# The Effects of Marzano's Six-step Process and the Frayer Model on Mathematics Vocabulary Instruction in Algebra I at a Selected High School

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**Abstract**

The purpose of this study was to determine the effects of Marzano's Six-step Process and the Frayer Model as a vocabulary instructional strategy for instruction in a high school Algebra I class. The participants consisted of 19 algebra I students in a semi-rural public high school located in Northeastern Tennessee. The students were taught a four-week unit that was divided into two halves of equal difficulty and complexity. The students were taught using the Frayer Model as a vocabulary instructional strategy for the first half of the unit, then given the Star Math assessment. The students were taught using Marzano's Six-step Process as a vocabulary instructional strategy for the second half of the unit, then given the Star Math assessment. The Star Math assessment is a component of Renaissance Star 360 assessment suite and is used worldwide for screening and progress monitoring students. Data were collected from the Star Math assessments and analyzed using t-tests. The results of a paired t-test indicated that there was not a significant difference between using the Frayer Model and Marzano's Six-step process as a vocabulary instructional strategy $(t(18) = .316, p = .756)$. The results of the independent t-test indicated there was not a significant difference found between gender when using the Frayer Model $(t(17) = .150, p = .882)$ or Marzano's Six-step Process $(t(17) = .258, p = .800)$. The results suggest that both instructional strategies have equal effectiveness when implemented.

*Keywords:* vocabulary, Frayer Model, Marzano's Six-step Process, math, education

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Date: February 15, 2018

From: The Institutional Review Board (IRB) at Milligan College

Re: The Effects of Marzano's Six-step Process and the Frayer Model on Mathematics Vocabulary Instruction in Algebra I at a Selected High School

Submission type: Initial Submission

Dear Erika Hale,

On behalf of the Milligan College Institutional Review Board (IRB), we are writing to inform you that your study *'The Effects of Marzano's Six-step Process and the Frayer Model on Mathematics Vocabulary Instruction in Algebra I at a Selected High School'* has been approved as expedited. This approval also indicates that you have fulfilled the IRB requirements for Milligan College.

All research must be conducted in accordance with this approved submission, meaning that you will follow the research plan you have outlined here, use approved materials, and follow college policies.

Take special note of the following important aspects of your approval:

- Any changes made to your study require approval from the IRB Committee before they can be implemented as part of your study. Contact the IRB Committee at **IRB@milligan.edu** with your questions and/or proposed modifications.
- If there are any unanticipated problems or complaints from participants during your data collection, you must notify the Milligan College IRB Office within 24 hours of the data collection problem or complaint.

The Milligan College IRB Committee is pleased to congratulate you on the approval of your research proposal. Best wishes as you conduct your research! If you have any questions about your IRB Approval, please contact the IRB Office and copy your faculty advisor if appropriate on the communication.

Regards,
The IRB Committee

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# Chapter 1

## Introduction

Proper vocabulary instruction is a realized necessity in education, but it is equally essential specifically in mathematics (Monroe & Panchyshyn, 1995). A student may be able to master mathematical computations without specific vocabulary instruction. However, according to Bruun, Diaz, & Dykes (2015), even if the student is able to master computation he or she will not be able to apply his or her knowledge of such computations without the foundation of vocabulary knowledge. Mathematics vocabulary can be compared to learning and new language and without the vocabulary knowledge, students will not possess the ability to make inferences or communicate mathematical ideas and concepts (Wanjiru & O-Connor, 2015). Vocabulary instruction in the context of mathematics remains a challenge because there lacks an opportunity for specific mathematical instruction, and many mathematics teachers neglect to create a meaningful vocabulary instruction opportunity (Wanjiru & O-Connor, 2015).

To avoid entering a mathematics lesson with students who are unprepared to learn the mathematical concepts, new vocabulary must be introduced at the beginning of a lesson (Bay-Williams & Livers, 2009). There are four categories of mathematical vocabulary that need to be intentionally taught that are crucial for students to gain the ability to develop mathematical concepts and competency. The four categories are technical, subtechnical, general, and symbolic (Monroe & Panchyshyn, 1995). Technical vocabulary in mathematics are terms that are not expressed in everyday language but general vocabulary are terms that are encountered regularly in daily experiences. Subtechnical terms have meanings that vary from one content area to another. Symbolic vocabulary is the mathematical symbols used that are both alphabetic and non-alphabetic that are used to represent different meanings. Bay-Williams and Livers (2009) warn not to introduce too much vocabulary at one time and before teaching vocabulary, determine what the students already know. Words that may present the greatest challenge in mathematics vocabulary are the words that have multiple meanings that vary from one content area to another (Bay-Williams & Livers, 2009; Wanjiru & O-Connor, 2015; Monroe & Panchyshyn, 1995). These words fall into the category of subtechnical vocabulary terms (Monroe & Panchyshyn, 1995).

These challenges can be overcome by actively teaching vocabulary during mathematics instruction using the same methods that are appropriate and used for other subject areas (Monroe & Panchyshyn, 1995). Frayer, Frederick, & Klausmeier (1969) researched a schema consisting "of 13 behaviors from which concept learning may be inferred". The concepts may be defined structurally, semantically, operationally, or axiomatically. Concepts may also be grouped according to attributes and depending on the relationship with other concepts will be considered supraordinate, coordinate, or subordinate (Frayer, Frederick, and Klausmeier, 1969). Relevant and irrelevant concept properties are formed to develop examples and non-examples of the concept. Frayer, Frederick, and Klausmeier's (1969) study provided the following summary of behaviors that permit concept knowledge:

> These behaviors include discrimination of attributes; identification of concept examples and non-examples; labeling of concept instances; differentiation of relevant and irrelevant attributes; definition of the concept; relating the concept to supraordinate, coordinate, and subordinate concepts; indicating the proper relationship between concepts in a principle;

and solving problems by showing the proper relationship between relevant principles. (p. 7)

The Frayer Model graphic organizer was later a product from Frayer, Frederick, and Klausmeier's research. Wanjiru and O-Connor (2015) reported that the Frayer Model was a more effective teaching strategy compared to a definition-only teaching strategy when used during mathematics instruction. The Frayer Model allowed students an opportunity to think about the vocabulary in multiple ways, define the vocabulary, give characteristics, examples and non-examples of the term (Wanjiru & O-Connor, 2015).

There are multiple variations of the Frayer Model graphic organizer for vocabulary instruction. Thompson and Rubenstein (2000) used the Frayer Model in a study that also included a pictorial representation of the vocabulary term that was created by the student. It was reported that the students that used the Frayer Model graphic organizer with vocabulary instruction improved on post-test scores and many created drawings on their post-test to aide in remembering and make inferences (Thompson & Rubenstein, 2000).

Another vocabulary instruction strategy was introduced by Marzano (2009) called the "Six-step Process to vocabulary instruction". Marzano's Six-step Process is as appropriate for mathematics vocabulary instruction as it is with any other subject specific vocabulary instruction. Marzano reported that the Six-step Process works best when all six steps are implemented. The first three steps are to be used when introducing the term. The last three steps are used later when reviewing the term, and not necessarily used together (Marzano, 2009).

The first step of the Six-step Process to vocabulary instruction is providing a description or example of the vocabulary to the student. Next, the student is asked to restate the same description or example in their own words based on their own understanding. The third step is the student's creation of a pictorial description of the term from his or her understanding (Marzano, 2009). After the term has been introduced, Marzano suggests using the last three steps later when reviewing. Step four is to periodically engage students in activities that allow them to expand his or her knowledge of the newly learned term. Then, the students are directed to engage in a discussion of the term with his or her peers. Finally, the students are engaged in games and activities involving the new terms (Marzano, 2009).

Clearly, intentional vocabulary instruction is needed in conjunction with mathematics instruction for students to develop the ability to effectively communicate mathematical concepts and ideas. This communication is essential to the progression of student comprehension and learning. Whether it be the Frayer Model, Marzano's Six-step Process, or another vocabulary instruction strategy, it is definitive that vocabulary does need to be intentionally taught in the mathematics classroom to achieve higher success among student learning.

## Statement of the Problem

The need for intentional vocabulary instruction during mathematics instruction is often overlooked. It is now recognized that vocabulary strategies used during mathematics instruction is beneficial to student learning and comprehension, but it is unclear what strategy is more effective. Studies have been conducted comparing the integration of a vocabulary instruction strategy to definition-only instruction (Wanjiru & O-Connor, 2015). While other studies have compared one vocabulary instruction strategy to another (Thompson & Rubenstein, 2000). Marzano's six-steps to better vocabulary instruction has proven to be effective in many studies, but has also showed to be counter-productive in some (Marzano, 2009). Marzano emphasizes that no strategy is "foolproof" and that the six-step strategy is most effective when implemented correctly (Marzano, 2009). Therefore, for this study, the problem was to show the effects of Marzano's six-step strategy and the Frayer Model for vocabulary instruction integrated during mathematics instruction.

## Purpose of the Study

The purpose of this study was to determine the effects of Marzano's Six-step Process strategy and the Frayer Model as vocabulary instructional strategies during vocabulary instruction in an Algebra I class.

## Significance of the Study

Finding an effective strategy for mathematics vocabulary instruction would create a more conductive learning environment for students and provide an effective tool for teachers to utilize during instruction in his or her classroom. This would increase the comprehension and content understanding among students studying mathematics. Students would be able to communicate mathematical ideas and concepts to further understanding and conceptual growth. Acquiring the ability to use mathematical vocabulary also will give students the ability to make mathematical inferences when learning new concepts that would not be possible without that specific vocabulary knowledge.

## Limitations

The following limitations were encountered:

1. The population of this study was limited to a single Algebra I class at a local public school, and therefore the results could not be generalized to other populations.
2. The timeframe for this study was limited to a four-week instructional period
3. The instructional content delivered during this study was limited to a single unit.

## Definitions

The following were important operational definitions used in this study:

1. "Algebra I" is defined as a branch of mathematics that deals with general statements of relations, utilizing letters and other symbols to represent specific sets of numbers, values, vectors, etc., in the description of such relations.
2. "Frayer Model" is defined as a graphic organizer for building student vocabulary and requires students to define target vocabulary, apply his or her knowledge by generating examples and non-examples, give characteristics, and draw a picture to illustrate he meaning of the word.
3. "General Vocabulary" is defined as terms used in everyday language.
4. "Graphic Organizer" is defined as a visual display that demonstrates relationships between facts, concepts or ideas.

5. "Grade Equivalent (GE) Score" is defined as a score given by the Star Math assessment ranging from 0.0-12.9+ that indicates the grade placement of students for whom a particular score is typical.
6. "Marzano's Six-step Process" is defined as a research-based vocabulary instruction strategy designed by Robert J. Marzano to effectively teach vocabulary and boost student achievement.
7. "Normal Curve Equivalency (NCR) Score" is defined as a norm-referenced score given by the Star Math assessment ranging from 1-99 that is based on an equal-interval scale.
8. Percentile Rank (PR) Score" is defined as a norm-referenced score given by the Star Math assessment ranging from 1-99 that indicates the percentage of a student's peers whose scores were equal or lower than the score of that student.
9. "Scaled Score (SS)" is defined as a score ranging from 0-1400 given by the Star Math assessment that compares student performance over time and identifies performance in relation to a vertical scale and all criterion and norms associated with that scale.
10. "Star Math" is defined as a student-based, computer-adaptive assessment for measuring student achievement in math. Star fulfills a variety of assessment purposes, including interim assessment, screening, standards benchmarking, skills-based reporting and instructional planning and progress monitoring.
11. "Student Growth Percentile (SGP)" is defined as a score ranging from 1-99 given by the Star Math assessment that measures the growth between a pre- and post-assessment relative to the growth made by other students in the same grade with the same pre-test score.

12. "Subtechnical Vocabulary" is defined as terms that have more than one meaning varying from one content area to another.
13. "Symbolic Vocabulary" is defined as terms that consist of, but are not limited to, alphabet symbols, non-alphabet symbols, numerals, and abbreviations that convey meaning.
14. "Technical Vocabulary" is defined as terms generally viewed as mathematical terminology that convey mathematical terms that are difficult to express in everyday language.
15. "Tier 1 word" is define as a word that is commonly spoken, heard frequently in numerous contexts, and rarely require explicit instruction.
16. "Tier 2 word" is defined as a high-frequency word that is used by a mature content user over a variety of domains and usually require explicit instruction.
17. "Tier 3 word" is defined as a low-frequency word, extremely specialized and usually limited to a specific content domain.

## Overview of the Study

This study is made up of five chapters. Chapter one gives an introduction to the study; offers a statement of its problem, purpose and significance; describes its limitations; presents definitions for important terms and concepts, and offers an overview of the study. Chapter two consists of a critical review of the literature relevant to the study. Chapter three includes the research questions, methodology, and procedures of how information was obtained and the study was conducted. A data analysis and the findings of the study are detailed in chapter four. The fifth and final chapter is comprised of a discussion of the findings, implications, research conclusions drawn from the findings, and recommendations for future study.

# Chapter 2

## Literature Review

### Introduction

Vocabulary is encountered in every content domain by every teacher and student on a daily basis. As our state educational standards continue to evolve, an increasing emphasis is placed on literacy. All content domains now have literacy standards to meet. To meet these literacy standards, vocabulary instruction has become a necessity across all content disciplines. But, is vocabulary instruction really important? Is vocabulary instruction really important in each content discipline, such as mathematics? If so, what are effective strategies for vocabulary instruction?

### Teaching Vocabulary Importance

Educational experts, educators across all content domains, and research, all agree that teaching vocabulary is important. Vocabulary is important because it is part of what gives the ability to access background knowledge, the ability to gain new knowledge and the ability to communicate those ideas (Rupley, Logan & Nichols, 1998). A significant amount of education and gaining knowledge is obtained from reading and the ability to comprehend the text. Because vocabulary knowledge is highly correlated to reading comprehension, vocabulary knowledge is a strong indicator of a person's reading comprehension (Blachowicz & Fisher, 2015; Graves, 2016; Monroe & Orme, 2002; Nagy, 1988; Vacca, Vacca & Mraz, 2014). Unless a person understands most of the vocabulary in what he or she is reading, that person will not be able to understand what he or she is reading (Nagy, 1988; Nilsen & Nilsen, 2003). This could be because the amount of difficult vocabulary found within a text contributes to the text difficulty level (Chall & Dale, 1995; Nagy, 1988).

Vocabulary knowledge is also important because that knowledge allows the ability to make connections to oral and written languages by adding depth to a person's thinking (Blachowicz & Fisher, 2015). Depth and higher order thinking is necessary for a person to grow academically. Vocabulary knowledge is required to be able to have the capacity to reach an individual's full academic potential and to exercise higher order thinking within a content area (Nilsen & Nilsen, 2003). In many cases, vocabulary knowledge can be a factor that contributes to a student's success or failure in school (Graves, 2016; Nagy, 1988; Simmons & Kame'enui, 1997). Part of being successful academically is a student's ability to communicate ideas correctly and effectively. Vocabulary is like the "glue" that hold our thoughts and ideas together to have the means to effectively communicate our knowledge (Rupley, Logan & Nichols, 1998).

Another significant part of a student's academic success is determined by his or her performance on standardized tests. Standardized tests have become a part of every public school student's educational experience. Students will encounter a great deal of vocabulary on standardized tests. For a student to be successful on such standardized tests they will need to have adequate vocabulary knowledge of the vocabulary encountered on these standardized tests (Marzano & Pickering, 2005; Nilsen & Nilsen, 2003).

A person with adequate vocabulary knowledge can have successes that extend beyond the classroom. Marzano and Pickering (2005) claim that a person's success in life can be based on vocabulary knowledge. This is because knowledge and information possessed about any topic is grounded on the vocabulary relevant to that topic (Marzano & Pickering, 2005). A person cannot communicate their ideas to others if the relevant vocabulary knowledge is not acquired (Nilsen & Nilsen, 2003). To give students the ability to become successful in the classroom and later in life a teacher must intentionally teach content-specific vocabulary. Teaching vocabulary is the most effective way a teacher can ensure a student develop the necessary background knowledge to understand specific content knowledge (Marzano & Pickering, 2005).

## Teaching Vocabulary Challenges

Intentionally teaching vocabulary comes with a number of challenges. The first challenge is attitude. There are teachers that do not believe teaching vocabulary should be his or her responsibility due to his or her specific content domain. Teachers across content domains have verbally expressed annoyances of being asked to implement literacy strategies into content-specific instruction (Draper, Broomhead, Jensen, & Nokes, 2012). For instance, a middle-school math teacher expressed frustrations when asked to explicitly teach vocabulary in his math classroom. This teacher believed that teaching vocabulary fell under the duties of the English and language arts teachers. This disgruntled teacher formed the argument that by teaching vocabulary in a mathematics classroom takes away valuable instructional time (Dunston & Tyminski, 2013).

Though this teacher should have had the attitude of doing what is necessary for the better of the student, his concerns regarding the loss of valuable instructional time is valid. When intentionally teaching vocabulary, a teacher has to incorporate the instruction into the lesson. Part of this preparation includes designating instructional time for the vocabulary (Greenwood, 2002). When scheduling instructional time for teaching vocabulary the teacher must determine the costs and benefits of utilizing this instructional time. When teaching more difficult concepts and vocabulary, a greater amount of time is demanded of the teacher and the student. However, the benefits of this time surpass the costs. However, the teacher must be able to distinguish which vocabulary words are significant enough to allocate a greater amount of time for (Greenwood, 2002).

In every content area, there are more words that need to be learned by the student than can possibly be taught by the teacher (Graves, 2016). It is important for the teacher to develop the skill of discerning which vocabulary words are significant enough to teach. The number of words specific to each content area is overwhelming. This becomes a challenge for teachers to deliver instruction on all subject specific vocabulary. This is why it is important for teachers be able to discern which vocabulary is the most significant. Teacher can develop this discernment by asking if the vocabulary is relevant to the content material and how useful it is. Also, by analyzing if the students would learn this vocabulary in context or without receiving direct vocabulary instruction. Finally, the teacher can determine how the vocabulary will affect the motivation of the students (Blachowicz, Fisher & Watts-Taffe, 2005).

The challenges in teaching vocabulary will vary across the content areas. Each content area will have specific vocabulary relevant to that content domain. When a large number of words are unfamiliar to a student in a content domain, an obstacle has been created for the student to have the ability to make connections to prior knowledge. This, then, creates challenges for the students to comprehend and gain new knowledge in the content domain (Kieffer & Lesaux, 2010).

## Mathematics-Specific Vocabulary Challenges

Vocabulary in the mathematical content domain is unique because much of the vocabulary has both general and specific meanings. Many specific vocabulary terms have to be taught in a meticulous manner for precision (Shanahan & Shanahan, 2008). Reading in mathematics requires skills that students may not have used in other content areas (Barton, Heidema, & Jordan, 2002). Also, the vocabulary exposed to in mathematics are not used in everyday language or other content areas. Therefore, the opportunity to practice the newly procured terminology is rare and creates its own challenges in mastering the new knowledge.

Another particular challenge this new vocabulary presents for students is the number of terms that are homonyms. These are words that are spelled the same but represent a different meaning across other content areas. A student may be familiar to particular vocabulary terms in the context of another content domain. But the meaning of such vocabulary terms may remain foreign to the student in the context of mathematics (Smith, Angotti & Fink, 2012). When a student is exposed to these homonyms in the context of mathematics, it may be difficult for the student to decipher how the word applies to the content of mathematics when the student is already familiar with the term in the context of other content. Some examples of words that have different meanings across various content domains are: even, expression, factor, legs, or, origin, pie, point, product, right, and set. To add to the difficulty, there are terms in mathematics that have different meanings across different topics being discussed. For instance, in elementary school setting or a high school classroom, a student may be studying a square. In the elementary school setting a square is a polygon with four sides. But, in a high school math classroom, a student may not be encountering square that is a polygon with four sides. Instead, the student could be encountering the vocabulary term square that is the product of a number or polynomial multiplied by itself. Requiring students to decipher between the appropriate meaning of the encountered homonym is another challenge in mathematical vocabulary.

A student must also distinguish the meaning of these sometimes ambiguous terms in the context provided when solving word problems. Even a student who has mastered the mathematical computations will fail at solving word problems if they do not possess the adequate vocabulary knowledge. The student will need to be able to read the problem, interpret the problem and what it is asking, and rewrite the problem in mathematical symbols for computation (Xin, 2007). Teachers must specifically teach how to read mathematical word problems. Teachers may use generic strategies by saying “and means plus”, “is means equals”, or “of means to divide”. This is not teaching students the procedural literacy needed for solving mathematical word problems, but only giving the student enough to solve the single problem at hand (Kenny, Tuttle, Metsisto, Heuer, & Hancewicz, 2005). Why do mathematics teachers often only give students enough instruction to solve only the problem they are working on and not strategies to solve word problems in the future? It is because teachers have not had the training or do not know how to teach vocabulary and literacy in his or her content domain (Draper et al., 2012). The National Council for Teachers of Mathematics (1996) addresses this common predicament by advising mathematics educators that it is the teacher’s responsibility to teach students to have procedural literacy and how to read mathematical sentences. Teachers do not always recognize the importance of this because of the amount of numbers and symbols in math. However, the vocabulary that corresponds to those mathematical sentences and symbols must be intentionally taught for the students to develop the comprehension needed to become proficient in the content (Elliott & Kenney, 1996).

## Ineffective Vocabulary Instruction Strategies

A teacher can intentionally teach vocabulary and still be unsuccessful in getting the results intended. This usually happens when ineffective strategies are used to teach vocabulary. One ineffective strategy is the use of some memory devices or puns. According to Nilsen and Nilsen (2003) using puns are not teaching the student the vocabulary, but instead teaching them a pun. The student may learn the pun but the student will not be able to apply the vocabulary in context because the student is not learning the depth of the meaning of the word. The student must use the word to be able to learn it (Nilsen & Nilsen, 2003).

Ineffective strategies can unknowingly take place by trying to help the students gain a conceptual understanding of something also. Starting early in elementary school, teachers with good intentions begin teaching improper uses of words. For instance, teacher will refer to a numerator as a "top number" or a denominator as a "bottom number". Teachers have even used offensive references such as "Dolly Parton fractions" instead of the correct terminology, improper fractions. This poor conceptual foundation contributes to a student's lack of understanding and commonly creates a student's negative attitude toward math (Castellon & Buck, 2009). By teaching students what the teachers may perceive as easier words, educating the student has actually become more complicated because the student now must unlearn the improper terminology and learn the proper terminology.

Again, with good intentions, teachers have also provided the students the new vocabulary terms in multiple, acceptable contexts and ask the students to choose the most appropriate one. This is also commonly found on standardized tests. Having the student choose from multiple prompts that contain the new vocabulary term used in context is not an effective vocabulary strategy. This is not an effective strategy because students are spending a great deal of time reading and deciphering out of all of the acceptable contexts, which representation is more appropriate than the other. More detrimental than wasted time, the student may form a distorted perspective or a misconception about the meaning of the word from these types of activities or assessments (Nilsen & Nilsen, 2003).

The use of a dictionary has been a vocabulary instruction strategy for decades. The sole reliance of a dictionary for students to learn new vocabulary is now a known ineffective strategy. A dictionary can be used to enhance vocabulary instruction but the using the dictionary as the only tool of vocabulary instruction is an ineffective strategy because the words are superficial and do not become meaningful to the student. It is likely that the students will forget the written meaning of the term shortly after they read it (Barton, Heidema, & Jordan, 2002; Greenwood, 2002; Nagy, 1988). Even if the student is able to remember the definition of a word, it is unlikely that the student will be able to apply the term based solely on a definition because the definition only gives a small insight of the word (Monroe & Orme, 2002). For a student to understand a word, the student must have the ability to integrate the new word in his or her prior knowledge of other concepts and terms (Greenwood, 2002).

Another ineffective strategy commonly used is providing the student the new vocabulary in a sentence and asking the student to determine the meaning based off of context clues. This is a common strategy used among educators. Without having any prior knowledge of the vocabulary term, the students may determine nonsynonymous words that appropriately fit into the context provided. This often leads to misconceptions about the meaning of the new vocabulary term by creating incorrect connections between the new term and another term that fits into the provided context (Nagy, 1988). However, if the two previous ineffective strategies are combined they create an effective strategy. An effective strategy is created by this combination because it provides students a new word in context to decipher its meaning and it also provides the student the definition of the unknown word. The combination of the two strategies allows the student to weed out the misconceptions they may have formed when only using one of these strategies without the other (Nagy, 1988).

## Effective Vocabulary Instruction Strategies

There are a variety of effective strategies that teachers can use during instruction to allow students to develop new vocabulary knowledge. For students to learn new vocabulary they must "encounter the words in context more than once to learn them" (Marzano, Pickering, & Pollock, 2001, p.124). The students must have multiple opportunities to use the vocabulary verbally and in writing to fully comprehend the new term and obtain the knowledge of how it is conceptually related to other words (Marzaon, Pickering, & Pollock, 2001; Vacca, Vacca, & Mraz, 2014). One strategy that allows students to encounter vocabulary in a written manner on multiple occasions is having the students write journal entries to communicate their mathematical ideas using accurate mathematical vocabulary to do so. This allows the students to increase their depth of understanding and allows them to ask and answer questions they may have regarding the concepts encountered (Thompson & Rubenstein, 2000).

Another written strategy that is effective is having the students create songs or poems with the vocabulary. This can be appealing to students across multiple intelligence domains. Teachers have found this to be an effective strategy when students do this activity independently or with a partner. Allowing the student to create writing utilizing the vocabulary makes the vocabulary become meaningful to them personally and increases the retention of the word and its meaning (Kucan, Trathen, & Straits, 2007).

Effective vocabulary instruction will not take place in isolation, it will take place in context of the content instruction (Blachowicz & Fisher, 2015). Effective strategies can be simply displayed on classroom walls as well. Mathematical posters with vocabulary in context and used in examples displayed around the room for student's frequent reference is an effective strategy when accompanied with other effective strategies. When these posters are created by other students the strategy has even greater effects on students comprehension (Kucan, Trathen, & Straits, 2007; Rubenstein & Thompson, 2002).

Research has shown that students learn best when they are actively engaged (Richek, 2006). This is why games are an effective vocabulary strategy. Games engage the student as well as offer them interactive, visual representations of the vocabulary (Shields, Findlan, & Portman, 2005). Vocabulary games can be formed from any number of games the students already know and play. Some games that have been used for effective vocabulary instruction are Pictionary, charades, jeopardy, bingo, concentration, and fake-out (Shields, Findlan, & Portman, 2005, Rubenstein & Thompson, 2002; Stahl & Nagy, 2007).

A popular effective strategy among teachers used across multiple content areas is the use of graphic organizers. Graphic organizers allow students to organize their ideas and concepts of a specific topic. The most effective use of graphic organizers is when the student is directed on how to complete and utilize the organizer (Daniel & Zemelman, 2004; Vacca & Vacca, 2002). Michelle Pendergrass studied the effects of graphic organizers on vocabulary instruction on two pre-algebra classes in a junior high school located in Orem, Utah. The students were randomly assigned to a treatment group and a control group and given a pre-assessment. After teaching a two-week unit on ratios where the control group received definition only instruction and the treatment group received graphic organizers as a vocabulary instructional strategy the students were assessed on a post assessment. The pre-assessment and the post assessment were compared by looking at the overall average score of both groups and the groups combined had a significantly higher average on the post assessment than on the pre-assessment. The two groups were not equivalent when given the pre-assessment. The control group had a mean that exceeded the experimental group by 0.48 of a standard deviation on the pre-written assessment and 0.27 of a standard deviation on the pre-objective test. However, the average score of the groups combined on the post-assessment was significantly higher than the average score of the groups on the pre-assessment. This difference supports that graphic organizers are an effective instruction strategy (Monroe & Huber, 2014). A graphic organizer that has gained popularity because if its effectiveness over the years is the Frayer Model graphic organizer.

## The Frayer Model

The Frayer Model is known for its versatility across content domains. The Frayer Model did not originate as a graphic organizer, but as a seven-step process to analyze and test concept attainment (Greenwood, 2002, Reed & Parhms, 2014). These seven steps were the following:

1. "Give the word and name its relevant attributes.
2. Eliminate irrelevant attributes.
3. Give examples.
4. Give examples of what the word is not (non-examples).
5. List subordinate terms.

6. List superordinate terms.
7. List coordinate terms" (Frayer, Frederick, & Klausmeier, 1969; Reed & Parhms, 2014).

Positive results in reading comprehension were observed among a wide range of reading comprehension levels when utilizing these seven steps. Michael Graves (1985) later reduced the list to six steps and eventually the list was assimilated into a four-square graphic organizer (Graves, 1985; Reed & Parhms, 2014).

The Frayer Model is time consuming and is intended to take place of a several day period of study. It is also suggested that the Frayer Model not be used with all terms in vocabulary instruction. Instead, the teacher should first complete the Frayer Model ahead of time to analyze the effectiveness of utilizing this graphic organizer as a strategy. Other strategies can be used along with the Frayer Model to take a holistic approach to effectively teaching multiple related vocabulary terms encountered in a conceptual unit of study (Allen, 2007). One strategy that the Frayer Model can be used in conjunction with is Marzano's Six-step vocabulary instruction process.

## Marzano's 6-Step Vocabulary Instruction Process

Robert J. Marzano was able to encompass all of the above mentioned effective strategies into a single, effective, research-based vocabulary instruction strategy. Marzano (2004) introduced his Six-step Process for teaching vocabulary as an effective vocabulary instruction strategy after conducting more than fifty studies over the span of five years. The findings of this study showed that the Six-step Process worked on every grade level. It did not specify over what content domains the strategy was studied in the secondary education levels (Marzano, 2004).

Marzano's Six-step Process contains six steps beginning with the teacher introducing and explaining to the new vocabulary term to the student. This is done by providing an example or a definition on an academically appropriate level. The next step is to have the student restate the meaning in his or her own words the way he or she perceives the meaning. It is suggested that the student record his or her explanation in a notebook. The third step the student is constructing a graphical representation from his or her perception of the word's meanings. This step requires the student to think of the term in a completely nonlinguistic way. Then, step four, the students are engaged in discussions involving the new term. Student classify, compare and contrast, and create analogies during the discussion. In step five, the students are given another opportunity to discuss the vocabulary term while refining his or her original explanation in his or her notebooks. The students reflect on his or her own work and compare his or her perceptions with his or her peers'. Finally, in the sixth and final step, the students are engaged periodically in games to review the terms and to reexamine his or her understanding (Marzano, 2004).

Flaws have been discovered in use of Marzano's Six-step Process. Marzano reported that if the students simply restate the definition the teacher provides in step one for his or her explanation of the meaning in step two, the process becomes ineffective. It was also reported that the third step of non-linguistically representing the term is crucial to the process and cannot be skipped or the process will become ineffective. Games are also an essential part to the process because they allow the students to review the term and become motivated about reemphasizing the meaning. After the games, Marzano explains the need to go back over difficult terms in a whole-class discussion (Marzano, 2009).

## Conclusion

Vocabulary is a key to student success. It is a general consensus that there are challenges regarding vocabulary instruction and that mathematics vocabulary possess a set of challenges all of its own. But, a limited amount of recent research has been conducted on specific vocabulary instruction in a secondary mathematics classroom. However, there are a number of research based strategies that are effective across multiple age groups. Because the Frayer Model and Marzano's Six-step Process encompass a number of these strategies into a single specific strategy it would appear that they would be the most versatile and effective across content domains, including mathematics vocabulary instruction.

# Chapter 3

## Methodology and Procedures

Based on the review of the literature concerning research-based vocabulary instruction strategies for mathematics, research was conducted at a specific Northeast Tennessee pubic high school to investigate the immediate effects of two different research-based vocabulary instruction strategies on student academic performance. The research-based instructional strategies implemented in the classroom for this study were the Frayer Model and Marzano's Six-step strategy. Student assessments were compared after each instructional strategy was implemented and completed. This chapter contains five sections: population, sample, data collection instruments, procedure, and research questions.

## Population

This research took place in a semi-rural 9-12 public high school in Northeast Tennessee. The school had 1,351 students enrolled. Of those students, 635 were female and 635 were male. The racial demographics consisted of 94.5% that identified as Caucasian. Students from families that met eligibility criteria for economically disadvantaged made up 71.7% of the student population. The percentage of students who qualified to receive special education services made up 12.1% of the population. The economic demographic for the county the school was located in was characterized as lower middle-class.

## Sample

The sample for this study comprised of one intact Algebra I high school class. The class consisted of 19 students. Of those 19 students, 14 were female and 5 were male. This class was not randomly selected. All nineteen of the students were assigned to this class by school administration at the beginning of the academic semester.

The racial demographics of the participants in this class were 5.26% Hispanic, 15.79% Black, and 78.95% Caucasian. All nineteen of the participants in this class were in their freshman year of high school. The ages of these participants in this class consisted of nine 14-year olds, nine 15-year olds, and one 16-year old.

The academic abilities in mathematics of the participants in this class span across 6 grade-levels. Four of the participants in this class are above an algebra 1 grade-level for academic skills achievement in mathematics. Five of the participants in this class are on an algebra 1 grade-level for academic skills achievement in mathematics. Four of the participants in this class are 1 year below grade-level for academic skills achievement in mathematics. Four participants in this class are 2 years below grade-level for academic skills achievement in mathematics. Two participants in this class are 3 years below grade-level for academic skills achievement in mathematics. One participant in this class is 4 years below grade-level for academic skills achievement in mathematics. Two of the participants in the sample had an Individualized Education Program (IEP) plan in place. One of these participants with an IEP plan is 2 years below grade-level for academic skills achievement in mathematics and the other is 1 year below grade-level for academic skills achievement in mathematics.

## Data Collection and Instruments

Data were collected from using the Star Math Assessment made by Renaissance. Star Math is a short, computer-adaptive assessments that adjust according to each individual student response given. Star Math is used for grades 1-12 and identifies which skills and sub-skills students know, and which skills they're ready to work on next by tracking development in four domain. The four domains are: numbers and operations; algebra; geometry and measurement; and data analysis, statistics, and probability. The Star Math assessment generates data to measure student achievement using a five different types of measurements. The scaled score (SS) uses scores ranging from 0-1400 based on the difficulty of questions and number of correct responses. The SS is useful in comparing student performance over time and identifying student performance in relation to a vertical scale an all criterion and norms associated with that scale. The percentile rank (PR) uses norm-referenced scores ranging from 1-99 that provide the best measure of the student's level of math achievement compared to other students in the same grade nationally. The PR indicates the percentage of student's peers whose scores were equal or lower than the score of that student. The grade equivalency (GE) uses norm-referenced scores ranging from 0.0 to 12.9+ that are based on how a student's test performance compares with other student's performance nationally. The student open growth uses multi-dimensional item response theory to calculate scores ranging from 0-1400 by combining data from all assessment sources creating an overall score for the student. Every time the student takes an assessment using Star Math, the open growth score is recalculated. The Star Math also provides domain scores ranging from 1-100 to estimate the student's percent of mastery skills in each mathematical domain at their current level (Renaissance, 2017). The domain scores for math include three domains in the area of algebra, three domains in the area of functions and one domain in the area of statistics and probability. The scores assigned to the three algebra domains are the domain of arithmetic with polynomials and rational expressions; the domain of creating equations; and the domain of reasoning with equations and inequalities. The scores assigned to the three functions domains are the functions domain of interpreting functions, the functions domain of building functions, and the functions domain of linear, quadratic, and exponential models. The score assigned to the statistics and probability domain is the domain of interpreting categorical and quantitative data.

The students were taught for four weeks using research-based instructional strategies. After two weeks of instruction using the Frayer Model as a vocabulary instruction strategy, the Star Math assessment was given to the students as a post-assessment for the Frayer Model instructional strategy. During the last two weeks of the study, the students were taught using Marzano's Six-step Process as a vocabulary instruction strategy. The students were given the Star Math assessment again as a post-assessment for Marzano's Six-step Process as an instructional strategy. The post-assessments from the Frayer Model as an instructional strategy was compared to the post-assessment from the Marzano's Six-step Process as an instructional strategy. These data were analyzed statistically to determine the effects the Frayer Model and Marzano's Six-step Process as instructional strategies had on student academic achievement in mathematics. These data were also analyzed statistically to determine if there was a difference between the academic performance of boys and girls after receiving the Frayer Model as an instructional strategy. Similarly, these data were analyzed statistically to determine if there was a difference between the academic performance of boys and girls after receiving Marzano's Six-step Process as an instructional strategy.

## Procedures

Before the study began, permission was sought from the principal of the high school. Next, I sought permission from the Institutional Review Board (IRB) at Milligan College. After receiving approval from the IRB a 4-week unit of study was selected that the teacher would use as instruction material to deliver during the study. Materials needed to conduct the study were gathered and the necessary lesson plans needed to implement the study were developed. The study was then carried out in an algebra 1 class at a high school.

As groups were not randomly assigned, this quasi-experimental study used a pretest-posttest design, wherein the students were given the Star Math assessment prior to the experiment in order to establish equivalency between the groups and eliminate possible confounding variables which might threaten internal validity. The results of the assessments were printed and stored in a secure place until needed for analysis.

At the beginning of the selected unit of study, the teacher delivered vocabulary instruction using the Frayer Model as a research-based vocabulary instruction strategy. The teacher using the Frayer Model instructional strategy for the first half of the unit that was equivalent to the second half in difficulty and comprehension. The students completed a Frayer Model graphic organizer template that was provided to them for each Tier 3 vocabulary encountered during the first two weeks of the unit of instruction. To complete the Frayer Model, the students wrote the term in the circle in the center of the graphic organizer. In one box the student wrote the definition of the term in their own words. In another box, the student described the term by listing its characteristics. Then, in the third box, the student gave examples of the term, or algebraic representations of uses of the term. Finally, in the fourth and final box, the student represented non-examples of the term. The students completed the assessment and the results were stored in a secure location until needed for analysis. Instruction using the Frayer Model as an instructional strategy continued throughout the second week of the unit. At the end of the second week the students were given the Star Math assessment. The students completed that assessment and the results were stored in a secure location until needed for analysis.

During the next two weeks of instruction the teacher delivered the second half of the unit using Marzano's Six-step Process of vocabulary instruction as a vocabulary instructional strategy. For each tier 3 vocabulary term introduced the teacher provided a description, explanation, or example of the new term. Then, the students were provided a place in their guided notes to complete the next two steps of Marzano's Six-step Process of vocabulary instruction. After the teacher introduced the new tier 3 vocabulary term, the students restated the description, explanation, or example in their own words. The students then constructed a picture, symbol, or graphic representation of the word next to their description in the place provided in their guided notes. During in-class practice sessions, the students worked in small groups. The students were instructed to discuss all new vocabulary terms introduced that day with their group. The students recorded a summary of what their peers said about the new terms. This summary was collected by the teacher as a form of formative assessment and returned to the students the next class period. An exit ticket was given at the conclusion of every lesson that required the student to reference the terms added in their notes and built onto their knowledge about those terms. At the end of each week as a quiz review, the students were engaged in a game that allowed them to encounter and play with the new terms learned that week. Instruction using the Marzano's Six-step Process of vocabulary instruction as an instructional strategy continued throughout the fourth week of the unit. After the 4-week unit of study was complete, the students were given the Star Math assessment again. The results of this assessment were printed and stored in a secure location until needed for analysis. Upon the completion of the data collection period, the assessments were retrieved from their secure location and were compared for analysis using statistics software. The student's identification was kept confidential throughout the entire process.

## Research Questions and Hypothesis

Research Question #1: Is there a difference in academic performance in mathematics when using the Frayer Model instructional strategy and when Marzano's six-step vocabulary instructional strategy?

Research Hypothesis #1: There is a difference in academic performance in mathematics when using the Frayer Model instructional strategy and when Marzano's six-step vocabulary instructional strategy.

Null Hypothesis #1: There is no difference in academic performance in mathematics when using the Frayer Model instructional strategy and when Marzano's six-step vocabulary instructional strategy.

Research Question #2: Is there a difference in academic performance between genders when they are taught using the Frayer Model as an instructional strategy?

Research Hypothesis #2: There is a difference in academic performance between genders when they are taught using the Frayer Model as an instructional strategy.

Null Hypothesis #2: There is no difference in academic performance between genders when they are taught using the Frayer Model as an instructional strategy.

Research Question #3: Is there a difference in academic performance between genders when they are taught using Marzano's Six-step Process as an instructional strategy?

Research Hypothesis #3: There is a difference in academic performance between genders when they are taught using Marzano's Six-step Process as an instructional strategy.

Null Hypothesis #3: There is no difference in academic performance between genders when they are taught using Marzano's Six-step Process as an instructional strategy.

# Chapter 4

# Results

## Data Analysis

Vocabulary is an important factor in education that is often overlooked in the mathematics classroom. The purpose of this study was to determine the effects of Marzano's Six-step Process strategy and the Frayer Model as vocabulary instructional strategies during vocabulary instruction in an Algebra I class. The study was conducted at a specific Northeast Tennessee public high school. Student performance was measured with computer delivered Star Math assessments by Renaissance. This chapter relates the data organization and analysis.

## Collection of Data

The data for this research were collected from an intact Algebra I high school class in a semi-rural 9-12 public high school in Northeast Tennessee. The participants consisted of a total of 19 students assigned to the class by school counselors at the beginning of the semester. The demographics of the participants is displayed in Table 1. The students were taught a unit that was divided into two halves that were equal in difficulty and comprehension. The students were given the Star Math assessment before instruction on the unit began. The first half unit was taught using the Frayer Model as a vocabulary instruction strategy. At the end of this half unit, the students were given the Star Math assessment. For the last half unit, students were taught using Marzano's six-step strategy as a vocabulary instruction strategy. After the unit concluded, the students were given the Star Math assessment. Data were collected using a computer delivered Star Math assessment by Renaissance.

**Table 1**

Demographic Profile of Participants

| Students | Frequency (f) | Percent (%) |
|---|---|---|
| **Gender** | | |
| Male | 5 | 26.30 |
| Female | 14 | 73.70 |
| *Total* | *19* | *100.00* |
| **Ethnicity** | | |
| Caucasian | 15 | 78.90 |
| African-American | 3 | 15.80 |
| Hispanic | 1 | 5.30 |
| *Total* | *19* | *100.00* |

## Research Questions and Related Hypotheses

To guide the analysis of the data collected for this study, two research questions were considered. Each question was followed by the related research hypothesis and null hypothesis. All data were analyzed using the .05 level of significance.

## Results for Research Question 1

**Research Question1:** Is there a difference in academic performance in mathematics when using the Frayer Model instructional strategy and when using Marzano's six-step vocabulary instructional strategy?

In order to answer Research Question 1, the mean of the scaled scores from the Frayer Model instructional strategy results were compared to the mean scores from the Marzano's six-step instructional strategy results. The mean scaled score for the Frayer Model instructional strategy was 846.26. The mean scaled score for Marzano's six-step instructional strategy was 842.21.

**Research Hypothesis 1:** There a difference in academic performance in mathematics when using the Frayer Model instructional strategy and when using Marzano's six-step vocabulary instructional strategy.

**Null Hypothesis 1:** There is no difference in academic performance in mathematics when using the Frayer Model instructional strategy and when using Marzano's six-step vocabulary instructional strategy.

To determine whether the means were significantly different a paired t-test was conducted. No significance difference was found in the means of the two groups $(t(18) = .316, P = .756)$. The mean scaled score for the Frayer Model instructional strategy $(M = 846.26, sd = 62.93)$ was no different than the mean for Marzano's six-step instructional strategy $(M = 842.21, sd = 51.05)$. Therefore, the null hypothesis was retained. The results are displayed in Table 2.

**Table 2**

Paired t-test for Frayer Instruction Strategy and Marzano Instruction Strategy

| Instructional Strategy | M | SD | df | t-value | Sig. (2-tailed) |
|---|---|---|---|---|---|
| Frayer Model | 846.26 | 62.93 | 18 | .316 | .756 |
| Marzano's six-step | 842.21 | 51.05 | | | |

## Results for Research Question 2

**Research Question 2:** Is there a difference in academic performance between genders when they are taught using the Frayer Model as an instructional strategy?

In order to answer Research Question 2, the mean of the Frayer Model scaled scores of male and female students were computed. The male mean score for the scaled score was 850.00 and the female mean scaled score was 844.93.

**Research Hypothesis 2:** There is a difference in academic performance between genders when they are taught using the Frayer Model as an instructional strategy.

**Null Hypothesis 2:** There is no difference in academic performance between genders when they are taught using the Frayer Model as an instructional strategy.

To determine if mean differences were significantly different, independent samples test was conducted. A Levine's test was conducted to determine if variances were assumed equal.

The Levine's test indicated that the variances were assumed equal for the scaled score ($F = .941, p = .527$). The results of the independent samples test indicated no significant difference between the mean of the scaled scores of male and female students ($t(17) = .150, p = .882$). The male mean scaled score ($M = 850.00, sd = 89.32$) was no different than the female mean scaled score ($M = 844.93, sd = 54.97$). Therefore, the null hypothesis was retained. The results are displayed in Table 3.

**Table 3**

Independent t-test on Gender and Frayer Model Instructional Strategy

| **Gender** | **M** | **SD** | **df** | **t-value** | **Sig. (2-tailed)** |
|---|---|---|---|---|---|
| Male | 850.00 | 89.32 | 17 | .150 | .882 |
| Female | 844.93 | 54.97 | | | |

## Results for Research Question 3

**Research Question 3:** Is there a difference in academic performance between genders when they are taught using Marzano's Six-step Process as an instructional strategy?

In order to answer Research Question 3, the mean of the Marzano's Six-step strategy scaled scores of male and female students were computed. The male mean score for the scaled score was 847.40 and the female mean scaled score was 840.36.

**Research Hypothesis 3:** There is a difference in academic performance between genders when they are taught using Marzano's Six-step Process as an instructional strategy.

**Null Hypothesis 3:** There is no difference in academic performance between genders when they are taught using Marzano's Six-step Process as an instructional strategy.

To determine if mean differences were significantly different, independent samples test was conducted. A Levine's test was conducted to determine if variances were assumed equal. The Levine's test indicated that the variances were assumed equal for the scaled score ($F = .618, p = .443$). The results of the independent samples test indicated no significant difference between the mean of the scaled scores of male and female students ($t(17) = .258, P = .800$). The male mean scaled score ($M = 847.40, sd = 68.85$) was no different than the female mean scaled score ($M = 840.36, sd = 46.21$). Therefore, the null hypothesis was retained. The results are displayed in Table 4.

**Table 4**

Independent t-test on Gender and Marzano's Six-step Instructional Strategy

| **Gender** | **M** | **SD** | **df** | **t-value** | **Sig. (2-tailed)** |
|---|---|---|---|---|---|
| Male | 847.40 | 68.85 | 17 | .258 | .800 |
| Female | 840.96 | 46.21 | | | |

# Chapter 5

## Findings, Recommendations, and Implications

The purpose of this study was to determine the effects of Marzano's Six-step Process and the Frayer Model as a vocabulary instructional strategy during instruction in a high school Algebra I class. The data from this study added to the conversation about which strategy should be utilized in the classroom. The results were examined using paired t-tests and independent samples t-tests. This chapter contains a summary of the findings, conclusion, recommendations and implications from the study.

## Summary of the Findings

**Research Question1:** Is there a difference in academic performance in mathematics when using the Frayer Model instructional strategy and when Marzano's six-step vocabulary instructional strategy?

To answer research question 1, a paired t-test was conducted to determine the effects on academic achievement in mathematics for the Frayer Model as an instructional strategy and Marzano's Six-step Process as an instructional strategy in a high school mathematics classroom. No significance difference was found in the means of the scaled scores from two groups. The mean scaled score for the Frayer Model instructional strategy $(M = 846.26, sd = 62.93)$ was only slightly higher than the mean for Marzano's Six-step instructional strategy $(M = 842.21, sd = 51.05)$, indicating no significance difference. Therefore, the null hypothesis was retained and the findings in this study suggest that the Frayer Model as an instructional strategy is as effective as Marzano's Six-step Process as an instructional strategy.

Past research, as discussed in chapter 2 of this study, indicate that both instructional strategies are effective. However, no research was found comparing the Frayer Model as an instructional strategy to Marzano's Six-step Process as an instructional strategy to determine if one strategy was more effective than the other. The findings in this study were not able to determine a significant difference in the two instructional strategies. When the Frayer Model was implemented as an instructional strategy, many of the participants were disgruntled when the Frayer Model was presented to them because of a past experience the participants shared in another class. These exasperated feelings could have affected the results of this instructional strategy. However, the alleviation that was shared when Marzano's Six-step strategy was not noticeable in the results of this study either. The participants responded that they enjoyed the activities delivered as part of Marzano's Six-step Process. Nevertheless, no significant difference was indicated between the two instructional strategies in the results of this study.

The findings of this study could be the result of the study being conducted over a brief, 4-week time period and focused on a single unit of study. Marzano (2009) stated that there were a number of factors that could cause the Six-step Process ineffective when implementing this teaching strategy. Meticulous care was taken to ensure all of Marzano's steps were implemented in instruction, but it was ensured that the participants were restating the vocabulary in their own words in such a way that it was meaningful to them. It also cannot be said with certainty that the participants created nonlinguistic representations that contained personal meaning. As warned by Marzano (2009), these factors could cause Marzano's Process to become ineffective. However, it is presumed that Marzano's Six-step Process was generally effective, as well as the Frayer Model strategy, because of the displayed impact that was observed.

As expected, both strategies appeared to have an overall effectual impact on the participants as an instructional strategy because the participant demonstrated mastery of the content on the teacher-made unit exam with a class average of 90.5%. Chapter 2 discusses multiple reasons why a particular strategy is effective when implemented. The Frayer Model is a research-based instructional strategy that has been found to be an effective strategy when implemented. This could be because the Frayer Model allows students the opportunity to overcome the challenge of homonyms in mathematics as suggested by Smith, Angotti & Fink (2012) or because the Frayer Model provides the opportunity for students to make the essential connections between mathematical vocabulary and symbols that are needed for students to develop the comprehension needed to become proficient in the content as suggested by Elliott & Kenney (1996). Marzano's Six-step Process is another research-based instructional strategy that has been found to be an effective strategy when implemented. This could be because Marzano's Six-step Process allows students across multiple intelligence domains apply the vocabulary in a meaningful way to increase retention of the word and its meaning as suggested by Kucan, Trathen, & Straits (2007) or because the students become actively engaged with the vocabulary with interaction and visual representations as suggested by Richek (2006) and Shields, Findlan, & Portman (2005). However, the results of this study indicate that the Frayer Model does not have a more significant effect on student academic achievement in mathematics in a high school mathematics classroom than Marzano's Six-step Process. This suggests that both strategies are effective in teaching mathematics vocabulary.

**Research Question 2:** Is there a difference in academic performance between genders when they are taught using the Frayer Model as an instructional strategy?

To answer research question 2, an independent samples test was conducted to determine if mean scale scores between male and female participants were significantly different. The results of the independent samples test indicated no significant difference between the mean of the scaled scores of male and female students. The male mean scaled score $(M = 850.00, sd = 89.32)$ was only slightly higher than the female mean scaled score $(M = 844.93, sd = 54.97)$. Therefore, the null hypothesis was retained. This suggests that there are no significant difference in academic performance between male and female students when taught using the Frayer Model as an instructional strategy.

These findings indicate that both genders of students respond in the same way to utilization of the Frayer Model graphic organizer as an instructional strategy for vocabulary in mathematics. It also suggests that male and female students are similarly affected by graphic organizers a vocabulary instructional strategy and that teachers should not worry about differences in gender when considering the use of the Frayer Model during mathematics vocabulary instruction. However, this study was implemented with nearly a 3:1 ratio of girls to boys. Because of the higher frequency of female participants in the sample size, this could have skewed the results in either a positive or negative direction.

**Research Question 3:** Is there a difference in academic performance between genders when they are taught using Marzano's Six-step Process as an instructional strategy?

To answer research question 3, an independent samples test was conducted to determine if mean scale scores between male and female participants were significantly different. The results of the independent samples test indicated no significant difference between the mean of the scaled scores of male and female students. The male mean scaled score ($M = 847.40, sd = 68.85$) was only slightly higher than the female mean scaled score ($M = 840.36, sd = 46.21$). Therefore, the null hypothesis was retained. This suggests that there are no significant difference in academic performance between male and female students when taught using Marzano's Six-step Process as an instructional strategy.

These findings indicate that both genders of students respond in the same way to the presentation of content specific vocabulary in multiple formats and engagement in activities involving the vocabulary as an instructional strategy for in mathematics. It also suggests that male and female students are similarly affected by Marzano's Six-step Process as a vocabulary instructional strategy and that teachers should not worry about differences in gender when considering the use of the Marzano's Six-step Process during mathematics vocabulary instruction. However, considering the same concern as stated in the results of the second research questions, this study was implemented with nearly a 3:1 ratio of girls to boys. Because of the higher frequency of female participants in the sample size, this could have skewed the results in either a positive or negative direction.

## Conclusion

The purpose of this study was to determine the effects of Marzano's Six-step Process and the Frayer Model as a vocabulary instructional strategy for instruction in a high school

Algebra I class. More specifically, this study looked to add to the conversation of what vocabulary instructional strategies are most effective in mathematics and if there is a difference in effectiveness between the Frayer Model and Marzano's Six-step Process when implemented in a high school mathematics classroom. The results indicated that there was no significant difference between the academic performance of students when taught using the Frayer Model and Marzano's Six-Step Process as an instructional strategy. The results of this study also indicated that there was no significant difference between gender and the Frayer Model as an instructional strategy. Similarly, there was no significant difference between gender and Marzano's Six-step Process as an instructional strategy. Therefore, all null hypotheses were retained.

## Recommendations

The following are recommendations for this study:

1. To better determine the effects of vocabulary instructional strategies in high school mathematics classrooms, future research should look at the use of the Frayer Model and Marzano's Six-step Process as instructional strategies in the classrooms of other mathematics content domains.
2. Future research should include expanding the study of the effects of the Frayer Model and Marzano's Six-step Process in a high school mathematics classroom over the course of at least an entire academic year to have an entire academic semester to implement and use each strategy as well as have a wider variety of content-specific vocabulary to use the graphic organizer with.

3. Based on the lack of difference found in effectiveness between genders, future research should increase the population participants as well as ensure a more balanced ratio of gender to better determine if there is a difference of academic achievement between genders when taught using the Frayer Model or Marzano's Six-step Strategy.

## Implications

1. Mathematics teachers should implement an instructional strategy to teach content-specific vocabulary because it increases the student retention of the vocabulary and increases overall student academic achievement in mathematics.
2. Teachers should not favor implementing one research-based vocabulary instructional strategy over another based the assumption of effectiveness, but should chose the strategy based on students' needs and learning styles.
3. Teachers should not favor one gender over another when considering the implementation of research-based vocabulary instructional strategies in mathematics for their classrooms.

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