go on to state, “Each of the above activities reinforces
definitional or contextual information about the word and gives students a chance to own the word for themselves,” (n.d., p. 4).

Johnson and Johnson believe that for vocabulary development to be effective and purposeful, a combination of strategies is required, as the development of vocabulary can be highly complicated if not implemented correctly. Thus, vocabulary instruction requires direct instruction from the teacher in which he or she presents the new word and definition by modeling an example and/or non-example. Discussion and active encouragement to use the new words is also pertinent in vocabulary development. This means the teacher needs to use the word(s) multiple times in speech, writing, and visual representation. Vacca and Vacca (2005) state that teachers need to show words through context clues at least two-to-three times in a week over the course of a school year to obtain 80 to 120 applications with new words. However, despite the previous findings, contrary to this belief, Webb (2007) states that findings from research have not been concrete and the exact number of encounters needed from context are not definitive. Webb gives two possible reasons for this; no studies have controlled the type of context in which the target words were used, and the research which has been conducted has only recognized gains in knowledge of meaning when using the word. He further advises at least ten or more encounters with the unknown word for students to develop full knowledge of the word.

Furthermore, Reehm and Long (1996) state the best place to teach specific reading skills, including the development of mathematical vocabulary, is right in the mathematics classroom versus an independent reading class. According to them, “Reading specialists are accomplished in the uses of graphophonic, syntactic and semantic cue systems to construct meaning. However, they are unlikely to have the conceptual knowledge of mathematics needed to teach reading and comprehension of mathematical material,” (p. 36). They believe mathematics texts in the middle
and secondary grade levels are overall more complex syntactically and semantically than those used in elementary grades. This is especially true in regard to vocabulary.

However, this vocabulary development does not need to grow from direct instruction alone. Students can also increase their vocabularies on their own, in working with peers, and even through involvement with parents. In their text, *Remediating Reading Difficulties*, Crawley and Merritt (2009), offer several suggestions: having students creating a class word chart/wall consisting of words they discover as they read aloud in small groups and a class, creating collages of words based on a theme, and even creating class or self dictionaries, where students record interesting or difficult words, the words’ meanings, origins, and even antonyms and synonyms. The teacher would help scaffold and model these different activities to students and continue to do the activities with the students or have them work on these in small groups or even at home with parents.

Completing activities that involve students in using graphic organizers, or different graphs/pictures which help them to organize information and also act as strategies to develop literacy skills, is an example of indirect instruction. Examples of graphic organizers are Venn diagrams, semantic maps, definition maps, and even graphics with short portions of text such as those found in comics. Any of these general strategies can be used in the classroom to conduct vocabulary instruction (Johnson & Johnson).

Venn diagrams are examples of graphic organizers used to help students develop the skill of comparing and contrasting information, “clarifying similarities and differences” (Johnson & Johnson, n.d., p. 13). They consist of two intertwining circles in which similar details are placed in the center where the two circles interconnect, and differing details are listed in the designated outer portions of the circles.
Semantic maps help students develop an understanding of the relationships between a particular concept or a group of related words. Students start this process with the focus term or concept in the center of the board/paper. From here, they brainstorm words related to the key term or concept. As students do this, they need to define and discuss the words they list, grouping related words together to create a semantic map (Johnson & Johnson).

Definition or Concept maps visually depict the typical information of a dictionary definition, but in an easier format for students to use and understand. For example, the word under study is placed in the center, enclosed in a circle or square. Connected to the circle/square are four different circles/squares branching off of this, each with a different purpose. One is designated to be the meaning/definition and description of the concept, one is designated to be a list of examples of the word, one is designated to be non-examples of the word, and one more is designated to be the use of the concept/word in a sentence (Johnson & Johnson).

Vocabulary Instruction in the Mathematical Content Area

Every content area has its own specified list of vocabulary terms that are pertinent in understanding lessons and skills, in addition to communicating information. The key to success within each of these contents is forming a strong understanding of the terminology, and this is especially true in mathematics. Vocabulary instruction is vital in this particular subject as it allows students the ability to solve and use a combination of symbols and words to complete or answer a variety of problems (Fitzgerald, 2006). According to Fitzgerald’s *Math Dictionary for Kids* (2006), one of many keys to being proficient in math, “is knowing what the problem is asking,” in other words, having an idea of what the vocabulary means and being able to determine the best strategy to use in order to solve the problem, (p. 1). In her book, Fitzgerald addresses more than just the wording for each term among the different areas of math. Each
term is depicted with a concise definition (as too many words can be just as confusing and
unhelpful as too few words), an example, and an illustration. The book itself, much like
vocabulary instruction, is meant to be used throughout the year as a support and reference to help
aid students in their mathematical development (Fitzgerald).

Dunlap and McKnight (1978) claim many children at all academic levels have difficulty
performing the reading/thinking process as it applies to mathematics. They do not believe this is
a fault of reading teachers for not teaching certain literacy skills applicable to mathematics.
Instead, they found that students struggle with math terminology in word problems, especially
because of the three-level translation of vocabulary required, which includes the general,
technical, and symbolic forms of vocabulary (Dunlap & McKnight). In this process, when
students come across unknown words, they must first decode the terms to consider the general
meaning or recognize them as sight words. They must then translate the word’s general meaning
into the mathematical form. A multitude of words occur in both the general and technical forms,
with some of these forms having multiple meanings; thus, the cause for confusion and frustration
when reading math problems (Dunlap & McKnight). For example, the word “plane” in a math
problem may first be recognized by a student as an aircraft, but when translated to its
mathematical meaning, this word refers to its homonym, “plane,” which is a flat surface on
which points lie. In some cases, the word must also be conceptualized symbolically to compute
the problem. In the example of “plane,” a student would need to draw or create a visual image of
a square- shaped flat surface, and not the aircraft, as some struggling students may think (Dunlap
& McKnight).

Dunlap and McKnight (1978) also found students’ inability to analyze and respond to the
question at hand to be another component of the struggle with math word problems due to the
terminology. The reason for this is that in most math textbooks, vocabulary words are rapidly introduced in a short amount of space, exhibiting vague or confusing definitions (Latta, & Fordham, 2007). Barton and Heidema further support this by stating, authors of math textbooks usually write using a short and to the point style, containing a great deal of information, with little repetition (2002). Schell (1982) states that teachers should be aware of how difficult it is for students to read math, as English uses the standard alphabet of 26 letters, but math uses these symbols and more. Also, the sentence structure in which these English and math symbols are used is much different than studied in English class. Additionally, students do not only read the page from top to bottom and left to right in math, as they generally do standard English prose. Latta and Fordham (2007) believe that, for some students, vocabulary in the math text is approached much like that of a new or foreign language, as the technical meanings are generally used very little outside of the math content and when they are, they are associated with a completely different meaning all together as in the example word, “plane.” Thus, this example demonstrates the need for teachers to implement rich study of vocabulary the math content classes.

Extending this idea further, is Eugenia Francis, author of *Teach Your Child the Multiplication Tables, Fast, Fun & Easy with Dazzling Patterns, Grids and Tricks.* (2010). She claims students’ frustration in with math can even stem from their parents who demonstrate the same attitude of frustration and discouragement with math terminology because they experienced the same frustration. She has had several parents approach her at book fairs telling her they were not particularly good at math, and some even claim to “hate math,” so they are not surprised to see their child struggling with the terminology (para 1).
Two Forms of Strategies in Vocabulary Instruction

*Teaching through Context*

Among the various forms of vocabulary instruction, many look to the use of context, or descriptions and clues that surround an unknown word within a text, to decipher the meaning of the unknown word. In fact, traditional vocabulary instruction is based on the theory that a word’s morphology is actually presented and learned better through the use of context than definition, association, or even categorization (Beck, McKeown, & McCaslin, 1983). Likewise, textbooks and basal readers “almost universally advise” vocabulary growth through the method of context. According to Beck, McKeown and McCaslin, there are two forms of context: pedagogical and natural. Pedagogical contexts are crafted expressively for the reader to learn the unknown vocabulary term. In the natural form of context, the reader may learn the morphology of an unknown word based on its surroundings; however, learning the word’s meaning is not the author’s specific intent.

Vacca and Vacca (2005) further support the importance of context strategies by stating, “Constructing meaning from context is one of the most useful strategies at the command of proficient readers” (p. 124). They describe these strategies as being beneficial to all readers, but especially struggling readers, as context clues help boost students’ self-confidence and inquiry skills, which they feel are necessary in order to “unlock the meaning” (p. 124), of words that can often lead to confusion and frustration. Vacca and Vacca categorize context clues into three categories: typographic, syntactic and semantic. *Typographic clues* are the visual and obvious forms of making a word stand out—bold face, footnotes, italics, pictures, charts, and even definitions or synonyms listed in parentheses following the focus words. *Syntactic clues* are the ways in which words are arranged in a sentence within a paragraph, and *semantic clues* are the
relationships among the words and their meanings within sentences. Vacca and Vacca claim the latter two clues to be much more subtle and harder for students to use than typographic clues.

In their text, *Content Area Reading: Literacy Learning Across the Curriculum* (2005), Vacca and Vacca suggest several different forms of syntactic and semantic clues most frequently encountered and used by students. One type of clue is the definition, in which the author uses the form of a “to be” verb (is, am, are, was, were) following the unknown word. An example is, “A critical review IS an attempt to evaluate the worth of a piece of writing.” (p. 126). Another clue is linking the unknown word with synonyms, by setting the word off with commas and a list of words similar to this new or unknown word. “Kunte Kinte was the victim of cruel, evil, malevolent, and brutal slave traders” (p. 126) in which cruel is the new or unknown word followed by words that mean the same.

In addition to linking words with synonyms, authors can also use the context clue strategy of contrasting words as a way to help students define unknown words. “It wasn’t a Conestoga like Pa’s folks came in. Instead it was just an old farm wagon drawn by one tired horse.” (p. 127). Cause and effect is another form of context strategy. The author will encourage the student to infer the meaning of the unknown word based upon the cause and effect relationship established by the author using such signal words as, when, then, and, from here. “The domestication of animals probably began when young animals were caught or strayed into camps. As a result, people enjoyed staying with them and made pets of them” (p. 127).

Latta and Fordham (2007) suggest, however, that the use of context is not the sole strategy for vocabulary development, as it is not always beneficial or even suitable, and cannot possibly address all of the various reading levels among a class. Typically, context is the style used by authors in basal readers, as they use a variety of words to communicate, but not for the
development of teaching meaning (Beck, McKeown, & McCaslin, 1983). Schatz and Baldwin (1986) suggest that context clues are helpful for high frequency words, but for words that are considered “low frequency” and are used sparingly, they do not provide sufficient clues in determining a word’s meaning. They also state that, “Context clues actually inhibit the correct prediction of word meanings just as often as they facilitate them,” (p. 440). They conclude that while context clues work effectively when the target word is redundant and contributes new information to the selection, they probably do not work as effectively or as often as many teachers and educators believe (Schatz & Baldwin).

Furthermore, the more a word impacts the reading selection, or the more it is used, the less likely context clues will help a student to decipher its meaning. Reehm and Long (1996) are in agreement with this idea. They encourage readers to consider the following passage: “To find the answer to a fraction multiplication problem, multiply the numerators to get the new numerator, and multiply the denominators to get the new denominator” (p. 36). They state that if a student does not understand or know the meaning and process operation of the terms numerator, fraction, and multiplication, then the student will struggle with this passage, as it does not offer any context clues to help the student infer what he/she is to do in order to complete the problem.

Schatz and Baldwin (1986) also realize that for many students who are graduating and going into the workforce, magazines and newspapers will be their primary form of literature. They state that if their sole reading strategy in learning and deciphering vocabulary remains using context clues, these students may end up at a loss. They may not be able to decipher the words, and may develop a misunderstanding of meanings, since their use of context will be based on an incorrect inference; thus, they are less likely to retain the words (Schatz & Baldwin).
In their study, Chun and Plass (1996) used a hypermedia application, *Cyberbunch*, having students read a German text containing different types of annotations. A group of 160 second year university students were involved in this study looking to answer three questions. One of the questions pertained to the “effectiveness of annotations with different media types for vocabulary acquisition” (p. 189): assessing the use of pictures, text, and even video, to demonstrate how visuals in combination with technology can be beneficial in helping teachers deliver vocabulary instruction. In their experiments, they had the students first watch a tutorial on the *Cyberbunch* program, then preview a video of the German short story, “Anekdote zur Senkung der Arbeitsmoral,” by Heinrich Boll, to give the students some background knowledge. Next, the students were asked to read the short story on the *Cyberbunch* computer software program, and they were given the chance to look up the 82 annotated words by freely selecting any of the different annotations available (text only, text and pictures, video). As the students read, the program recorded their actions in user logs of behavior data, as Chun and Plass were curious to see the number and type of annotations the students chose. After one-to-two weeks, they found through vocabulary testing that their results showed a “significant difference between scores for words that had picture + text annotations and for words with only text definitions or with video and text glosses,” (Chun & Plass, p. 189). The correctness rate for answers produced via words with picture + word annotations was 31.2%. Video and word annotations produced a 23.0% correct rate, whereas the correct answers for words with text-only resulted in 17.9% correct.

According to Beck, McCaslin, and McKeown (1980), it takes an “extended series of fairly intensive exposures [to a word]…before it can be quickly accessed and applied in appropriate contexts” (p. 8). Furthermore, as Baumann, Kame’enui, and Ash (2003) suggest,
students learn words in segments or degrees, understanding words through different types of knowledge and in different forms. They state that using context clues alone is “relatively ineffective for inferring the meanings of specific words,” and that the use of semantics and mnemonics were actually more preferable (Baumann, Kame’enui & Ash, p. 774). According to the authors of Vocabulary Cartoons (2007), a mnemonic is a “Device that helps you remember something by associating what you are trying to remember with something you already know” (p.25) They also state, “Memory experts agree that mnemonics are the surest, fastest, and easiest way to remember names places, events, words and anything else you want to remember” (Burchers, 2007, p. 9). When students rely solely on the use of contextual clues, they tend to learn the unknown words superficially and only for a short duration, causing them to later make mistakes about the words’ meanings in future references. Thus, there is a need for students to learn new words, not by context alone, but through multiple strategies including the use of visuals, such as comics. Students can then learn these unknown words thoroughly and not just for the duration of the unit or school year. As stated earlier, students can make these new words their own and associate with their meanings more quickly (Johnson & Johnson, n.d.).

Using Comics as a Form of Visual Representation in Addition to Context

When students learn and develop meanings for vocabulary words, this is best obtained through multiple and varied encounters with the words, a reason that context alone is not sufficient in helping students. As stated before by theorists such as Gardner (1999) and Vygotsky (Wood. & Wood. 1996), among others, students learn in a wide variety of styles; thus, learning vocabulary through the words and sentences around a specific word may not be concrete enough to be helpful. According to Cunningham (2009), vocabulary has to be “an all day, every day, pervasive part of the curriculum” (p. 10). The International Reading Association (2000)
found that if the goal is to make a difference and to inspire growth in the classroom, teaching has to be different, too. They state that comics are one way to achieve this goal.

Furthering this idea, Cunningham (2009), asserts that vocabulary is also best learned when it is based on definitive and substantial experiences. According to Cunningham, “Children can solidify their vocabulary knowledge by creating drawings and other visuals to illustrate the concept.” (p. 104). Visuals such as comics are just one of the many examples of adhering to Cunningham’s recommendation. In fact, the use of visual representation is effective, as it allows students to solidify their vocabulary knowledge through opportunities for viewing and illustrating concepts, unlike learning words through context alone and writing them in sentences for rote memorization (Cunningham). These activities can be de-motivating and ineffective. With a visual representation, students have a tool to help them associate and retain the word, in addition to differentiating it from other similar words such as homophones. Regardless of which type of word is being studied (verb, adjective, or noun), visuals “provide a rich and engaging introduction to new words” (Cunningham, p. 10).

According to Morris, Merritt, Fairclough, Birrell, and Howitt (2007), concept cartoons, a form of comics, can be effective in the teaching and learning of science in early childhood. Developed by Keogh and Naylor, “Concept cartoons are a highly visual and stimulating approach to science teaching and learning. They use a cartoon-style format to represent a discussion or argument between various children presented in the cartoon,” (Morris, et al., p. 42).

In using this form of visual representation, students are encouraged to consider the views and terms being discussed and to decide which view they support or how they will encode the information being presented. Where context alone can overwhelm and confuse students, concept cartoons use a minimal amount of text, and often rely on using the dialogue form, making the
concepts easier to comprehend for those with limited literacy skills. In addition to making the content more accessible, concept cartoons also use “visually appealing” (Morris, et al., p. 42) pictures in presenting the information, grabbing the students’ attentions and providing a stimulus for discussion. The cartoons keep students motivated and engaged in the lessons.

In connection to this, Gene Yang, a high school teacher and cartoonist (2003), states, “In the struggle to engage students of all learning dispositions, comics can prove to be a formidable tool,” (2003). Yang also believes in the “educational potential of the comics medium,” believing that comics offer five strengths that can improve and benefit any subject at any grade level, and claiming, “Many teachers have already done so with much success,” (Conclusion para 1). He identifies motivation, visualization, permanence, intermediary potential and popularity as assets delivered by comics.

Motivation is a key component to getting students to focus and learn vocabulary, and this is one of the most frequently-mentioned assets comics provide (Yang, 2003). In an experiment conducted by Katherine Hutchinson in 1949, she found that 74% of the teachers surveyed found comics to be helpful for motivation, and 79% of the teachers responded that the use of comics actually produced an increase in student participation (p.244). Hutchinson (1944) developed a curriculum focused on the comic, *Puck-The Comic Weekly*, in which a weekly newsletter and manual were sent to those participating teachers across the country giving the teachers ideas on how to implement the comic into their curriculum. Teachers found that those students who struggled to understand the content material were often unmotivated, as the materials provided to them were typically childish and not of their interest. However, the comics proved to be a resource in this matter, as the language was written in a simplistic form, but the content and action were more mature and interesting, which led to an increase in attention and motivation
from the students. With the increase in motivation from the use of comics came the growth in understanding the content material (1949). In Hutchinson’s study, she looked at the content areas of literature, social studies, geography, and science vocabulary, but this same affect of motivation can also be applied to math.

Comics are also seen as a fundamentally visual medium, according to Yang (2003). In a study conducted by W. W. D. Sones in 1944, in comparing comics to texts, he found that visuals and their quality actually increase learning. In the study, he divided 400 sixth-through-ninth-grade students into two groups. He presented a story in comics with both pictures and text to the first group, as they were the treatment group, but presented the story using only text to the second group, the control group. Both groups were then given the same test assessing the content of the story. The following week he reversed the process by having the first group (the treatment group) be the control group and the second group (formally the control group) be the treatment group, and again both groups were assessed. In his results, Sones concluded, “A strong trend in favor of the picture continuity was indicated by the two sets of results,” (p. 238), indicating this proved effective for those students of the low and middle ability levels.

In addition to being visuals, comics offer the benefit of permanence. Where movies and even music control how fast the viewing is progressed, comics allow for the reader to decide this. Students who process more slowly can take their time reading the comics and not be rushed in their level of understanding by the next scene or dialogue, as is the case in movies and music media. In his book, Understanding the Comics: The Invisible Art (1993), McCloud associates “time and space as one in the same” in the world of comics (p. 100), as time only progresses by the rate at which the reader moves his or her eyes across the panels. The information from this “visual permanence” (Yang, 2003), is gleaned at the account and control of the student.
Thirdly, comics can act as an intermediary, in that they can serve as a go-between or connector to difficult concepts and ideas. As previously stated in Hutchinson’s 1949 experiment, teachers found comics to be helpful for those students who were below level and struggling, as the language was easy for them to decode and understand, but it was also at their interest levels, thus bridging the gap between confusion or loss of interest and engagement with an understanding of the content. Additionally, in their intermediary function, teachers can use comics beyond just the language arts curriculum, as other visuals such as concept cartoons have been used in science and social studies. On his website, Yang references Jay Hosler’s *Sandwalk Adventures* (2003), a comic book focused on the topic of evolutionary biology, and *Maus* (1986), a historical comic by Art Spiegelman as a biography about his Polish-Jewish father who was a Holocaust survivor as two examples of comics being used in science and history. While no specific comic books have been developed for the subject area of math, several popular comic strips such as *Zits* by Jerry Scott (2011) and Jim Borgman, and *FoxTrot* by Bill Amend (2012) have printed strips on this content area.

Furthermore, and probably the easiest to see, is the popularity that comics hold. Yang (2003) states, “The inclusion of popular media (like that of comics) promotes media literacy,” (Strengths of Comics in Education: Popular, para 1). If students are attracted to this form of pictures and text, reading comics both in and outside of school for leisurely purposes, they will more than likely be apt to read them for educational purposes, too. Versaci (2001) uses comics in nearly all of his composition and literature classes. Before he introduces them, he is amazed that as each time he asks his students if anyone has ever read a comic before, nearly every student raises his or her hand. He states, “As youths, we probably weren’t given comic books by our teachers or parents; instead, we sought these out on our own and found value in them” (p.
63), and as students grow into adulthood similar to that of the act of climbing trees is an idea for kids, adults tend to find the idea of reading comics to be just the same, an activity for kids.

However, he believes adults’ perspective of comics is inaccurate, especially with today’s growing interest in graphic novels or “long comic books” (p. 63), as these can provide a mature and engaging approach to multiple topics and contents. Thus, popularity due to their motivating, visual, permanent, and multimedia characteristics demonstrate that comics can prove to be quite effective, especially in regard to education.

Comics in Math Vocabulary Instruction

With the successful use of concept cartoons in science, as presented in the three different case studies in Morris et. al’s (2007) article, concept cartoons have been applied as visual aids to learning vocabulary in other contents, one being math. Math is a complex content area on its own, but in some cases with the addition of humor, students are more likely to experience less stress and more success with the topics and terminology. As Cunningham (2009) states, “All children enjoy jokes, even the corny ones” (p. 185), and using humor, for example in jokes and even comics, will promote and increase students’ motivation and attitude toward words and terminology. By definition, “Comics are understood as narratives told by a sequence of pictures, with the dialogue of the characters incorporated into the pictures in the form of speech balloons” (Harvey, 1996, p. 3). In the most basic of terms, comics are simply a mixture of both pictures and words, as each helps support the other.

To Cunningham (2009), “Jokes are everywhere” (p. 185), and the same holds true for mathematics…, thus the benefits of using humor, particularly in the comic form. In concurrence with this, Halpern and Halpern (2005-2006) believe connecting literature in the form of pictures with math is not only beneficial to students’ math learning, but it can serve as a form of
motivation, as well. In their study, Halpern and Halpern noted that students in the ninth grade enjoyed the stories and illustrations used in the classroom. They were better able to make connections with the story, learn, and more importantly, remember the vocabulary. In creating assignments in which students were to create comic-like stories, the researchers found that students were also able to observe mathematics in everyday living and recognize the pertinence of using terminology effectively. For example, when a student drew an inaccurate picture for a term, or the term did not correctly represent the illustration, they were able to recognize this and explain why the story/term was confusing and how to correct it.

Comics can also be defined as “a text structure with a story to tell” (McVicker, 2007, p. 85). These strips can incorporate both visuals and text, offering teachers a tool to use in helping students develop their visual literacy skills, an imperative component in vocabulary instruction. Similar to reading a story, using comics in math requires students to comprehend the intended communication. As they simultaneously increase multiple literacy abilities, including visual literacy, comics can also be used to relate concepts to everyday life. This is key, according to McVicker, as students will retain information when vocabulary is more relevant to them.

Struggling readers do not view word problems in math with much enthusiasm or confidence. However, when using comics in math, students’ visual literacy and comprehension can be impacted, as comics offer a visual element to understanding words students may not have otherwise known, or may have forgotten quickly, (McVicker, 2007).

Additionally, with multiple schools experiencing budget cuts in regard to supplies and tools for the classroom, comics are beneficial in that they are readily accessible and, for the most part, free to use. Furthermore, comics are more student-friendly in that they do not overwhelm
students, especially with content-rich material that can often be a part of vocabulary study. By learning through the use of comics as one means of visual instruction, students will have an extra support in understanding and retaining vocabulary terms, especially in math content, where new terms are presented rapidly and learning via context is not always sufficient (McVicker).

Summary

Studies have shown the pertinence of vocabulary in core academic areas such as language arts and mathematics. Context and visual representation can offer extra support that enables students to grasp an unfamiliar word’s meaning. Howard Gardner recognized eight different types of intelligences, and Lev Vygotsky focused on teaching students using the method of scaffolding to help them reach their level of proximal development. The use of the VARK model has also been designated as practical in that it addresses the different styles of learning: visual, auditory, reading/writing, and kinesthetic, helping to make tasks such as vocabulary instruction more concrete and effective.

Vocabulary instruction has been a classroom focus for years, as teachers believe it is imperative to learning content material. It is best learned through direct instruction in the classroom and at home. Language development is critical for students if they are to experience success in their everyday academics and life outside of school. Furthermore, the need for vocabulary instruction applies itself to the math content, as this content area has various terms with multiple meanings.

To teach vocabulary in mathematics, teachers have used different strategies such as visual aids, using the word in a sentence, and having students learn the terms by writing down definitions. While each strategy is unique, just as each student is, some strategies are more effective when combined, in particular the use of context skills and visuals when teaching
vocabulary. For example, in his book, *Vocabulary Cartoons*, by Sam Burchers (2007), he helps students to develop and grow in their vocabulary by providing word associations and visual images that make learning new words easy and entertaining. In using his book, on average students in Southwest Florida in 1996 and 1995 who took independent school tests were found to know 72% more words than those students who used the remote memorization process of context strategies alone. These same students using the *Vocabulary Cartoons* also performed better in the area of retention than the later group, and were more likely to continue using the words in their general studies. While the use of context clues has been debated as being both effective and inefficient, combining it with visuals such as comics has been found to be beneficial. Students are able to create a concrete association with the word, and with the use of humor in comics, students can also remain engaged in the lesson.

Overall, vocabulary is everywhere, and as educators, it is imperative that vocabulary instruction be effective and efficient, but with current budget cuts and multi-level classrooms, this can be a difficult task. However, by incorporating the use of visualizations in the form of comics in the math classroom, topics that were once difficult and confusing can now be more student-friendly and retainable, allowing students to learn and grow, developing into critical thinkers in both reading and math.
CHAPTER III. METHODS AND PROCEDURES

Vocabulary is a pertinent component to all content areas, as each subject area has its own unique set of words with various meanings. Students need to learn these words to communicate and to comprehend information in that particular subject. This is especially true in math, as Fitzgerald (2006) points out, “Knowing the vocabulary of mathematics is having the power to unlock the problems” (p. 1). To be proficient in math, students need to know what the problem is asking, in other words to understand the vocabulary being used and, from there, decide what strategy to use to solve the problem.

Traditionally, the direct instruction of teaching vocabulary terms using context clues has been used, and can be helpful, but as Greenwood (2002) states, is not always sufficient. Using context clues alone and committing definitions to memory leads, at most, to an artificial, weak understanding and rapid forgetting of words (McKeown, 1993). Definitions do not always contain enough information, which is why the use of visuals in addition to using context strategies is more beneficial in helping students to gain a deeper understanding and longer retention of mathematics vocabulary. More specifically, using comic strips as a visual to help define and teach the vocabulary should enhance and extend the text communication. Comics also attract and engage the students’ interest. Additionally, the use of comics provides a visual representation to connect with the term, something students can use to recognize the terms in future lessons and use of the words (McVicker, 2007).

Thus the purpose of this study was to answer the questions: Is teaching mathematical vocabulary using context clues with visual representations such as comics more effective than teaching vocabulary with context alone? And which method do the students prefer? In this chapter, the methods, including the design of research, the description of the participants, and the
instruments used are described and justified. The procedure is explained, with details of how
data were collected and the instruments used to accomplish this.

Methods

Research Design

In an attempt to answer the question of whether using visuals in addition to context
strategies is more effective than using context strategies alone to teach mathematics vocabulary,
this study used a quasi-experimental design. It included a knowledge survey prior to vocabulary
lessons and a post-test for two groups of students who each represented the control and
experimental groups. It focused on the use of both qualitative and quantitative data, as both
would not produce sufficient results independently.

Qualitative data are a form of subjective descriptions, often using words, images, and
categories. In this study, the qualitative data were generated from the student surveys during the
knowledge survey and two post-tests. However, according to Creswell and Plano Clark (2007),
in being used alone, qualitative data can be “seen as deficient because of the personal
interpretations made by the researcher, the ensuing bias created by this, and the difficulty in
generalizing findings to a large group because of the limited number of participants studied”
(p. 9).

As such, quantitative data were also generated. Quantitative data are numerical
descriptions consisting of values (Burke & Christensen, 2012). For this study, the quantitative
data analyzed consisted of the number of students participating, the number of words tallied
within each of the three categories on the Knowledge Rating Scale, the number of
correct/incorrect subjective answers on both post tests, and the percentages gleaned from the
students’ tests. Again, however, looking at quantitative data results alone was not sufficient.
Quantitative data is thought to be “weak in understanding the context or setting in which people talk,” (Cress & Plano Clark, p. 9). Therefore, focusing on this numerical information alone would leave future educators without a true understanding of the effects and outcomes of this study. It is also argued that the direct opinions and responses of the subjects are not heard, nor are the interpretations of the researchers considered, thus making the study less personal.

Despite having weaknesses in being used independently, by considering and analyzing both qualitative and quantitative data in the form of a mixed method research, these weaknesses are then offset, making the data collected more applicable. Furthermore, as Cress and Plano Clark (2007) clarify, “Individuals tend to solve problems using both numbers and words, they combine inductive and deductive thinking…” (p. 10), hence, the basis for quasi-experimental research. For this study, using solely qualitative data or quantitative data did not produce ideal evidence in answering the questions at hand, as focusing on either the students’ survey responses or their post-test percentages alone was not a natural representation of communicating and interpreting the results.

As a quasi-experimental research design, this study specifically focused on the techniques of action research. Action research is a positive form of research that is a never-ending process, as no problem is ever solved in one sole study. This is especially true in education, with so many different learning styles in the classroom, as pointed out by Gardner (1999) in Chapter II of this study. Action research is centered on solving a specific problem in which the local practitioner uses a local setting to design and conduct a research study (Burke & Christensen, 2012).

For this specific study and form of action research, two sixth grade classrooms at a local rural junior high school were utilized, making it a convenience sample. A convenience sample is a form of action research in which the researcher includes people who are available and can be
easily recruited to be included in the sample (Burke & Christensen, 2012). In many cases, researchers choose this form of sampling due to “practical constraints” (Burke & Christensen, p. 230), such as time, money, or lack of available subjects. Specifically for this study, the practical constraints consisted of limited time, money, protocol of school codes, and ethical regulations in working with minors, thus the need for convenience.

Furthermore, action research also requires a positive state of mind toward research, as the studies are often ongoing. In addition, action research requires teachers and professionals to apply their findings and to learn from their attempts as they adjust the studies to accommodate the different learning styles in their classrooms. For this study, the comparison of using the traditional style of context strategies alone to the use of context strategies with the addition of comics as a form of visual representation, and the idea of the latter being a more beneficial way to learn mathematics vocabulary, was assessed. While one outcome was favored more, it was most productive to keep a positive and open mind, especially when working with young adolescents who already present a struggle with terminology in math. The results gleaned from this study will be relayed to the educational community as a way to share information in mathematical vocabulary instruction.

Participants

The participants of this study were 48 sixth grade students from a local rural junior high school located in the northwest area of Ohio. For the 2010-2011 school year, the school district received the designation of “excellent” out of six possible designations (excellent with distinction, excellent, effective, continuous improvement, academic watch, or academic emergency), and met 25 out of 26 state indicators as determined by the state of Ohio. In the sixth grade, 79.6% performed at and above the “proficient level” in the area of math. This was a
decrease in performance from the 88.1% received in the prior year of testing, which caused the school district to fall below expected growth in the area of math (Ohio Department of Education, 2010).

The school population consisted of approximately 360 students spanning grades 6-9, with 130 currently in the sixth grade. Thirty-seven teachers are employed at this junior high school, with five teaching sixth grade. The mathematics teacher for the sixth grade had taught at this junior high for eight years, but had taught for a total of 11 years. She had taught math for 10 of these years and was licensed by the state of Ohio to teach grades one through eight. At the time of this study, she was using the Everyday Mathematics program in her classroom, for which she had 45 minutes per period, every day of the five-day school week, to implement mathematics instruction. When asked how she taught her students mathematics vocabulary in her classroom, she said she had the students learn vocabulary through memorization strategies, such as writing the words and definitions down in their math journals and having frequent quizzes on the terms. She also played games with them such as “I Have, Who Has?” to help her students stay engaged with the vocabulary, in addition to practicing using the terms.

Upon receiving the initial approval from the Human Subjects Review Board (see Appendix A) and consent from the school (see Appendix B), the researcher went forward with conducting this study. The participants for this study were sixth grade students who ranged in age from 11 - 12 years old, and consisted of both females and males chosen from two of the five total classes taught by the math teacher. All students were accepted to participate upon receiving the approval of both their parent/guardians (see Appendix C) and their own willingness to participate (see Appendix D). In addition, letters of approval were given to the school’s principal (see Appendix E) and to the math classroom teacher, along with the sixth grade team of
teachers whose classes were involved (see Appendix F), as this was protocol when working with minors under the age of 18, and in a public school district. This meant that all students, without regard to their academic capabilities (below average, average, above average) or classifications (I.E.P., 504 plan, advanced/accelerated, or physically disabled) were considered and analyzed in the study’s results. Furthermore, economic status, ethnicity, and gender were not of concern in participating in the study, nor did they have an effect on data analysis.

The number of students initially asked to participate in this study was chosen from two classrooms taught by the same math teacher. Initially, 50 students, with 25 from each class, were invited to participate, but due to unanticipated parental approval rates, educational ethics, and personal choice, the expected final participation count was less. As this was a convenience sample, the students for this study were chosen based on the researcher’s former interactions with the school district in past educational experiences. However, no interactions were held with the participating students involved prior to this study.

**Instrumentation**

Several forms of instrumentation were used to successfully conduct this study.

*Knowledge Rating Scale*

A researcher-generated list of 30 math vocabulary words that fall under the benchmarks and indicators of topics to be taught at the sixth grade level were composed to assess students’ prior knowledge. This word list was distributed in the form of a Knowledge Rating Scale/survey given prior to the vocabulary lessons. The Knowledge Rating Scale (see Appendix G) was administered to all participating students who turned in both the consent and assent forms. This scale consisted of a three-column chart in which students placed a check mark in a one of the three columns: “I know this word and understand it,” “I have heard of this word, but am not too
sure what it means,” and “I have never heard or understood this word” for each of the 30 vocabulary words. The Knowledge Rating Scale also included one open-ended survey question inquiring as to what the students personally believed would help them to better learn their math vocabulary (see Appendix G).

**Comic Strips Sets A and B**

For this particular study, comics were used as the form of visual representation for the 10 vocabulary words selected. These comics were developed and created by the conductor of this study using the website Bitstrips for Schools (Bitstrips Inc., 2011). Two different sets of comics were developed, each focusing on five of the ten vocabulary words learned per lesson. The first set of comics, “Comic Set A,” consisted of five different comic strips, a strip for each of the five words: volume, area, histogram, symmetry, and coordinate (see Appendix H). The second set of comics, “Comic Set B,” also consisted of five different comic strips, a strip for each of the second set of five vocabulary words: proportion, product, reciprocal, equation, and summation (see Appendix I). Each comic strip included a number of cells containing images with text using the vocabulary term in a sentence and listing the word’s formal definition. The strips were printed in color and distributed to all students regardless of whether they were in the treatment or control groups, with the control groups receiving the comics at the conclusion of each lesson. Forty-eight sets of comics A and B were distributed.

**Context Strategies Sets A and B**

The control groups for each lesson received their vocabulary instruction using only context strategies. For each lesson, Lesson A1 and Lesson B2, the words were defined in a Word document (see Appendix J and K) uploaded on the classroom SMART Board. Each of the five words contained a formal definition derived from Fitzgerald’s text, *Math Dictionary for*
Kids (2006), followed by an example using mathematical symbols. The students were asked to copy down each term’s definition on an index card.

Lesson Plans

The next materials used in this study were two sets of lesson plans. The lesson plans supported using the Common Core State Standards for the English Language Arts and Math at the sixth grade level. The procedures for each lesson were established beginning with a one-two minute engagement, 30 minutes of direct instruction, and concluding with a one–two-minute closure. The first set of lesson plans was denoted as “A1 & A2” (see Appendix J) and focused on the first of five vocabulary terms to be taught to both classes. “A1” focused on teaching the students the vocabulary using context strategies only and was classified as the control group. “A2” focused on teaching the students the vocabulary using context strategies and pre-created comic strips as visuals, and was classified as the experimental group.

The second set of lesson plans were denoted as “B1 & B2” (see Appendix K) and focused on the second set of five vocabulary words to be taught to the students. “B1” focused on teaching the students the vocabulary using context strategies and pre-created comic strips as visuals. This lesson was taught to the same class who previously learned the first set of words from “A1” and was previously the control group. For this second lesson, they were the treatment group. “B2” focused on teaching the students the vocabulary using context strategies only. This lesson was taught to the same class who had previously learned the first set of words from “A2” and was previously the experimental group. For this second lesson, they served as the control group. Each set of lesson plans also included the materials needed for each control and treatment group.
Post-test/Survey

Following each lesson, both classes completed a post-test assessing them on the set of five vocabulary terms. After the first lesson, both the control group (A1) and the treatment group (A2) took Post Test A (see Appendix L). Both classes received the same version of the test. After the second lesson, both the control group (B2) and the treatment group (B1) took Post Test B (see Appendix M). Again both classes received the same version of the test. Both post test A and post test B consisted of five multiple choice questions pertaining to the five vocabulary words focused on for that particular lesson. Post test A also had three survey-type questions. The first two questions asked the students for a subjective “yes” or “no” answer and for an objective explanation. The third question was objective. Post test B had four survey-type questions following the multiple choice questions. The first three questions asked the students for a subjective “yes” or “no” answer and to provide an explanation. The fourth question was objective. Forty-eight tests were administered prior to the lessons being taught.

Procedures

To conduct this study, several procedures were followed. First, approval from the Human Subjects Board of Research (HSRB) was requested (see Appendix A). Upon receiving this, letters of approval, assent, and consent were sent to the junior high principal, the selected sixth grade teachers, the students in the two selected math classes, and their parents/guardians (see Appendices C and E-F). Even though the math teacher was the main and only teacher truly involved with the study, it was still important to include the homeroom teachers of both classes in the study to keep them informed of the study and its purpose. Furthermore, letters of approval were also sent home with the students to their parents and/or guardians asking for their permission for their child to participate in this study (see Appendices C and D). During the
researcher’s initial visit to the school, the Student Assent (see Appendix D) and Parent Consent forms (see Appendix C) were distributed to the students. Due to the main participants being under the age of 18, and this being a requirement when working with minors, it was necessary to send a letter home to the parents. The letters were hand-delivered to the school by the researcher, with the exception of the parent/guardian letters being taken home and returned to the school by the students. Both forms were read aloud to the students explaining the researcher’s purpose and procedure for this study. The need for their assent and parental consent was also explained. Students were told that their grades would not be affected whether they participated or not, and they were allowed to withdraw from the study at any time. The students were then given the opportunity to ask questions.

The initial portion of this study began with a Knowledge Rating Scale and a short response survey question (see Appendix G). Both were administered to both classes involved in the study. The Knowledge Rating Scale was constructed to be similar to a Know-Want to Know-Learned (KWL) style chart created by Donna Ogle in 1986. This occurred one day during each of the selected classes’ 45- minute math periods. The researcher read the directions aloud to the students and reviewed the example included. The Knowledge Rating Scale asked the students to place a check mark in the respective categories of “I know this word and understand it,” “I have heard of this word but am not too sure what it means,” or “I have never heard of this word or understand it.” The list of 30 math terms was developed and selected from the sixth grade math Common Core State Standards for Mathematics (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). Students completed the Knowledge Rating Scale at their leisure and turned in both this and their signed
assent forms. They were asked to return their Parental Consent forms to their teachers by the following week for the researcher to collect.

Following administration, the Knowledge Rating Scales and survey responses were then analyzed. The researcher split the top 10 words placed in the last column, “I have never heard of this word or understood it” into two groups of five words to be used in two vocabulary lessons. In selecting these words, two sets of handouts (one for each set of five vocabulary words) consisting entirely of context strategies were created (see Appendices N and O), in addition to two sets of handouts consisting of context strategies with corresponding researcher-created comic strips (see Appendices I and L) as visuals. One of these lessons involved one set of five words being taught to one class using context strategies alone, while being taught to the other class using context strategies with comics as visuals (see Appendices H and I).

The following week, the first set of lessons and post-tests were administered. Those students who had turned in their Student Assent (see Appendix D) and Parent Consent Forms (see Appendix C) were eligible to complete the study. The first lesson was taught third period from 9:21 A.M. until 10:04 A.M. to 19 students, using Lesson Plan A1 (Appendix J): learning the vocabulary words using only context strategies. The remaining students went with the math teacher to the library to work on makeup work in their math textbooks. This class was designated as the control group for this study. The researcher first read aloud to students the five vocabulary words: volume, area, histogram, coordinate, and symmetry. Next, the words and their correlating definitions, as defined by Fitzgerald (2006) in Math Dictionary for Kids, were displayed in a Word document labeled Context Set A (see Appendix N) on the SMART Board. The researcher read each word’s definition aloud to the students and provided a verbal example with each term. Students were asked if they had any questions or confusion over the words’
definitions. They then received five index cards and were asked to write each word and its
definition on one of the cards. (How the students chose to write the terms on the note cards--term
on one side of the card and definition on the other, or both on the same side--was not considered
for this study). When the class was finished, they were asked to spend a few minutes reading the
five words and definitions to themselves.

Next, the researcher asked the students to turn to their elbow partners and to practice the
words together. An allotted time of ten - twelve minutes was designated for this portion of the
lesson. Following this, students were then asked to put their index cards away and to clear their
desks as Post-test A (see Appendix L) was distributed. Again, the researcher read the directions
aloud to the students before beginning the assessment. As the students completed the
assessment, the researcher collected them and with the remaining time, a math game, “I Have,
Who Has?” was played as a class.

Following third period was fourth period, from 10:04 A.M. until 10:58 A.M., and 18
students were eligible to participate in the study. The remaining students again went with the
math teacher to the library to work on makeup work in their math texts. The researcher taught
the first set of five vocabulary words, volume, area, histogram, coordinate, and symmetry, as
defined by Fitzgerald (2006) in Math Dictionary for Kids, using Lesson Plan A2 (see Appendix
J), learning the vocabulary with context strategies and comics as a form of visual representation.
This class was considered the treatment group.

Again, the words were read aloud to the students before they were given the set of comic
strips denoted as Comic Set A (see Appendix H). Once the students had the comics in front of
them, the researcher read each word and its corresponding definition aloud and discussed it with
students. The connection between the comic’s main idea and the vocabulary word as a form of a
visual were addressed. Students were then asked to take a few minutes to look over the comics and vocabulary by themselves before turning to their elbow partners to practice learning the words. After 10-12 minutes, the students were asked to clear their desks with the exception of a pencil. Post-test A (see Appendix L) was then administered and, again, the researcher collected their assessments as students completed them. Time also remained at the end of this class, during which the “I Have, Who Has” game was also played.

During the third week in the schools, the researcher administered the second set of lesson plans and post-tests (see Appendices K and M). These lessons centered on the second set of five vocabulary terms: proportion, product, reciprocal, equation, and summation. These words’ definitions were also based on Fitzgerald’s (2006) in *Math Dictionary for Kids*. The first class, third period, was now considered the treatment group as they learned the words using Lesson Plan B2 (see Appendix K), using context strategies with comics as a form of visual representation. Nineteen students were again present for the lesson, and the remaining students returned to the library with the math teacher for more makeup lessons in their textbooks.

Again, the researcher read the words aloud to the students before they were given the set of comic strips denoted as Comic Set B (see Appendix I). Each word and its corresponding definition was read aloud and discussed. The connection between the comic’s main idea and the vocabulary word were addressed. Students were then asked to take a few minutes to look over the comics and vocabulary by themselves before turning to their elbow partners to practice learning the words. After 10-12 minutes, the students were asked to clear their desks, with the exception of a pencil. Post Test B (see Appendix M) was administered and, again, the researcher collected the assessments as students finished. Time also remained at the end of this class, during which the “I Have, Who Has?” game was played.
The following period was fourth, and for this session the class served as the control group, learning the second set of vocabulary words: *proportion, product, reciprocal, equation,* and *summation* using context strategies only according to Lesson Plan B1 (see Appendix K). Seventeen of the 18 original students were present, making one student exempt from the entire study. Those remaining students returned to the library to continue makeup work with the math teacher.

The researcher first read aloud the five vocabulary words: *proportion, product, reciprocal, equation,* and *summation,* Next, the words and their correlating definitions, as defined by Fitzgerald (2006) in *Math Dictionary for Kids,* were displayed in a Word document labeled “Context Set B” (see Appendix O) on the SMART Board. The researcher read each word’s definition aloud to the students, along with discussing a verbal example for each word. Students were asked if they had any questions or confusion over the words’ definitions. Students then received five index cards and were asked to write the word and its definition on the card. (How the students chose to write the term on the index card--term on one side of the card and definition on the other, or both on the same side--was not considered for this study). When the class was finished, the researcher asked them to spend a few minutes reading the five words and definitions to themselves. Next, the students were asked to turn to their elbow-partners and to practice the words together. An allotted time of 10-12 minutes was designated for this portion of the lesson. Following this, the researcher asked students to put their index cards away and to clear their desks, and Post-test B (see Appendix M) was distributed. Again, the researcher read aloud the directions to the students before beginning the assessment. The researcher collected the assessments as students completed them. With the time remaining, the math game “I Have, Who Has?” was played as a class.
The data collected from each of the post-tests for both classes were analyzed and examined. The data from any students who were not present for both of the lessons were discarded. The remaining data were then organized based on the qualitative and quantitative data analysis. When the data had been transcribed and documented, then the primary question of this study could be answered. The overall findings of this study with no recognition or acknowledgement of the students’ identities were shared with the classroom teacher and presented to the educational community.

Data Collection

Several forms of data were collected for the duration of this study. The initial data collected were the pre-tests containing the Knowledge Rating Scales, in which students placed the 30 listed vocabulary words (determined based on sixth grade Common Core Standards and benchmarks) in one of three designated columns and responded to one survey question. The data collected from these pre-tests allowed the researcher to select the 10 words to be used for the vocabulary lessons (five vocabulary terms were chosen per lesson). The survey question helped the researcher to understand how the students were taught vocabulary in the past, how well they comprehended mathematics vocabulary, and whether they had used comics or other visuals as a way to learn vocabulary prior to this study.

The next set of pertinent data collected during this study came from the post-assessments consisting of multiple choice and short-answer survey questions. A series of post-tests were administered after the researcher taught each lesson covering each set of five vocabulary words. Thus, an overall total of four post-tests were administered, with each class completing a total of two post-tests used as data analyzed for this study. The post-tests distributed to the students asked them to circle their answers for the multiple choice questions and hand-write their short
answers for the survey questions. The multiple choice questions asked the students to read a sentence that defined one of the five vocabulary words used in the lesson and to choose the best answer among the words selected. For the survey questions, students were asked to describe how they felt about the lesson and if they felt they learned the vocabulary words or would another method have helped them more.

Data Analysis

For this study, several different data components were collected and analyzed. As quasi-experiment research, the data collected were both quantitative and qualitative in nature. Furthermore, as the subjects were minors, their names and assessment information was kept confidential; only the researcher and committee overseeing and advising this study knew their names and saw their handwritten tests. For the quantitative forms, the data analyzed came from the two sets of post-tests (see Appendices K and N) conducted after each lesson of five vocabulary words taught to each class. Percentages calculated from the correct multiple choice questions on each of the students’ post-tests from both of the lessons were compared and analyzed to demonstrate which strategy (context alone or context with comics as a visual) was more beneficial to the students learning of the vocabulary. A t-test of independent samples comparing the control group (learning vocabulary with only context strategies) to the treatment group (learning vocabulary with context clues and comics as visual representations) was developed using the information gleaned from the students’ percentages earned on their post-test results from the multiple choice questions. The t-test allowed for the sample (students’ performance on each post-test from each experiment) to be compared to the null, learning vocabulary through context strategies alone (also known as the control group) by using the sample standard deviation. This again demonstrated the comparison between the different
lessons and how the students performed in each. It also contributed to answering the primary questions for this study: Does using context strategies in addition to comics as visuals help students learn and retain mathematics vocabulary better than teaching solely using context strategies and which method do the students prefer?

The qualitative data included the students’ written responses on both their Knowledge Rating Scale in answering the survey question at the end, and the open-response portion of the post-tests. These data were analyzed, compared, and synthesized. This information was compiled into a written analysis discussing the students’ responses and comparing their responses to their performances on the assessments of the different lessons according to their test results.

Summary

This quasi-experimental research study involved two classrooms from a sixth grade rural junior high school located in northwest Ohio. The study itself focused on the comparison and benefits of using comics as visuals in addition to context strategies versus solely using context strategies when teaching mathematics vocabulary. It involved parents/guardians, principal, student, and teacher approval for the participation of students in two vocabulary lessons (two for each class for a total of four lessons), each being held at a different time. One lesson consisted of teaching five vocabulary words using context strategies alone, and the other lesson pertained to teaching the same five vocabulary words using context strategies in addition to comics as visuals. A week later, this process was repeated using five different words, and each class learned these new words using the opposite form of study from their initial lesson.

Prior to this, a one-day Knowledge Rating Scale consisting of categorizing vocabulary words and answering a short survey question was administered. The information gleaned from
the Knowledge Rating Scale determined the words selected for the two classroom lessons (two sets of five for each class for a total of four lessons), which were conducted over a two-week period. After each set of lessons, students received a post-test consisting of multiple choice and open-response survey questions. The post tests were kept confidential and remained so following the duration of this study. The results were analyzed for quantitative and qualitative data in answering this study’s research question. The data were displayed in a t-test, a graph of students’ performance scores, and a written reflection. Upon analyzing the data, instructional results were also shared with the classroom teacher to increase her awareness of the possibilities in mathematics instruction related to her students’ mathematical vocabulary knowledge.
CHAPTER IV. RESULTS AND DISCUSSION OF RESULTS

As suggested by Cunningham (2009), “Children can solidify their vocabulary knowledge by creating drawings and other visuals to illustrate the concept” (p. 104). The purpose of this study was to assess which method of teaching mathematical vocabulary to students was more effective; using context alone, or using context in conjunction with comics as a form of visual representation. The second purpose of this study was to determine which of these two methods students preferred. The rural junior high school chosen for this study was selected based on convenience, the researcher’s prior experience in working with the school, and on the school’s cooperation. The sixth grade math teacher was chosen for this study based on the researcher’s established relationship with her, as well as her own interest in the study’s results. The math teacher and the homeroom teachers of the two classrooms were approached by the researcher during a team meeting and asked to participate in this study. The homeroom teachers of each classroom were only made aware of the study and asked for permission to use their students, but were not involved with the study in any further way. The math teacher was the only teacher actually involved in the study. The two classes of students were chosen based on convenience of the periods in the math teacher’s schedule and the recommendation from this teacher based on student cooperation and behaviors.

The study was carried out over three consecutive weeks. For each of the two classes, one class period of 45 minutes was devoted to the study. This period of assessment fell in the middle of the second grading period of this junior high’s academic year. Forty-eight total students were accounted for, 24 students in each class. Due to the necessity of student consent and assent forms to participate, their personal reasons (illness, lack of interest, or teacher application of behavior consequences), only 36 students total were involved in the study…19 from the third
period class and 17 from the fourth period class. Student identities, abilities, or academic needs (I.E.P., 504 plans, or other health/behavior needs) were not addressed or considered for this study.

This chapter presents the results for this study. First, inferential results are presented for the research question.

Results

Knowledge Rating Scale

To assess students’ prior knowledge of relevant math terms, the researcher administered a two-section pre-assessment survey to subjects in this study. In Part I of the survey students were given a Knowledge Rating Scale (Blachowicz, 1986) to self-assess their familiarity with researcher-selected math vocabulary. The chart consisted of 30 math terms aligned with the 2011 Common Core Math Standards (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), in which students indicated their knowledge of the terms listed by checking one of three columns for each word on the Knowledge Rating Scale (see Appendix F). The words denoting angles (right, obtuse, scalene, triangles-scalene and isosceles, and mean, median, range, and mode were among the words students checked as “I know this word and understand it.” However, the words volume, area, histogram, symmetry, coordinate, proportion, product, reciprocal, equation, and summation were the top 10 words most ranked in the category, “I have never heard or understood this word,” with histogram being the most frequently checked, followed by the word summation.

Section II of the survey asked students to answer one question, “What do you think will help you to learn math vocabulary for longer periods of time?” A majority of the students
provided responses indicating that flashcards and/or pictures would make learning these words easier, adding that this made it easier to study alone, with relatives, or classmates.

Research Question

To examine the differences in vocabulary learning between the two instructional treatments (context only versus context with comics), two t-tests were conducted. First, a t-test of independent samples was conducted for each experiment (A and B). The results found little difference in scores for either experiment. For experiment A, the Control Group (context only) of 19 students produced a vocabulary post-test mean of 4.58, while the Treatment Group (context with comics) generated a mean score of 4.61. Table 1 presents the means and standard deviations for the groups and treatments. T-test results showed no significant difference between the two groups: t(35) = -0.08, p = .9371, two-tailed. For experiment B, the instructional method was switched for the two classes. The Control group had a mean score of 3.82; the Treatment group generated a mean of 4.42. Although the Treatment group mean was higher than the Control group, this difference was not significant: t(34) = -1.20, p = .2368, two-tailed.
Since both groups experienced the context only (control) and the context with comics (treatment) instruction, a *t*-test of related samples was conducted to examine the treatment differences between the related measures. Means and standard deviations for these measures are presented in Table 2. A total of 36 students completed both methods and assessments. When experiencing the context only instruction, the students generated an overall mean score of 4.22. In contrast, when these students experienced the context with comics instruction, they produced a higher mean score of 4.50. However, *t*-test results indicated no significant difference between the two scores: $t(35)=-1.05$, $p=.2983$, two-tailed.

<table>
<thead>
<tr>
<th></th>
<th>Experiment A</th>
<th>Experiment B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Control: Context only</td>
<td>4.58</td>
<td>1.22</td>
</tr>
<tr>
<td>Treatment: Context and Comics</td>
<td>4.61</td>
<td>1.55</td>
</tr>
</tbody>
</table>

Table 2

Comparison of Overall Control and Treatment Results

<table>
<thead>
<tr>
<th></th>
<th>Control (context only)</th>
<th>Treatment (context and comics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.22</td>
<td>4.50</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.51</td>
<td>1.23</td>
</tr>
</tbody>
</table>
Post-Test Survey Results

In addition to five multiple choice subjective answers, both sets of post-tests included a series of survey questions. The first post-test consisted of two survey questions: “Did you find this form of learning (context, or context strategies with comics as a visual) the vocabulary helpful?” and “Do you think you will remember these words in the future when you come across them in word problems or homework/test problems?” As shown in Table 3, only 68% of the students who learned the first set of vocabulary words using context strategies alone found this method to be helpful, whereas 83% of the students who learned the first set of vocabulary words using context strategies and comics as visuals found this method to be helpful. When asked if they would remember these words in the future, again a higher percentage from the second group who learned the first set of vocabulary words using context strategies and visuals answered “yes,” in comparison to the first group, which learned the vocabulary words using context alone.

Table 3

Group Comparison of Experiment A Post Survey Results

<table>
<thead>
<tr>
<th></th>
<th>Context (n =19)</th>
<th>Context with comics (n = 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1. Did you find this form of learning (context or context strategies with comics as a visual) the vocabulary helpful?</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>2. Do you think you will remember these words in the future when you come across them in word problems or homework/test problems?</td>
<td>15</td>
<td>4</td>
</tr>
</tbody>
</table>
The post survey for Experiment B consisted of three survey questions. The two questions from the previous post-test were again included, in addition to a third question (which was labeled #2 on the post-test; see Appendix M): “If this is the second post-test, please check which method of learning you found to be the MOST helpful.” The group that learned the first set of vocabulary words using context strategies alone (Lesson A1; see Appendix J) and then context strategies with comics the second time (Lesson B2; see Appendix K) found the latter method to be effective by 94%, a 26% difference from the first method with which they learned. The second group, which learned the first set of vocabulary terms using context strategies with comics (Lesson A2; see Appendix J) and the second set of vocabulary terms using solely context strategies (Lesson B1; see Appendix K), found the second lesson’s method to be effective by only 70%. This was a 13% decrease in preference in comparison to their response of 83% finding the vocabulary words by context strategies with comics to be more helpful. (Note: This group was reduced from 18 to 17 due to a student being ill for the second set of lessons).

Question three also posed the same results as in the second test, since the first class found the context strategies and comics method to be 94% more effective, with 18 students saying this method would help them remember these words in the future. Only one student disagreed. The second class had 65%, or 11 of the 17 students, finding the context strategies alone to be more helpful.
Table 4

*Group Comparison of Experiment B Post Survey Results*

<table>
<thead>
<tr>
<th></th>
<th>Context with comics(n =19)</th>
<th>Context(n = 17)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1. Did you find this form of learning (context or context strategies with comics as a visual) the vocabulary helpful?</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>3. Do you think you will remember these words in the future when you come across them in word problems or homework/test problems?</td>
<td>18</td>
<td>1</td>
</tr>
</tbody>
</table>

The additional survey question asked the students (n = 36) after learning vocabulary using both methods to consider which method they found most helpful. Only 10 (27.8%) students preferred the context only method, whereas 26 (72.2%) indicated preference for context with comics. Students gave reasons for the context strategies with comics to be more beneficial because, “I could visually see what the problem looks like,” “The comics are funny, so they helped me to remember the words,” and “I can now have a picture in my mind.” However, some students did state they found the comics to be distracting stating “…the comics were very distracting,” and “weird and creepy.” These students felt their usual form of writing the definition and using just context strategies was still more helpful.
Summary

Although the statistical results indicate that the treatment of context with comics did not generate a significant difference in vocabulary learning when compared to the context only method, survey results indicate that students perform better and prefer the context with comics instructional method.
CHAPTER V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study answered the questions, “Is learning math vocabulary using context strategies with comics as a form of visual representation more effective than learning vocabulary through context alone?” and “Which method do students prefer?” In this chapter, the research study is summarized, as are the conclusions and results of chapter four. Following this, a series of recommendations are offered for other educators and replication of this study.

Summary of Study

The key to success in math is forming a strong conceptual understanding of its terminology. Vocabulary instruction is vital in this particular subject, as it enhances students’ abilities to use a combination of symbols and words to complete or solve a variety of problems. According to Fitzgerald’s Math Dictionary for Kids (2006), one of many keys to being proficient in math is knowing what the problem is asking, in other words, having an idea of what the vocabulary means and being able to determine the best strategy to use in order to solve the problem. A common form of math vocabulary study has been to write the words on note cards or paper using context strategies to define the words. However, math language presents unique challenges in that students do not just read it from left to right, or up and down, and there are more than the 26 symbols of the English alphabet used in mathematical context, which is why context strategies have not always been enough (Schell, 1982). By adding visuals such as comics to learning math vocabulary, it is believed that students will better understand and retain the material.

For this study, 37 of students in a rural North West Ohio junior high school were participants, based on convenience to the researcher. They were given a Knowledge Rating Scale (see Appendix G) during the first visit, on which they categorized 30 math vocabulary
terms into three categories and answered one survey question about how they believed they would best learn math vocabulary words. Following this collection of data, the researcher taught two math lessons (see Appendices J and K) to these students over the course of two weeks, during which they learned five math vocabulary terms using context strategies alone and context strategies with comics as visuals. Both classes of students learned a set of five vocabulary words and took a post-test following each lesson (see Appendices L and M) in which they answered five multiple choice questions and two (the second post-test had three questions) survey questions. Following the completion of the second set of post-tests, results from the data were analyzed.

Conclusions

After conducting this study, the researcher can draw three primary conclusions. First, comics combined with context clues were found to be more effective in teaching mathematical vocabulary than in teaching with context strategies alone as shown by the students’ survey responses. The comics provided a visual connection with the terms under study, allowing for the students to gain a deeper understanding of the word. The use of the comics also provided humor and interest to the students, keeping them engaged in the lesson.

In concurrence with the researcher’s own findings in this study of visuals combined with context being an effective instructional strategy for teaching vocabulary, are several other researcher’s findings. For example, as stated in chapter two, Chun and Plass (1996) found in their study of 160 university students that the students recalled the words presented with pictures and definitions better than those presented with other methods such as words alone or even with words and video (p. 189). In agreement with this are two seminal studies, which were among the first of this nature. Sones’ (1944) own findings from his study demonstrated that there was a
“strong trend in favor of the picture continuity…” (p. 238), in that once both groups had experienced the reading in picture form, they reached “the saturation point” (p. 238), or highest level of understanding. Hutchinson found similar results to this study, as well, in her 1949 study based on the use of comics in the classroom. Teachers who used her comics-based lessons saw the benefits the components of the comics provided to students, such as an increased interest in reading and participation, both of which were also seen in this study, according to the data gleaned from the results. Hutchinson also reported that the “physical form of the comic strip which gives clues in the pictures to the meaning of the printed text, was an aid in assisting poor readers.” (p. 239).

Second, visuals in the form of comics seem to benefit those students who are on I.E.P.s. The first class (19 students from third period) was noted to have more students on behavioral plans and I.E.P.s than the second class (18 students from fourth period), and of these students, 74% felt more confident in their performance and retention of the words, based upon their survey responses. One student in this class stated the lesson with comics made it easier to learn the vocabulary words, “because I can picture the word and what it means faster.” Another student stated, “I am a visual learner and seeing images that go along with the pictures help me to remember them.” However, the number of students on I.E.P.s was not taken into consideration for the lessons and assessments.

Thirdly, the researcher-designed comics in this study may be an important variable. The style, content, and clarity of the comics are likely essential to student understanding. For a majority of students, these comics were helpful and engaging, but for some, the comics were confusing and even distracting. One student claimed “…the comics were very distracting,” and another deemed the comics “weird and creepy,” finding the lesson learning the words with
context strategies alone to be of more value than the lesson taught using context strategies with
comics as visuals. A reason for these responses regarding the comics being confusing and
distracting may lie in some students having developed other forms of metacognitive strategies
when learning vocabulary. For example, some students may already have had preconceived
notions or visions of the words that they felt were more helpful in remembering and learning the
words.

Recommendations

Recommendations for Teachers

Based on both the qualitative and quantitative data collected, the researcher has
suggestions for these students’ classroom teachers as well as for other interested math educators.
It is recommended that the importance of vocabulary be stressed to students. An understanding
of vocabulary in math will allow students to understand the word problems and questions they
encounter, opening doors of confidence and engagement in the lessons. In using visuals,
particularly comics, students will have a visual connection to the words and their meanings that
they will not only recall faster, but also retain, helping them master future math objectives. At
minimum, students find the visuals/comics motivating. This was supported in this study, as
students responded in their second post-tests stating, “The comics and visuals (comics) made me
want to learn,” “The context and visuals (comics) gave me a better idea and helped me to see
what (the word) was,” and “It was fun learning and just the words (learning with only context
strategies) were boring; and “I will remember the words (in the future), because of learning with
the pictures.” Using visuals is also effective, because they address more than just the tactile
learners who benefit in writing the words; they also target the many students who are visual
learners, including those who are on I.E.P.s. Again, students in this study supported this by
stating that the comics with visuals (comics) were more helpful “because I could visually see what the problem looks like,” and “I am more of a visual learner and I sometimes struggle with vocabulary.” Additionally, with the growing interest in graphic novels, students may adapt to using the comics as a form of visual for learning math vocabulary much faster and more willingly, as supported by Hutchinson’s 1949 study, in which 74% of teachers reported comics being helpful for motivation, and 79% reported students increase in participation (p.244).

Another suggestion for teachers is to have students create a notebook or binder in which to hold vocabulary visuals, composing their own mathematical dictionary. This notebook or binder might be beneficial to students, as it would be a resource they can reference when preparing for chapter and state assessments, or when they simply need a refresher on what a term means in order to complete a problem. This notebook can also serve as a way for students to develop their mathematical metacognition and may increase their attitudes towards math overall.

A third suggestion for teachers is to involve their students in this visual process. They can do this by simply asking the students through a survey, what form of learning vocabulary they find to be helpful--context strategies, visuals, or both. They can also implement the *VARK Learning Styles Inventory* created by Neil Fleming (Miller, 2001) to gain a perspective on their students’ learning styles. Furthermore, teachers can also provide students choice in learning vocabulary by offering the incentive of having students create their own comics for themselves and/or the entire class. This sense of ownership may further help the students to form a connection with the terminology, providing for a stronger understanding of the words’ meanings and a longer retention rate. An idea is to have a class contest or group vote on the comics students create as to which is the most creative or effective in representing the math vocabulary.
Even parents can become involved in using the visuals and context strategies to learn math vocabulary. If a classroom website exists, the teacher can upload the section or week’s comics for the words being introduced, so parents can be aware of what their child is learning. Often, parents are unsure of what math words mean and feel self-conscious or even negative towards math from their own past experiences. Eugenia Francis (Date), author of “Teach Your Child the Multiplication Tables, Fast, Fun & Easy with Dazzling Patterns, Grids and Tricks,” can relate to this, as she has had several parents approach her at book fairs telling her they were not particularly good at math, and some even claim to “hate math.” (para 1). However, providing parents access to the comics and contexts for the vocabulary may increase their understanding, assist them in feeling more confident in helping their child at home, and build a stronger communication between home and school. Furthermore, by adding the comic visuals to the classroom website, students will not be without a guide to complete their math homework when they forget or misplace their math notebooks or binders, as this can be common for the pre-adolescent and adolescent age levels.

**Recommendations for Administrators**

As students learn in different styles and variations, so do teachers; thus, it is recommended that administrators provide further information on the use of teaching vocabulary using context with comics as visuals. It is suggested this be conducted through various forms of professional development workshops. With research and information in education consistently changing, this would be a productive way for teachers to add to their knowledge of vocabulary instruction and better learn how to connect with their students. Seminars and programs on the effective use of not just comics, but other visuals such as graphic organizers, would enhance
teachers’ knowledge and presentations of their lessons, making them more effective and engaging for students.

Another suggestion is to purchase a package from a comic website such as the one used in this study, *Bitstrips for schools* (Bitstrips Inc., 2011). In making this purchase, all teachers and even students can have access to this tool to create comics that will stand as visual connections to their vocabulary. Furthermore, this website tool is considered cross-curricular in that it can be used for different subject areas and for all grade levels, a benefit even for those schools in financial need. The access is simple as well, since only an internet connection is needed. The comics can be created both at home and school, making this an effective tool. *Bitstrips for Schools*, however, is just one of many websites that may be considered for use and purchase. This decision is suggested to be applied to the school’s monetary funding, technology program allowances, and other culminating factors implemented by the administration.

A third suggestion for administrators is to seek the advice of a literacy coach, a district or school employee who is knowledgeable in reading strategies and the improvement of literacy skills. Such a person would be able to offer further ideas and support for using visuals to help students increase their vocabulary use and retention.

**Recommendations for Further Research**

Based on the outcomes of this study, as well as the changing nature of math and vocabulary instruction, it is the researcher’s hope that this study will be replicated. Suggestions for changes to the current study include the following: First, increase the number of participants: The number of students used for this study was quite small, with only 38 total students from both classes. Selecting more classes and students to assess would create a smaller chance for a margin of error, allowing for the end results to be more significant. Also, conducting both
lessons and post-tests in one session may have negatively impacted the significance the researcher hoped to be achieved. It is suggested that students be taught each set of vocabulary words over the course of a few days or over a week’s time before being post-tested, as this will give the researcher a better sense of retention rates. Also, utilizing a different school setting may be a factor to consider, as this study was conducted at a rural junior high school due to convenience. An urban, charter, or larger public school may produce different results. Using another website resource to create the comics, and using a different set of math words would be two other suggestions. Having students create their own comics for the selected words is yet another way to replicate this study, as this personalization may allow for further significance in post-scores to be achieved. As stated before in chapter two, students learn vocabulary through different mediums and learning styles; thus, through creating their own comics, they can apply their learning styles to better help them retain the words’ meanings.

In addressing the findings from this study, there are several areas in which future research can be conducted. For example, what other forms of visuals are effective? This particular study only focused on comics as a form of visuals, but there are several other forms such as the many types of graphic organizers that may also provide similar, or better, results. Which student ability levels most benefit from these two forms of vocabulary study-- those who are considered advanced students versus those considered struggling students? The researcher did not address student ability levels in this study, but was informed that they existed. Other research might also investigate what makes comics effective for some students and distracting for others? Why? Students in this study were asked which instructional method they preferred, but research has not been conducted as to why students varied in their perceptions of learning vocabulary with comics.
The researcher found this study to be appealing and easy to conduct, based on the students' anecdotal comments, and despite the lack of significance as stated in the students’ post-test results and in the tables in chapter four, even the smallest of differences still suggest that comics combined with context strategies may be more effective than using context strategies alone. In using some of the suggestions listed above, it is the researcher’s hope that future replications of this study will only help to answer the research questions more conclusively, for the enhancement of mathematical vocabulary instruction.

Summary

This chapter presented a summary of the investigation of determining whether using context strategies with comics was more effective than using context strategies alone in teaching math vocabulary, and which of these methods students preferred. It took place over three weeks in a rural Ohio junior high school, using two sixth grade classes of students. Conclusions from the data were presented pertaining to the students’ post-test scores following lessons in which they learned vocabulary words using both strategies, and reflected on which of the methods they preferred to better help them learn the words.

In conclusion to the information gleaned from the lessons and post-tests, when learning math vocabulary, context strategies with comics as visuals are more effective, but not by much. It was also concluded that students prefer learning math vocabulary using context strategies with comics as visuals more than context strategies alone. Following this, a series of reasons for the conclusions and results presented were listed, as this was only one study conducted in one school. This chapter then presents recommendations for future conduction of this study, as information and studies on vocabulary are often changing and in need of updating. Ideas for administrators and teachers to use based upon the results gleaned from this study are provided as
well as stated in other chapters the benefits and imperative use of vocabulary instruction. Thus, even with the small display of significance, it is the hope of the researcher that this study be of use and augment the benefits of using comics with context strategies to help students develop larger vocabularies and stronger skills in the math content area.
REFERENCES


APPENDIX A

HUMAN SUBJECTS REVIEW BOARD THESIS TOPIC APPROVAL FORM
DATE: January 31, 2012
TO: Amanda Gilles
FROM: Bowling Green State University Human Subjects Review Board
SUBMISSION TYPE: Revision
ACTION: APPROVED
APPROVAL DATE: January 30, 2012
EXPIRATION DATE: December 12, 2012
REVIEW TYPE: Expedited Review
REVIEW CATEGORY: Expedited review category # 7

Thank you for your submission of Revision materials for this project. The Bowling Green State University Human Subjects Review Board has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

The final approved version of the consent document(s) is available as a published Board Document in the Review Details page. You must use the approved version of the consent document when obtaining consent from participants. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that you are responsible to conduct the study as approved by the HS/IRB. If you seek to make any changes in your project activities or procedures, those modifications must be approved by this committee prior to initiation. Please use the modification request form for this procedure.

You have been approved to enroll 00 participants. If you wish to enroll additional participants you must seek approval from the HS/IRB.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. All NON-COMPLIANCE issues or COMPLAINTS regarding this project must also be reported promptly to this office.

This approval expires on December 12, 2012. You will receive a continuing review notice before your project expires. If you wish to continue your work after the expiration date, your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date.

Good luck with your work. If you have any questions, please contact the Office of Research Compliance at 419-372-7716 or hrsb@bgsu.edu. Please include your project title and reference number in all correspondence regarding this project.
APPENDIX B

INITIAL SCHOOL CONSENT FORM
November 30, 2011

Bowling Green State University
University's Human Subjects Review Board
309 A University Hall
Bowling Green, OH  43403

Dear Human Subjects Review Board,

I give permission to Amanda Gilles, a Masters' student of Bowling Green State University, to work with a sixth grade math teacher

She will be completing her thesis

research study with us.  If you have any questions please contact me at
(419)-823-4381

Thank you.

Sincerely,
APPENDIX C

PARENT CONSENT FORM
January 2012

Dear Parent or Guardian:

I am a graduate student at Bowling Green State University and am pursuing my Master of Education degree in Reading.

As a part of my Masters degree, I am completing a thesis. As a licensed mathematics and language arts teacher in grades 4-9, I plan to focus my thesis on the connection between reading and mathematics. More specifically, my study will focus on the use of teaching math vocabulary through context strategies alone, in comparison to teaching the vocabulary using comics as a form of visual representation in combination with context. Your student will be participating in a math vocabulary survey, two lessons, and a post-test, which is a test given after a lesson, to determine which of the above methods is most helpful to students. His or her participation will help to benefit me in answering my question in the field of teaching and possibly help students to better learn their math vocabulary.

I plan to conduct the math survey during the two class periods in one day. The first set of lessons and post-tests will be implemented the following week during one period for each class. The second set of lessons and post-tests will be administered the week following this, again during one period for each class.

The risks associated with this study will be no greater than those encountered in daily classroom life. Furthermore, participation in the study is voluntary, and should students decline to participate, neither their course grade in math, nor their relationship with their classroom teacher or BGSU will be negatively impacted. Students may withdraw from the study at any time.

In addition, participants' identities will all remain confidential and will not be revealed or published. All names on the post-tests and surveys will be removed and replaced with pseudonyms for the purpose of documentation. Also, all materials will be kept in a locked drawer, and only I and my advisor will be reviewing the results. Following the study, materials will remain in a confidential file for the following ten years.

If you have any questions or comments about this study, you may contact me at 440-476-3111, agilles@bgsu.edu or my advisor Dr. Nancy Fordham at 419-372-9819, nfordha@bgsu.edu

If you agree to allow your sixth grade student to participate in this study, please complete this form in its entirety by checking the appropriate ooxes and signing the back of this consent letter. Please have your student return it in a timely matter so the research for this study may begin.

If you do not agree to allow your sixth grade student to participate in this study, then you may disregard this form.
Thank you for your time and consideration.

Amanda Gilles

Please check the appropriate boxes and sign below. Doing so will indicate you have read this document, understand the premise of this study, and offer your consent to allow me to conduct this study with your student.

Again, if you do not agree to allow your sixth grade student to participate in this study, then you may disregard this form.

☐ I give permission for my child to participate in the research study being conducted in his/her math class by a graduate student in the Reading Program at Bowling Green State University.

☐ I would like a copy of this signed permission form returned to me.

__________________________  ______________________
Printed Name                  Date

__________________________
Signature
APPENDIX D

STUDENT ASSENT FORM
Dear Student:

I am a graduate student at Bowling Green State University and am pursuing my Master of Education degree in Reading.

As a part of my Masters degree, I will be completing a thesis, which is similar to a research paper. As a licensed mathematics and language arts teacher in grades 4-9, I plan to focus my thesis on the connection between reading and mathematics. More specifically, my thesis will focus on teaching math vocabulary using only context clues, versus teaching vocabulary using comics as a form of visual representation, in addition to context clues.

To determine which of the above methods is most helpful to you, for my study, I will conduct a survey on math vocabulary, teach two lessons, and then give two post-tests in two of the five sixth grade math classes. None of these tests will count for a grade; the results will only be used for my study. I plan to conduct the math survey during your class period in one day. The first set of lessons and post-tests will be given the following week during one class period for each class. The second set of lessons and post-tests will be given the week following this, again during one period for each class.

There will be no risks associated with this study to you or your grades, you will only be helping me answer my question on how students can better learn their math vocabulary; the risks will be no greater than those encountered in daily classroom life. Furthermore, participation in the study is your choice, and should you decide not to participate, neither your grade in math, nor your relationship with your teacher or BGSU will be impacted in any way. You may withdraw from the study at any time.

In addition, your identity will remain confidential and will not be published. I will replace your name with a fake name when I talk or write about the data. Also all materials will be kept in a locked drawer, for the next ten years, and only my advisor and I will be reviewing the results.

If you have any questions or comments about this study, you may contact me at 440-476-3111 agilles@bgsu.edu or my advisor Dr. Nancy Fordham at 419-372-9819, nfordha@bgsu.edu

If you agree to participate in this study, please check the appropriate boxes and sign the back of this consent. Please return it in a timely matter to me, so the research may begin in conducting this study.

If you do not agree to participate in this study, and I do not mind if you do not want to, then you may ignore this form and I will not use your data. Also if you agree to participate but then change your mind, this is also ok, just please let me know.

Thank you for taking the time to read this and think about taking part in my study.

Amanda Gilles
If you would like to participate please check the box and sign below

Again, if you do not agree to participate in this study, and you may withdraw at any time, then you may disregard this form.

Thank you.

☐ I will participate and have my results used in this study being conducted by a graduate student from the Graduate Reading Program at Bowling Green State University.

______________________________  ______________________
Printed Name  Date

______________________________
Signature
APPENDIX E

PRINCIPAL CONSENT FORM
Dear Principal:

As you may already know, I am a graduate student at Bowling Green State University pursuing my Master of Education degree in Reading.

As a part of my Masters degree, I will be completing a thesis. Since I have already been involved at this school through the completion of my methods and student teaching semesters in my undergraduate program, I have decided to ask your permission to use your junior high school's sixth grade as the subjects for my study. As a licensed mathematics and language arts teacher in grades 4-9, I plan to focus my thesis on the connection between reading and mathematics.

More specifically, my thesis will focus on teaching math vocabulary using context strategies alone, versus teaching vocabulary using comics as a form of visual representation in addition to context strategies. Your students’ participation will help to benefit me in answering my question in the field of teaching and possibly help support a more effective method for teaching math vocabulary.

For my study, I would be conducting a math survey, two lessons and two post-tests to two of the five sixth grade math classes. I plan to conduct the survey during the 45 minutes of each of the two class periods in one day in one week. The first set of lessons and post-tests will be implemented the following week in one day in one period for each class. The second set of lessons and post-tests will be administered the week following this, again in one day, for one period for each class. The potential dates/days/times are listed below:

- Deliver letters of permission (students/parents) - Monday January 23
- Conduct Pre-test for both classes during the 45 minute periods (total 90 minutes) - Friday February 3
- First set of five word vocabulary lessons and post-tests (one lesson being taught to class A using context alone, and one lesson being taught to class B using context and visuals) during the 45 minute class periods - Friday February 10
- Second set of five word vocabulary lessons and post-test (one lesson being taught to class B using context alone, and one lesson being taught to class A using context and visuals) during the 45 minute class periods - Friday February 17

There will be no risks associated with this study to the students or their grades; the risks will be no greater than those encountered in daily classroom life. Furthermore, participation in the study is voluntary, and should students decline to participate, neither their course grade in math, nor their relationship with their classroom teacher or BGSU will be impacted. Students may withdraw from the study at any time.

In addition, you, the teachers, and the students’ identities will all remain confidential and will not be revealed or published. All names on the post-tests and surveys will be removed and replaced with pseudonyms for the purpose of documentation. Also all materials will be kept in a locked drawer, and only I and my advisor will be reviewing the results. Following the study, materials will remain in a confidential file for the following ten years.
If you have any questions or comments about this study, you may contact me at 419-372-7323, agilles@bgsu.edu or my advisor Dr. Nancy Fordham at 419-372-9819, nfordha@bgsu.edu. For any questions about participant rights please contact the Human Subjects Review Board at 419-372-7716 or hsrh@bgsu.edu.

If you agree to allow your sixth grade students from the math teacher’s classes to participate in this study, please complete this form in its entirety by checking the appropriate boxes and signing the back of this consent. Please return it in a timely matter to this teacher or me, so the research may begin in conducting this study.

If you do not agree to allow your sixth grade students in this school to participate in this study, then you may disregard this form.

Thank you for your time and consideration.

Amanda Gilles

-----------------------------------------------------------------------------------------------------------------------------

Please check the appropriate boxes and sign below. Doing so will indicate you have read this document, understand the premise of this study, and offer your consent to allow me to conduct this study.

Again, if you do not agree to allow your sixth grade students in this school to participate in this study, then you may disregard this form.

Thank you.

I give permission for my sixth grade students at this junior high school to participate in the research study being conducted by a student in the Graduate Reading Program at Bowling Green State University.

I would like a copy of this signed permission form returned to me.

__________________________    __________________________
Printed Name                                               Date

__________________________
Signature
APPENDIX F

TEACHER CONSENT
January 2012

Dear Classroom Teacher:

As you may already know, I am a graduate student at Bowling Green State University pursuing my Master of Education degree in Reading.

As a part of my Masters degree, I am completing a thesis. Since I have already been involved at this school during the completion of my methods and student teaching semesters in my undergraduate program, I have decided to ask your permission to use your junior high school’s sixth grade as the subjects for my study. As a licensed mathematics and language arts teacher in grades 4-9, I plan to focus my thesis on the connection between reading and mathematics.

More specifically, my thesis will focus on teaching math vocabulary using context strategies alone, versus teaching vocabulary using comics as a form of visual representation in addition to context strategies. Your students’ participation will help to benefit me in answering my question in the field of teaching and possibly help support a more effective method for teaching math vocabulary.

For my study, I would be conducting a math survey, two lessons and two post tests to two of the five sixth grade math classes. I plan to conduct the survey during the 45 minutes of each of the two class periods in one day in one week. The first set of lessons and post-tests will be implemented the following week in one day in one period for each class. The second set of lessons and post-tests will be administered the week following this, again in one day, for one period for each class. The potential dates/days/times are listed below:

- Deliver letters of permission (students/parents)-Monday January 23
- Conduct math survey for both classes during the 45 minute periods (total 90 minutes)-Friday February 3
  - First set of five word vocabulary lessons and post-tests (one lesson being taught to class A using context alone, and one lesson being taught to class B using context and visuals) during the 45 minute class periods-
  - Friday February 10
  - Second set of five word vocabulary lessons and post-test (one lesson being taught to class B using context alone, and one lesson being taught to class A using context and visuals) during the 45 minute class periods-
  - Friday February 17

There will be no risks associated with this study to the students or their grades; the risks will be no greater than those encountered in daily classroom life. Furthermore, participation in the study is voluntary, and should students decline to participate, neither their course grade in math, nor their relationship with BGSU will be impacted. Students may withdraw from the study at any time.
In addition, participants’ identities will remain confidential and will not be revealed or published. All names on the post-tests and surveys will be removed and replaced with pseudonyms for the purpose of documentation. Also, all materials will be kept in a locked drawer, and only I and my advisor will be reviewing the results. Following the study, materials will remain in a confidential file for the following ten years.

If you have any questions or comments about this study, you may contact me at 440-476-3111, agilles@bgsu.edu or my advisor Dr. Nancy Fordham at 419-372-9819, nfordha@bgsu.edu. For any questions about participant rights please contact the Human Subjects Review Board at 419-372-7716 or hrsrb@bgsu.edu.

If you agree to allow your sixth grade students to participate in this study, please complete this form in its entirety by checking the appropriate boxes and signing the back of this consent. Please return it in a timely matter to me, so the research may begin in conducting this study.

If you do not agree to allow your sixth grade students in this school to participate in this study, then you may disregard this form.

Thank you for your time and consideration.

Amanda Gilles

Please check the appropriate boxes and sign below. Doing so will indicate you have read this document, understand the premise of this study, and offer your consent to allow me to conduct this study.

Again, if you do not agree to allow your sixth grade students to participate in this study, then you may disregard this form.

Thank you

I give permission for my sixth grade students to participate in the research study being conducted by a graduate in the Graduate Reading Program at Bowling Green State University.

I would like a copy of this signed permission form returned to me.

_________________________  ______________________
Printed Name                  Date

_________________________
Signature
APPENDIX G

KNOWLEDGE RATING SCALE AND SURVEY
For this pre test, you will need to read from the list of vocabulary terms written below. After reading through each of the words, you will check one of the three columns labeled: “I know this word and understand it,” “I’ve heard of this word but am not too sure what it means,” or “I have never heard of or understood this word.”

Next, you will need to complete the survey question listed on the back of this knowledge-survey. Answer this question honestly and to the best of your ability.

This is a survey to gain information for future lessons in the instruction of mathematics vocabulary. This will not count as a grade or affect your grade in math by any means; it will only benefit the research for the study.

**List of 30 Mathematics terms listed here:**

<table>
<thead>
<tr>
<th>Mathematics vocabulary</th>
<th>I know this word and understand it</th>
<th>I have heard of this word but am not too sure what it means</th>
<th>I have never heard or understood this word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Triangle</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1. Exponents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Greatest common factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Least common factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Proportion</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6. Quotient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Product</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Volume (formula)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Area (formula)</td>
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</tr>
<tr>
<td>10. Diameter</td>
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<tr>
<td>11. Radius</td>
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<td></td>
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<tr>
<td>12. Circumference</td>
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<td></td>
<td></td>
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<tr>
<td>13. Perpendicular</td>
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<td></td>
<td></td>
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<tr>
<td>14. Right angle</td>
<td></td>
<td></td>
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<tr>
<td>15. Obtuse angle</td>
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<tr>
<td>16. Scalene triangle</td>
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<td></td>
<td></td>
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<tr>
<td>17. Isosceles triangle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Histogram</td>
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<tr>
<td>19. Mean</td>
<td></td>
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<td></td>
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<tr>
<td>20. Median</td>
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<td></td>
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<tr>
<td>21. Mode</td>
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<tr>
<td>22. Range</td>
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<td></td>
<td></td>
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<tr>
<td>23. Symmetry</td>
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<tr>
<td>24. Coordinate</td>
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<td>25. Horizontal</td>
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<td></td>
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<tr>
<td>26. Vertical</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>27. Reciprocal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28. Variable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30. Summation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Survey Question:

1. What do you think would help you to learn math vocabulary words better and for a longer period of time?
APPENDIX H

COMIC VOCABULARY SET A
MATH VOCABULARY-COMIC STYLE

5 Math Vocabulary terms within the sixth grade standards using context (words) and visuals (pictures-comics) to help learn the meanings.

'COORDINATE'

We will never get there if we cannot coordinate and remember that the first number is x and the second number is y.

Two numbers in a numbered or ordered pair used to define the position of a point on a grid. The first number refers to the location on the x-axis and the second number refers to the location on the y-axis.

www.bitstripsforschools.com
When there was only one sandwich left to be fair the mother gave the twin girls the same size half piece.

My half is the same as yours.

When a figure can be folded (horizontally or vertically) into two identical halves.
'VOLUME Strip'

The amount of space measured in cubic units using the formula $L \times W \times H$.

When Height, Length, and Width get together to sing, these three create quite a volume!

'AREA'

"When length and width get together on the ice arena, it's hip to be square."

The measurement surface of a region in square units by multiplying the length of an object by its width.
The collected data showed how frequently the gram crackers get stuck together.

A type of graph that shows how frequently data occurs. The adjacent bars are touching.
APPENDIX I

COMIC VOCABULARY SET B
Here are 5 Math Vocabulary terms within the sixth grade standards using context (words) and visuals (pictures / comics) to help in understanding the meanings.

**'PROPORTION'**

An equation that shows that two fractions are equal.

These can be written in two ways:

\[
\frac{1}{2} = \frac{2}{4} \quad \text{or} \quad 1:2 = 2:4
\]

We may look different, but I am the same size as he is....

Eating two of the four slices of pizza $A$ is the same as eating $1/2$ of pizza $B$.

2 halves

www.bitstripsforschools.com
The result of multiplying two or more quantities/values.

Alex would have to save $10 each week from her allowance for ten weeks to produce enough money to buy her new iPod touch.
'RECIPROCAL'

A number that gives a product of 1 when multiplied by its reverse form of the original number.

(a fraction's numerator/denominator is multiplied by its denominator/numerator.)

To find the reciprocal of a number, switch the denominator and the numerator.

Example: $\frac{4}{3} \times \frac{3}{4} = \frac{12}{12} = 1$ or $\frac{5}{1} \times \frac{1}{5} = \frac{5}{5} = 1$

If Steve multiplied his total bill with the denominator at the top and his numerator at the bottom, or with his numerator at the top and his denominator at the bottom, his receipt still came out the same.

www.bitstripsforschools.com
A number sentence that uses the equal sign. Everything on the left side of an equal sign (=) has to equal everything on the right side.
Example: $8 + 4 = 14 - 2$

The volleyball net made the equation of the game fair as each side had the same number of players on their team.
The bill is how much?

The process of adding something up to find a total.

When she took her kids grocery shopping, the SUM of Julia's bill was more than she expected!
APPENDIX J

LESSON PLAN A1 & A2
**BGSU Student Name:** Amanda Gilles

**School/Teacher:**

**Grade Level:** Sixth grade

Period 3 (9:24-10:04): A1 Context Only

Period 4 (10:04-10:58): A2 Comics-Visuasl/Context

**Topic:** 6th Grade Mathematics Vocabulary (based from 2011 Common Core Standards)

**E/LA Common Core State Standards:**

L 6.4a. Use context (e.g., the overall meaning of a sentence or paragraph; a word’s position or function in a sentence) as a clue to the meaning of a word or phrase.

**Math Common Core State Standards:**

All five vocabulary terms are constructed from the 6th grade standards

**Engagement: (1-2 minutes):** Introduce myself to students and explain the purpose of my study—to find out how to help students better learn and retain mathematics vocabulary; and which style they perform to learn their vocabulary context only or context and visuals (comics). Remind students they may decline participation at any time.

**Direct Instruction: (30 minutes):**

Set A Vocabulary Words:

| a) Volume | b) Area | c) Histogram | d) Symmetry | e) Coordinate |

**3rd period (Context Only):**

- a. Introduce 5 vocabulary words to students-read each one aloud
- b. Give each student 5 index cards to write the definitions of words
c. Pull up Context Set A document on Smart Board

d. Read definitions aloud to students and ask them to copy on index cards

e. Once students have words copied read through definitions again giving an example with each.

f. Ask students to pair up with an elbow partner to practice learning words and terminology; ask students to assess one another

g. Ask students to put index cards away and clear desks as Post Test A is passed out

h. Read aloud directions to students for Post Test A—be sure students put their class/name/date information on test

i. When finished have students raise hands to collect and give each student Comic Set A as a resource

### 4th Period (Context and Comics):

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Introduce 5 vocabulary words to students—read each one aloud from Comic Set A template on Smart Board</td>
</tr>
<tr>
<td>b.</td>
<td>Pass out Comic Set A to each student—explain purpose to be as a resource and visual connection to words</td>
</tr>
<tr>
<td>c.</td>
<td>Read definitions aloud and examples for each word one at a time</td>
</tr>
<tr>
<td>d.</td>
<td>Ask students to pair up with an elbow partner to practice learning words and terminology; ask students to assess one another</td>
</tr>
<tr>
<td>e.</td>
<td>Ask students to put comics away and clear desks as Post Test A is passed out</td>
</tr>
<tr>
<td>f.</td>
<td>Read aloud directions to students for Post Test A—be sure students put their class/name/date information on test</td>
</tr>
<tr>
<td>g.</td>
<td>When finished have students raise hands to collect and advise students to keep comics as a resource</td>
</tr>
</tbody>
</table>

**Closure: (1-2 minutes):**

With both 3rd and 4th period play “I Have Who Has” multiplication game

Time students to see how fast the class can go through the set of cards

Keep track of time to see which class has faster time
MATERIALS FOR LESSON:

Smart Board
Comic Set A
Context Set A
5 index cards per students
Post Test A
“I Have Who Has” card game
APPENDIX K

LESSON PLAN B1 & B2
<table>
<thead>
<tr>
<th>BGSU Student Name:</th>
<th>Amanda Gilles</th>
</tr>
</thead>
<tbody>
<tr>
<td>School/Teacher:</td>
<td></td>
</tr>
<tr>
<td>Grade Level:</td>
<td>Sixth grade</td>
</tr>
</tbody>
</table>

Period 3 (9:24-10:04): B1 Comics-Visuals/Context  

**Topic:** 6th Grade Mathematics Vocabulary (based from 2011 Common Core Standards)

**E/LA Common Core State Standards:**
L 6.4a. Use context (e.g., the overall meaning of a sentence or paragraph; a word’s position or function in a sentence) as a clue to the meaning of a word or phrase.

**Math Common Core State Standards:**
All five vocabulary terms are constructed from the 6th grade standards

**Engagement: (1-2 minutes):** Introduce myself to students and explain the purpose of my study-to find out how to help students better learn and retain mathematics vocabulary; and which style they perform to learn their vocabulary context only or context and visuals (comics). Remind students they may decline participation at any time.

**Direct Instruction: (30 minutes):**
Set A Vocabulary Words:

- b) Proportion  
- b) Product  
- c) Reciprocal  
- d) Equation  
- e) Summation

**3rd period (Comics and Context):**

- h. Introduce 5 vocabulary words to students-read each one aloud from Comic Set B template on Smart Board
i. Pass out Comic Set A to each student-explain purpose to be as a resource and visual connection to words

j. Read definitions aloud and examples for each word one at a time

k. Ask students to pair up with an elbow partner to practice learning words and terminology; ask students to assess one another

l. Ask students to put comics away and clear desks as Post Test B is passed out

m. Read aloud directions to students for Post Test - be sure students put their class/name/date information on test

n. When finished have students raise hands to collect and advise students to keep comics as a resource

### 4th period (Context Only):

j. Introduce 5 vocabulary words to students-read each one aloud

k. Give each student 5 index cards to write the definitions of words

l. Pull up Context Set B document on Smart Board

m. Read definitions aloud to students and ask them to copy on index cards

n. Once students have words copied read through definitions again giving an example with each.

o. Ask students to pair up with an elbow partner to practice learning words and terminology; ask students to assess one another

p. Ask students to put index cards away and clear desks as Post Test B is passed out

q. Read aloud directions to students for Post Test B - be sure students put their class/name/date information on test

r. When finished have students raise hands to collect and give each student Comic Set B as a resource

### Closure: (1-2 minutes):

With both 3rd and 4th period play “I Have Who Has” multiplication game

Time students to see how fast the class can go through the set of cards
Keep track of time to see which class has faster time

**MATERIALS FOR LESSON:**

- Smart Board
- Comic Set B
- Context Set B
- 5 index cards per students
- Post Test B
- “I Have Who Has” card game
APPENDIX L

POST TEST A
Post Test A

Name: ___________________________ Class: _______________ Date: ____________

For this post test, you will be asked to answer five multiple choice questions over the five vocabulary words learned in the lesson. Be sure to read each question and all of the answers carefully, and then select the letter answer that you feel best answers the question. There is only one correct answer for each question.

This post-test will not affect your grade in math class; it will only provide data for the research study under investigation so take your time and do your best. Carefully read each statement below and select the best answer. Then please answer the short-answer survey questions that follow.

1. Two numbers in a numbered or ordered pair used to define the position of a point on a grid. The first number refers to the location on the x-axis and the second number refers to the location on the y-axis.
   a) Volume  b) Area  c) Histogram  d) Symmetry  e) Coordinate

2. A type of graph that shows how frequently data occurs. The adjacent bars are touching.
   a) Volume  b) Area  c) Histogram  d) Symmetry  e) Coordinate

3. The amount of space measured in cubic units using the formula (l \* w \* h).
   a) Volume  b) Area  c) Histogram  d) Symmetry  e) Coordinate

4. When a figure can be folded (horizontally or vertically) into two identical halves.
   a) Volume  b) Area  c) Histogram  d) Symmetry  e) Coordinate

5. The measurement surface of a region in square units by multiplying the length of an object by its height.
   a) Volume  b) Area  c) Histogram  d) Symmetry  e) Coordinate

Definitions referenced from:
Short answer survey questions:

1. Did you find this form of learning (context strategies, or context strategies with comics as a visual) the vocabulary helpful?
   a. □ YES □ NO
   b. Why or why not?

2. Do you think you will remember these words in the future when you come across them in word problems or homework/test problems?
   a. □ YES □ NO
   b. How will you remember them?

3. What other methods might help you to learn these words?
APPENDIX M

POST TEST B
Post Test B

Name:______________________________ Class:________________ Date:_________

For this post test, you will be asked to answer five multiple choice questions over the five vocabulary words learned in the lesson. Be sure to read each question and all of the answers carefully, and then select the letter answer that you feel best answers the question. There is only one correct answer for each question.

This post-test will not affect your grade in math class; it will only provide data for the research study under investigation so take your time and do your best. Carefully read each statement below and select the best answer. Then please answer the short answer survey questions that follow.

1. An equation that shows that two fractions are equal.
   a) Proportion  b) Product  c)Reciprocal  d)Equation  e)Summation

2. A number that gives a product of 1 when multiplied by the original number (flipping the numerator and the denominator).
   a) Proportion  b) Product  c) Reciprocal  d) Equation  e) Summation

3. The process of adding something up to find a total.
   a) Proportion  b) Product  c) Reciprocal  d) Equation  e) Summation

4. A number sentence that uses the equal sign. Everything on one side of the equal sign is the same as everything on the other side.
   a) Proportion  b) Product  c) Reciprocal  d) Equation  e) Summation

5. The result of multiplying two or more quantities/values.
   a) Proportion  b) Product  c) Reciprocal  d) Equation  e) Summation

Definitions referenced from:
Short answer survey questions:

1. Did you find this form of learning (context strategies, or context strategies with comics as a visual) the vocabulary helpful?
   c. □ YES □ NO
   d. Why or why not?

2. If this is the second post-test, please describe which method of learning you found to be MOST helpful.
   a. □ Context ONLY □ context AND visuals (comics)
   b. Why was this method helpful to you?

3. Do you think you will remember these words in the future when you come across them in word problems or homework/test problems?
   c. □ YES □ NO
   d. How will you remember them?

4. What other methods might help you to learn these words?
APPENDIX N

CONTEXT SET A
Math Vocabulary using Context Alone:

LIST A

1. **Coordinate:** The two numbers in a number or ordered pair used to find or define the position of a point or line. The first number in a pair refers to the location on the x-axis, and the second number refers to the y-axis. (example: (3,2); x =3 y =2)

2. **Area:** The measurement surface of a region in square units, found by multiplying the region’s length by its width. (example: a rectangle has a length of 4cm and a width of 2cm; 4 x 2 = 8cm²)

3. **Volume:** The amount of space measured in cubic units that something takes up; found by multiplying a region’s length by its width, and by its height. (example: a rectangular prism has a length of 2 cm, a width of 3 cm, and a height of 4 cm; 2 x 3 x 4 = 24 cm³)

4. **Histogram:** A special kind of bar graph that shows how frequently data occurs. The bars next to each other (adjacent) are touching.

5. **Symmetry:** When a figure can be folded into two identical halves horizontally and/or vertically. (examples: horizontal-letter B; vertically-letter T).

Definitions referenced from:

APPENDIX O

CONTEXT SET B
Math Vocabulary using Context Alone:

LIST B

1. **Proportion**: An equation that shows that two fractions are equal. These can be written in two ways: $\frac{1}{2} = \frac{2}{4}$ or $1:2 = 2:4$

2. **Product**: The result of multiplying two or more quantities/values.

3. **Reciprocal**: A number that gives a product of 1 when multiplied by its reverse form of the original number. To find the reciprocal of a number, switch the denominator and the numerator. Example: $\frac{4}{3} \times \frac{3}{4} = \frac{12}{12}$ or 1

4. **Equation**: A number sentence that uses the equal sign. Everything on the left side of an equal sign (=) has to equal everything on the right side. Example: $8 + 4 = 14 - 2$

5. **Summation**: The process of adding something up to find a total.

Definitions referenced from: