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Mathematics Vocabulary: Teaching Tier 3 Language Of Math Fractions To English Learners

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Mathematics Vocabulary:

Teaching Tier 3 Language of Math Fractions to English Learners

by

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A capstone submitted in partial fulfillment of the

requirements for the degree of Master of Arts in English as a Second Language.

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To my family and friends for your continuous encouragement and support. Thank you to my Capstone Committee. Your guidance helped me to complete this project. Special thanks to my husband and mother who were unfailing in their support during my journey.

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CHAPTER ONE: INTRODUCTION

Introduction

Dennis (his name has been changed for the purposes of this paper) was born in El Salvador, and traveled with his family on the arduous journey, including many miles by foot, to America, where he now attends a public school in a diverse suburb of Minneapolis. Dennis is a former student of mine. He was identified an EL (English Learner) in fourth grade. In the classroom, Dennis was learning a math curriculum which combined background knowledge, mathematical content, concepts, and functions, as well as vocabulary. I met Dennis in summer school, where he was my student.

My suburban school district offers summer school specifically designed for ELs. This programming was extended day, where the curriculum included math, literacy and furthering English development. I knew Dennis as an energetic 10-year-old-boy in fourth grade who sought to please his family and teachers but struggled in school. Dennis particularly struggled with math. That summer, the remedial curriculum focused on multiplication, division, and fractions, as these concepts make up the fourth grade curriculum. Many students struggled with these concepts. As the weeks progressed and we moved from multiplication and division to fractions, Dennis's struggles increased particularly with fractions. His struggles centered around confusion generated because he did not understand specific vocabulary terms. Struggles were greatest for word problems.

If a problem contained terms which he did not know, he would become confused and would struggle before he even moved on to the mathematical part of the problem.

As I reflected on Dennis's struggles, I recalled many conversations in my Master's program in ESL about the complexity and diverse nature of issues involved with ELs learning English. For Dennis, part of his struggles stemmed from being a non-native speaker of English who is continuing to learn English, while other struggles stem from his interrupted schooling on his journey to America.

As I reflected on my Master's classes and training as an English Language teacher, I began analyzing why fractions would be so much harder for him as opposed to double digit multiplication and division which combines multiple mathematical procedures including multiplication, division, carrying and regrouping, addition and subtraction. It became clearer to me why he would struggle more with fractions than multiple digit multiplication and division as I analyzed his background, including educational strengths and areas of need.

My certification in English as a Second Language Learner teacher (ESL) is an additional license for me. My undergraduate and first teaching certification is in Elementary Education. I taught upper elementary for five years before furthering my education by pursuing an additional license in ESL, as well as a Master's degree also in ESL. In my years as an elementary teacher, I taught 4th grade for three of the five years, and therefore have the experience of teaching mainstream 4th graders. When I think back to those students and recall their areas of struggle in math, they did not align with Dennis's struggles. He easily completed multiple-digit multiplication and division which involves a variety of mathematical concepts and abilities. This kind of math is not

linguistically dense, especially if the problems are number problems. Even if they are word problems, EL students can be taught to first identify the numbers needed, and then identify the kind of math they will need to do to solve the problem.

Multiple digit multiplication and division are straightforward mathematical concepts requiring mastery of multiple mathematical functions, as well as accuracy. However, this is not the case for fractions. Although fractions can also be added, multiplied and divided which includes multiple mathematical functions, initial fraction work is much more linguistically dense.

Non-linguistically dense word problem

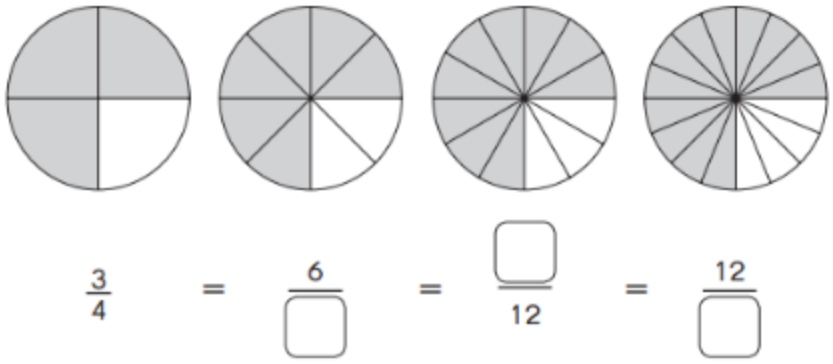

Figure 1. Math in Focus: Student Workbook, 2009, p. 94.

Figure 1 shows an example of a mathematical problem in a fractions unit from Math in Focus 4th grade curriculum. Students are to read the instructions, look at the picture models and complete the problems. This kind of problem is linguistically easy because the blank spaces make it clear for students that they need to find the missing numerator or denominator.

However, problems are more linguistically dense. Students may need to know the difference between fraction math terms like improper fraction and mixed number. For

example, Dennis encountered difficulty when it came to understanding directions like: "Add. Express each answer as a *mixed number* in *simplest form*" (Math in Focus: Student Workbook, 2009, p. 155) for such problems as $\frac{4}{9}+\frac{2}{3}$. For these problems the denominators must be the same so the fraction $\frac{2}{3}$ must be made to have the denominator of 9 before it can be added. Dennis was able to do the math, but failed to put his answer in the correct form as dictated by the instructions. He wrote $\frac{10}{9}$ instead of making that improper fraction into the mixed number of $1\frac{1}{9}$.

The summer school where Dennis was my student was a remedial summer school. These students had already attended 4th grade and had already been taught this specific vocabulary for this unit. It became clear to me that it was not the mathematical functions that caused problems for Dennis, but the wording of the questions and the use of the specific content terminology vocabulary words that he had never really understood and so they continued to cause him trouble. A generalist teacher checking this work may have assumed that Dennis was still struggling to understand the concept of fractions, rather than concluding that he was struggling with the intricacies of very specific mathematical terms instead.

My former mainstream students who struggled in math usually struggled with multiple integer division which combines multiple mathematical functions. These students did not struggle with introductory fractions, but may have struggled when the fraction work included mathematical functions. In contrast, Dennis struggled with introductory fractions. I believe the difference in their areas of struggle in mathematical concepts is because of the linguistically dense nature of work with fractions, especially

the increased number of vocabulary words associated with fractions. In addition to the vast number of vocabulary words associated with fractions, the terms used with fractions (e.g., numerator, denominator, mixed number, and equivalent fractions) are usually not used outside of work with fractions.

I reasoned that fractions were more difficult for Dennis, and for other EL students with whom I have worked in a pullout math group, because of the linguistically dense nature of fractions. My hope is to further research and analyze the unique needs of ELs and develop as curriculum addendum which can be added to the current fractions unit taught in my district.

Topic Statement and Research Questions

This capstone paper seeks to answer three essential questions. I am investigating math vocabulary instructional approaches in the upper elementary classroom and best practice strategies with regards to English Learners (ELs). Through this research I hope to identify vocabulary curriculum needs and provide a curriculum addendum for *Singapore Math- Math in Focus* 4th grade fractions unit which will better meet the needs of ELs receiving this instruction. It is my hope that these specific strategies and approaches described and detailed in this capstone can be applied to other math units and will seek to bridge the gap between vocabulary instructional theory and practical application in the classroom. The vocabulary curriculum approaches described in this capstone are applicable to EL elementary teachers as well as to math content teachers. This capstone provides practical application and guidelines of how to teach math vocabulary terms as well as providing numerous enriching opportunities for repeated exposure to content specific vocabulary. This approach can be applied to additional math

units and can be repeated and altered to follow the unit sequence in the mathematics classroom. Many content teachers, especially in the math and science fields, have limited training in the field of ELs. This capstone seeks to provide a framework for teaching unit vocabulary which can be repeated throughout the year.

This capstone will next review relevant scholarly articles and studies on best practice regarding vocabulary instruction with a focus on ELs. Chapter Three lays out methodology for including additional vocabulary activities to allow ELs to have repeated opportunities to interact with unit vocabulary. Chapter Four provides authentic vocabulary practice designed to complement and extend with *Singapore Math- Math in Focus* 4th grade fractions unit for ELs. Chapter Five concludes the paper with reflections on the process of math unit vocabulary instruction and additional opportunities to interact with vocabulary activities specifically designed for ELs. Recommendations for future study and vocabulary curriculum development are also provided and proposed.

Dennis was one of many learners who qualifies for ESL services. As an ESL student he was working not only to learn the content in his fourth grade classroom but also to continue to learn English. His struggles with the specific math terminology used in the fractions unit are not unlike the struggles of his many ESL peers. They also struggle with the vocabulary on top of the content they are learning. Dennis is just one of many ESL students whom I have taught. It became clear to me in my summer school lessons that it was the vocabulary and not the mathematical operations which he was struggling with. When I reflect back onto other ESL learners that I have had as both an ESL teacher and a mainstream classroom teacher I have seen a trend of difficulty surrounding content specific vocabulary.

These students were successful when their needs were being met through scaffolding from the teacher as he/she led the class through the math problems. With the teacher's guidance EL learners were not hindered by the content specific vocabulary because the teacher was displaying 'think aloud' techniques while instructing the students. Through these reflections it has become apparent that students, particularly EL learners, need to be specifically taught the applicable content specific vocabulary before the content teaching is started. In this model, EL students are able to learn and have practice with the new terminology before they are expected to use and understand it when it is combined with the mathematical functions in problems.

CHAPTER TWO: REVIEW OF RELEVANT LITERATURE

Introduction

My observations and reflections led me to believe that the main issue holding back many ELs in upper elementary math classes is the content-specific vocabulary, not the ability to correctly complete the mathematical functions. They were getting a number of problems incorrect, not because of their math ability, but because they are confused by the terminology.

Best practice in teaching vocabulary to native speakers of English is often transferable to the teaching of ELs (J. Krohn, personal communication, December 14, 2016). This literature review will describe practices in vocabulary which are transferable to the teaching of ELs. In this chapter, I will explore what research shows in this area, focusing on two areas of inquiry:

- What are the components of effective elementary vocabulary instruction for ELs?
- What strategies and techniques are recommended in teaching math vocabulary to ELs in the K-8 Setting?

What Are Components of Effective Elementary Vocabulary Instruction for ELs?

An effective vocabulary curriculum ensures experiences for elementary students with words that are unknown (Hiebert & Kamil, 2005) Unknown words comprise a significant portion of the texts 5th grade students and beyond (Hiebert & Kamil, 2005).

ELs are at a disadvantage because they need to simultaneously learn the content and content vocabulary, while increasing their English proficiency as well.

Contains Multiple Exposures

Mathematics involves an astounding amount of reading (Smith & Angotti, 2012). This reading includes mathematics and often thematic, content- specific vocabulary. Therefore, vocabulary instruction needs to be embedded in the teaching of math. Vocabulary instruction, particularly math vocabulary instruction, should be driven by the curriculum unit currently being studied. Publishers of mathematics curriculum break down concepts into thematic unit of study. These units are broken down into concepts, including new material and previously learned material. Many publishers provide introduction teaching, concept teaching, and 'reteaching' concepts which may be difficult for students to understand. Unfortunately, the vocabulary used in each unit is often overlooked. Vocabulary development and instruction is especially important for ELs. "The average native English speaker enters kindergarten knowing at least 5,000 words. The average ELL may know 5,000 words in his or her native language, but very few words in English. While native speakers continue to learn new words, ELLs face the double challenge of building that foundation and then closing the gap" (Colorin Colorado, n.d.)

Several studies describe the essential need for additional vocabulary exposure for ELs (Scott & Asselin, 2003; Mancilla-Martinez, 2010). Techniques and strategies for increasing exposure to content vocabulary are further explored in the recommended strategies and application section of the literature review. These strategies and techniques

provide educators with sound research-supported ways to increase exposure to academic vocabulary through teacher-led and student application activities.

A study in 2003 describes how only 6% of the school day is spent specifically on vocabulary and less than 2% is spent on content-specific vocabulary (Scott & Asselin, 2003). This statistic is very concerning, especially in classroom with a growing number of ELs. Researchers describe students need to know (not simply recognize and/or decode) nearly all of the words they encounter in text for successfully comprehension (Calderon, 2005). This statistic also applies to math. If students do not know the words they are encountering in mathematical word problems, they cannot begin to understand what mathematical operations are necessary to find the correct answer. Nor can they select the correct answer when answer choices are provided. Furthermore, Scott and Asselin (2003) describe the desperate need for additional content-specific vocabulary exposure in addition to meaningful activities that provide supplementary opportunities for ELs to work with and increase their comfort level with the vocabulary.

Relates to Content Material

Isabel Beck is a much respected theorist in the field of vocabulary instruction. Her theories are deeply embedded in the teaching of native speakers of English. However, her theories can also easily be applied to the teaching of ELs. Beck developed and published her Three-tiered approach to vocabulary. "Tier One words are basic and common terms used in everyday communication" (Zwiers, 2008). Tier Two words are "general but sophisticated words used across a variety of domains that mature users use to communicate complex thoughts" (Zwiers, 2008). Tier Three words are "content specific terms" (Zwiers, 2008).

Tier Three vocabulary selections should be determined from the unit of instruction. Vocabulary retention is raised when the terms are chosen based on the unit of instruction as opposed to semantically similar words. Semantically linked example terms include *quick/rapid, sick/ill,* and homonyms (*fair, fare*). The vocabulary chosen should also correspond with the current unit or units of instruction. Example early elementary literacy thematic vocabulary words include *character, setting, chapter, plot, beginning, middle,* and *end*. Erten and Teken (2008) conducted a study describing how students performed more accurately on assessments and learned the vocabulary more quickly when the word sets were not semantically similar, but were instead thematically linked.

Furthermore, a study completed by Mancilla-Martinez (2010) in a fifth grade classroom describes the need for specific vocabulary-targeted instruction with new vocabulary terms. Two student groups were compared. One group received targeted thematic and unit-specific vocabulary introduction, whereas the other cohort learned the vocabulary in isolation. The cohort that learned the new terms with specific thematic-explicit teaching performed better than the student group that learned the new terms in isolation. The content- specific terms for the *Singapore Math- Math in Focus* 4th grade fractions unit are semantically linked because they are used explicitly within the math unit.

Selected Vocabulary Strategically

Careful and deliberate selection of words is a key principle of effective vocabulary instruction Identifying vocabulary in advance helps teachers anticipate the kinds of support needed to make lesson content comprehensible especially for ELs (Harper & deJong, 2004; Lager, 2006). Researchers Smith and Angotti (2012) have

developed a "planning tool for vocabulary instruction called the 5 Cs which [they] developed to help teachers consider which words to teach in content-area classes such as mathematics." (Smith & Angotti, 2012, p. 43). Their 5Cs include concept, content, clarify, cut, and construct. See Figure 2.

Planning for Vocabulary Instruction: The 5 Cs

- Concepts: What Mathematics Words Are in this lesson?
- Content: What Subject-Matter Words Are in the lesson?
- Clarify: Which Words Should I mention of Clarify?
- Cut: Which Words Should I Rephrase or Eliminate?
- Construct: Which Words Should I teach? (Smith & Angotti, 2012, p. 46)

1. Concepts: What mathematics words are in the lesson?				
probability grid	percent conjecture	adjacent outcome	proportional	average
2. Content: What subject-matter words are in this lesson?				
burn rate devastation contained steepness	destruction factor out of control topology	wildfire forest fine density fuel	iteration subdivision moisture material	ignition manipulation vegetation topography
3. Clarify: Which words should I mention or clarify?				
proportional grid aspect factor	outcome contained moisture out of control	adjacent steepness destruction terrain	devastation environment rapidly fuel	intensity forest fire boundary uninterrupted
4. Cut: Which words should I rephrase or eliminate?				
conjecture decaying portion technology	iteration weaves topography vegetation	marshland catastrophic ignition	material subdivision manipulation	desert drainage density

5. Construct: Which words should I teach?		
word	definition or context	when to teach
probability	"How can you reduce the probability of a fire spreading in your home?"	before activity
percent	"If the probability of the fire spreading to an adjacent tree is 25%, what percent of the forest do you think will burn?"	during activity
density	"If the trees are spread out, there is less chance of the fire 'jumping' from one tree to another"	after activity

Figure 2. Describing the 5Cs of Planning for Instruction. Adapted from "Why Are There So Many Words in Math?" by Smith & Angotti, 2007, *The Reading Teacher* 61:2 Voices from the Middle p. 47

The first two Cs help teachers identify words from their math curriculum, the following Cs help teachers decide what to do with these words and how to teach them in class. The third C "Clarify asks teachers to select words from the first two Cs that might cause confusion but are not crucial to the main ideas or concepts in the lesson. These words may simply be mentioned or clarified in class without additional time on them" (Smith & Angotti, 2012, p. 4). According to Shanahan and Shanahan's study "They [mathematicians] decreed the presence of 'extraneous' text in mathematics textbooks." (p. 55). Shanahan and Shanahan described how extra information is often supplied in

math problems, specifically in word problems. These extraneous words should be clarified when necessary as described by Smith and Angotti (2012). If these terms cannot be removed, students should be taught to cross out terms that further complicate the problem and are not essential in figuring out what kind of mathematical operation is needed.

The fourth step *Cut* is designed to help educators remove unnecessary words from their list. These words can be removed or modified in the curriculum and students can cross them out and replace with more comprehensible words to make the content more accessible to learners. The final C is construct. These words were chosen from the first two Cs and should be math conceptual words. See Figure 2 below for an example with the curriculum *On Fire*.

Includes Clear Definitions and Context

"Mathematics vocabulary is unique in that many words have both general and specific meanings, while at the same time key terms must be defined in a precise manner." (Shanahan & Shanahan, 2008, p. 52). Isabel Beck (2002) describes the many drawbacks for simply providing a dictionary definition for new vocabulary. These drawbacks include "weak definitions which means that the definition done not differentiate how the target word is different from other similar words...for example consider *conspicuous* defined in a junior dictionary as 'easily seen'. This definition weakly differentiated conspicuous from the general domain of seen" (Beck, 2002, p. 44). Therefore, if more clarity is needed in the vocabulary teaching of ELs, it is also greatly needed for the EL learner who will need a clear explanation to fully learn and understand new and unfamiliar words.

"One factor that contributes to the complexity of studying word knowledge is the understanding of what it means to know a word. Knowing a word can range from being able to supply a definition to having a vague understanding of its semantic field…there are numerous related facets of knowledge that are not captured by a typical definition" (Scott, 2005, p. 70). Beck (2002) and Scott (2005) shared the opinion that typical dictionaries are often lacking in the complexity of the definitions provided. "Consider *typical* defined as 'being a type' at best a learner might ask 'A type of what?' it is unlikely that a young student would make enough sense of the definition to develop much if any, idea of what *typical* means" (Beck, 2002, p. 44). Finally, the third drawback of typical dictionary definitions describes the limited description of the connotation and denotations of defined terms (Beck, 2002). Beck describes in detail how typical dictionary definitions are not complete and often lack detail and clarity for learners. Instead Beck describes how student-friendly definitions can be created following two principles: "(1) characterize the word and how it is typically used. (2) Explain the meaning in everyday language" (Beck, 2002, p. 44). She provides the example for *improvise,* the dictionary definition describes improvise as "to make, invent, or arrange with whatever is on hand" as opposed to her definition "to make something you need by using whatever is available at the moment" (Beck, 2002, p. 44).

A study was conducted by August, Artzi, and Barr (2016) to determine whether embedded or extended vocabulary is more effective in EL classroom. This study focused on 18 schools conducting an EL summer curriculum program over 5 weeks. This program included daily one hour language arts lessons which focused on increasing academic language in specific content areas (August et al., 2016). See the figure below

for details on the differences between embedded instruction and extended instruction for this study. In embedded vocabulary instruction "definitions that were easy to understand were inserted into the text right after the target word" meanwhile in extended instructional conditions "teachers provided explicit, rich, multimodal vocabulary instruction" [following previous research] (August et al., 2016, p. 379). Results from this study indicate that vocabulary improvement occurred with both the extended and embedded instruction, "although there were greater gains in word knowledge for the words taught with extended instruction" (August et al., 2016, p. 386). It is not surprising that extended vocabulary teaching was more effective; however, it is encouraging that the quickest and easiest way to implement embedded vocabulary instruction was also helpful to ELs.

Vocabulary Instruction for Elementary Grade ELs: Embedded & Extended Instruction

condition	unique methods	common methods
Embedded instruction	·A clear definition of the word followed each target word (e.g., for the target word *interact*: "another interesting thing is how magnets *interact* with each other")	·Target vocabulary was inserted into informational text that was read aloud to students ·Students learned about cognates
Extended instruction	·Meanings were pretaught with picture cards/sentence strips ·Words were highlighted in the text · Students completed glossary entries related to the words ·Words and meanings were posted in a word wall ·Words were assessed at the end of the unit ·Students listened for target words during interactive reading	
Reinforcement	· Vocabulary games with words and pictures were played in groups	

Figure 3. Differences Between Embedded and Extended Instruction. Adapted from "Helping ELLs Meet Standards in English Language Arts and Science: An Intervention

Focused on Academic Vocabulary" by August, Artzi, and Barr, 2016, *Reading & Writing Quarterly,* 32: 373-379.

Draws on Native Language (LI) Cognates

Several prominent researchers described the effectiveness of incorporating native language (L1) cognates in vocabulary instruction and in student application when possible. For L1 cognates to be included in rich vocabulary instruction there needs to be a dominant L1. Many studies describe native Spanish speakers as ELs. Teachers of Spanish-speaking ELLs, should use cognates as bridges to English. (Calderón, August, Durán, Madden, Slavin & Gil, 2003). Spanish speakers are often ELs; however, there is a growing number of ELs who are not native Spanish speakers. The changing face of ELs may make L1 cognates less applicable depending on the classroom makeup. The developmental age of the student, and the literacy ability in the L1 can make cognates a less effective practice for certain ELs. However, teachers should encourage L1 cognates when applicable and helpful to students. Instructors can also provide cognates through the use of cognate websites.

Transference from First Language to Second Language

The use of transference from literate Spanish readers to English readers was researched by Calderón, August, Slavin, Duran, Madden, and Cheung (2005). This study was designed to utilize reading comprehension strategies and knowledge from student's L1 (First language, Spanish in this case) and facilitate the transition into L2 (Second Language, in this case English). Sixteen classrooms were part of this study which included eight experimental and eight control classroom in Texas. All of the students in this study were literate in Spanish and had not endured interrupted schooling or education. "Because students could already read in Spanish, the instructional pace for

teaching English reading was rapid, spending little time on skills common to Spanish and English but stopping to focus on areas in which the languages differ...a major focus was vocabulary" (Calderón et al., 2005, p. 124). They referred to Beck's tiers of vocabulary for their vocabulary instruction and word selection. Their findings indicated that carefully chosen, implicit vocabulary instruction was successful in improving vocabulary knowledge. Additionally, this study also showed vocabulary gains in Spanish for the students involved.

Combines Multiple Strategies

Researchers Kieffer and Lesaux (2007) conducted a study on the effectiveness of including explicit morphology instruction into vocabulary instruction and vocabulary curriculum. The relationship between morphology and reading comprehension had mainly been studied with native English speakers in suburban contexts, Kieffer and Lesaux (2007) researched if this relationship was also accurate with Spanish-speaking English Language Learners. Their research supports the idea that morphology was related to reading comprehension. These researchers felt that students should be instructed to search for the unbound morpheme (roots which can stand alone, example: popular). Then they will also be able to identify the bound morphemes (prefixes and suffixes ex: -re and -ity). With the unbound morpheme identified they are more likely to recognize a word even when there are bound morphemes. The example Kieffer and Lesaux provided is *popularity*, which can be broken into *popular* and *-ity*.

Prefixes and suffixes or bound morphemes should be taught explicitly as prefixes can change the meaning of a word as in *underpaid*. In this example learners need to understand the importance of both morphemes *paid* and *-under* to comprehend the

meaning of this word. Kieffer and Lesaux (date) describe four principles in the teaching of morphology.

1. Teach morphology in the context of rich, explicit vocabulary instruction
2. Teach students to use morphology as a cognitive strategy with explicit steps
3. Teach the underlying morphological knowledge needed, including common Latin and Greek derivatives, both explicitly and in context
4. For students with developed knowledge of Spanish, teach morphology in relation to cognate instruction

Findings from their research include a connection between morphology and reading comprehension, that "students with greater understanding of morphology also have higher reading comprehension scores" (Kieffer & Lesaux, 2007, p. 138). Their research also described how the improved reading comprehension due to morphology instruction for native speakers showed the same growth with Spanish speaking ELs. Kieffer and Lesaux further describe how morphology and reading comprehension work hand in hand. As these students become better readers, they increase both their morphological understanding as well as their reading comprehension skills. They concluded that "students with greater understanding of morphology are more successful at learning academic vocabulary and comprehending text is a strong argument for including morphology instruction in curriculum" (Kieffer & Lesaux, 2007, 138).

Multifaceted Vocabulary Instruction

Several studies were conducted to determine the effectiveness of different singular strategies in vocabulary instruction and increasing vocabulary knowledge in ELs. A study by Kelly, Lesaux, Kieffer, and Faller (2010) explored the effectiveness of a

vocabulary instructional curriculum which combined the use of several strategies. This study was designed to meet the needs of underperforming middle school students, including nearly five hundred sixth grade students, with almost 350 ELs and 130 NS (Kelly et al., 2010). The intervention program included target word mastery, word association, morphological awareness, and word meanings in context. These strategies were aimed at increasing the vocabulary of ELs. The study was multifaceted, including vocabulary instruction and reading comprehension techniques. Results indicate that there were positive gains due to the treatment which included Target Word Mastery, Morphological Decomposition, and Word-Meanings-in-Context (Kelly et al., 2010.)

Furthermore, a study by Carlo, August, and Snow (2005) also investigated the multi- pronged approach and its effectiveness as it relates to vocabulary instruction. Their study focused on the implementation of the instructional intervention "which we referred to as the Vocabulary Improvement Project (VIP) use what ELs do know- their first language-as a starting point of instruction" (Carlo et al., 2005, p. 138). The students' L1, (Spanish for this study) was utilized to access academic vocabulary from Spanish into English. This approach encouraged prior knowledge transfer from L1 to L2. These researchers described that low-reading comprehension in ELs comes from a limited vocabulary. This problem can stem from a "lack of *breadth* of English vocabulary (not knowing as many English words as their English speaking peers), as well as depth (not knowing as much as they need to know about the words that they do know" (Carlo et al., 2005, p. 138). They described the example of the term *handicap*, which a student thought only applied to people and not to situations.

The VIP curriculum included a planned curriculum in addition to an instructional routine. Their curriculum focused on building connections between words, across languages and semantic meaning, as well as morphological study. Their curriculum sought to increase both depth and breadth in English vocabulary instruction. Results indicated positive growth in the VIP classrooms in the fields of word mastery, word association, and polysemy (i.e., multiple- meaning words).

Close Reading & Rereading in Math

Mathematics includes a surprising amount of reading. Story problems are continuing to become more numerous in math curriculum particularly in the elementary setting. Close reading is a reading strategy and process which can be transferred to math. Students are now being encouraged to incorporate close reading techniques into math class. See a detailed description of the components in close reading below. "Close reading is thoughtful, critical analysis of a text that focuses on significant details or patterns in order to develop a deep, precise understanding of the text's form, craft, meanings, etc. It is a key requirement of the Common Core State Standards and directs the reader's attention to the text itself" (Burke, 2014).

Close Reading Techniques

- Focusing on the text itself (careful reading of the text).
- Rereading deliberately (rereading the text as needed to further comprehension).
- Reading with a pencil (underlining/highlighting crucial facts which will later be needed).
- Noticing (and noting) things that are confusing.

- Discussing the text with others (when students discuss texts with others they are able to share ideas and talk through a problem as a team building off each other's strengths and understanding of the text) (Burke, 2014)

Timothy and Cynthia Shanahan (2008) completed a two year study where they compiled "disciplinary literacy that reveals how content experts and secondary content teachers read disciplinary texts, make use of comprehension strategies, and subsequently teach those strategies to adolescent readers." (T. Shanahan, & C. Shanahan 2008, p. 40). Their findings included the usefulness of think alouds and close reading, two approaches which are usually associated as a reading method. According to the Shanahans, "during think-alouds (accurate verbal reflection and questioning of the text which demonstrates a high level of comprehension), the mathematicians emphasized rereading and close reading as two of their most important strategies." (T. Shanahan, & C. Shanahan 2008, p. 49). The results of this two year study by the Shanahans displayed how reading techniques which are usually only associated with language arts should also be used in the mathematics classroom.

Furthermore, one of the mathematicians, from the Shanahans study explained that, unlike other fields, even "function" words were important. 'The' has a very different meaning than 'a,'" he explained (T. Shanahan, & C. Shanahan 2008, p. 49). Students often attempt to read mathematics texts for the gist or general idea, but this kind of text cannot be appropriately understood without close and careful reading. Math reading requires precise reading, each word must be understood specifically in service to that particular meaning" (Shanahan & Shanahan, 2008, p. 49). "Regarding vocabulary, for example, the mathematicians and chemists alike noted the challenge of words that had

both general and specific meanings. The Shanahans described the confusing nature of mathematical terms as they can also be part of regular vocabulary. These terms which have multiple meanings can be confusing to students, particularly EL learners. Unfortunately, the concept of multiple meaning words is often not addressed enough in the classroom. For example, the close semantic relationship between the words fracture and fraction is typically not taught to students.

Shanahan and Shanahan were adamant that the precise mathematical definition[s] needed to be learned — memorized . . . in order to obtain true understanding of the mathematical meaning in contrast to its more general meaning (Shanahan & Shanahan, 2008).

What Strategies and Techniques Are Recommended in Teaching Math Vocabulary to EL in the K-8 setting?

Many theorists have researched and completed studies on the effectiveness of vocabulary instruction and meaningful student activities in regards to reading vocabulary. Unfortunately, there has been considerably less research in the area of math vocabulary instruction, particularly regarding meeting the needs of ELs. However, there are many strategies which are transferable to math vocabulary including semantic mapping, the Frayer Model, interactive vocabulary wall, and others.

Teacher-Led Direct Instruction: Beck's Model for Tier 2 Vocabulary

Isabel Beck is a highly regarded researcher in the field of vocabulary. Her theories describe components of effective programming as well as instructional techniques (Beck, 2013). She developed the three tiers of vocabulary as well as direct instructions on how to teach vocabulary. Beck's tiers and approach to vocabulary instruction are also being

utilized in the EL classroom and in co-taught situations with a classroom teacher and EL teacher (J. Krohn, personal communication, December 14, 2016). Beck's instructional approach begins with a student-friendly definition, oral practice, non-text example use of the term, and ends with questioning techniques for formative assessment

Isabel Beck's Tier 2 Vocabulary Instruction Steps

Procedure: Repeat for each word. A sample is provided below.

1. Provide a student-friendly definition.
2. Give aural prompt (e.g., Say the word with me). Have children repeat word to help build memory for the sound & meaning of the word.
3. Give a non-text example but maintain the meaning of the word (no additional meanings at this point).
4. Ask questions to assess comprehension of meaning. Give guided prompts that help students connect meaning to personal knowledge and then demonstrate comprehension and use of the word.
5. Follow up in the lesson or at other times throughout the week with practice and review activities. (Beck, 2013)

Tier 2 word	context	SF Definition	Aural Prompt	Non Text Reference	question prompt
explore	You're ready to explore lands you've never seen before.	to go somewhere to find something	say it with me	My soon likes to explore the woods near our house to find toads.	What have you explored before? What would you like to explore?
opportuniti es	When you visited the Americas, the explorers	good things that make life easier	say it with me	In our country, everyone has the opportunity to go to school and learn for free	What's a better opportunity: winning $100,000 or getting a job

	discovered many opportunities.				that pays $100,000? Why?
discover		to find something before someone else does	say it with me	In 1849 Gold was discovered in California.	Is this an invention or a discovery? lightbulb? electricity? Mars? car?
determined	Ponce de Leon was determined to make a Spanish colony in Florida	to do something and not give up when its hard	say it with me	The most determined people are those who fail over and over again but keep trying.	Tell me a person you know who is very determines. Why

Figure 4. How to Implement Beck's Tier 2 vocabulary (from B. Erickson, personal communication, August 14, 2016)

Beck's approach to vocabulary instruction is a strategy most closely-aligned with Language Arts vocabulary; however, this strategy can also be applied in the mathematics classroom.

Frayer Model Graphic Organizers

Ann and Thomas Freedman (2016) described The Frayer model as a strategy which utilizes a graphic organizer for vocabulary terms. The Frayer model is often used in Language Arts classes to learn vocabulary, but it is also applicable to vocabulary in other content areas. This technique requires students to (1) define the target vocabulary words or concepts, and (2) apply this information by generating examples and non-examples. This information is placed on a chart that is divided into four sections to provide a visual representation for students" (Freedman & Freedman, 2016, para. 1). Figures 5 and 6 show completed Frayer Model graphic organizers for science and mathematics.

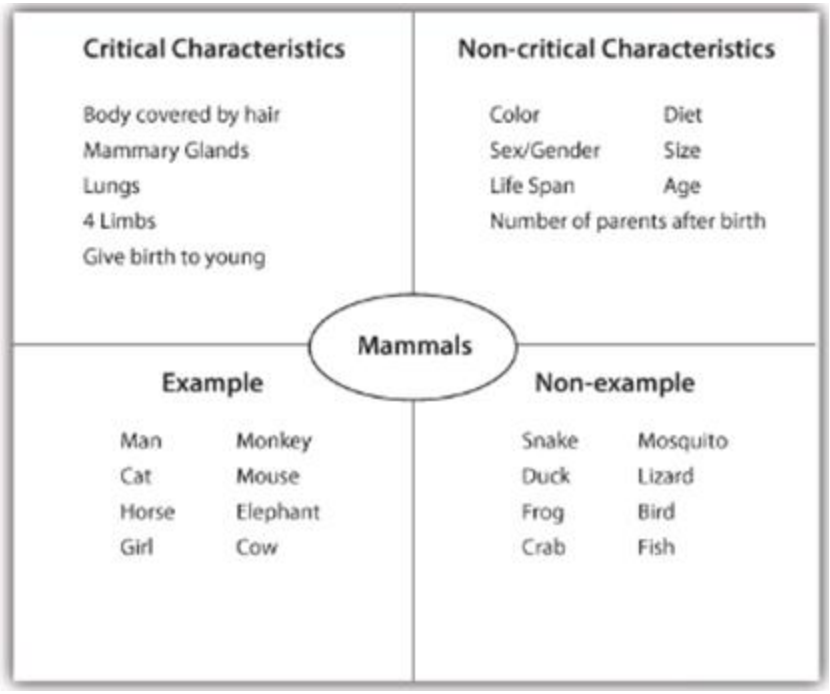

Figure 5. Frayer model example for 'mammals', by http://www.cehd.umn.edu/DHH-resources/Reading/Frayer.html

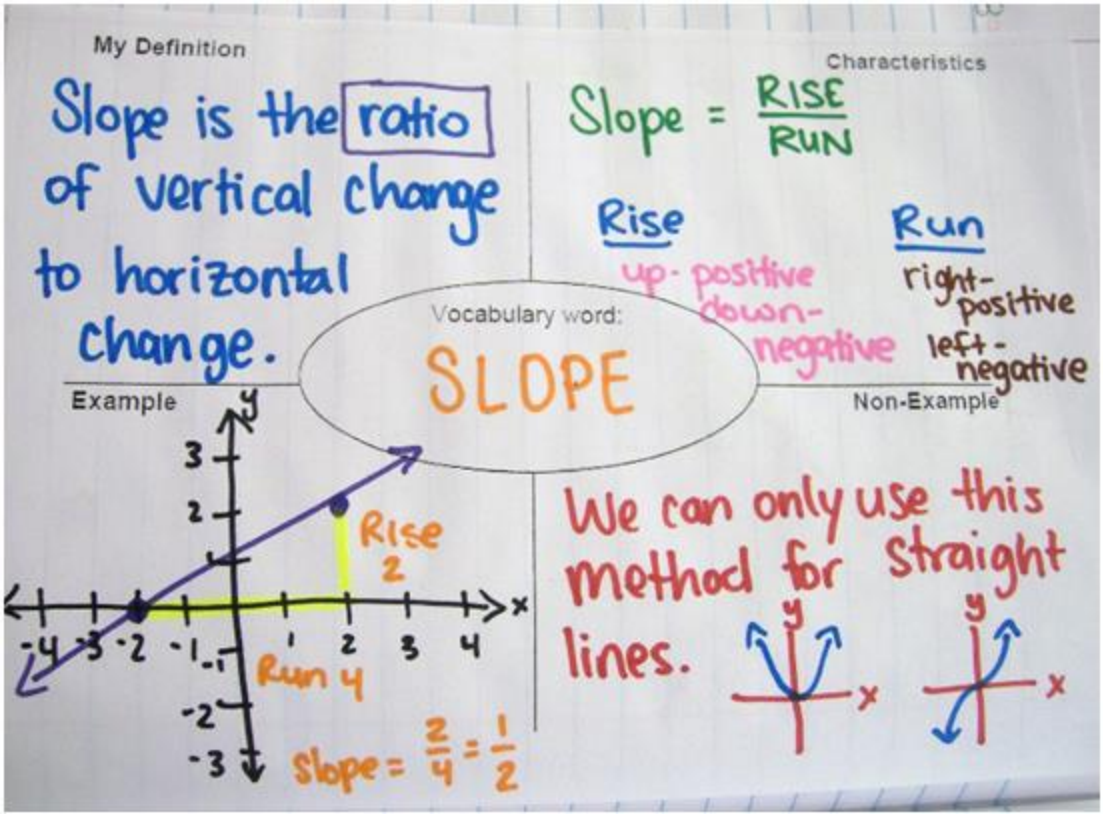

Figure 6. Frayer Model example for 'slope,' by Sarah Carter (2012)

The Frayer Model's effectiveness has been tested in several studies, including a study with fourth grade math students by Monroe in 1997. This study combined the Frayer Model with the Concept of Definition (CD) approach. The CD model "includes examples, important attributes, the class or category of the concept, and a comparison of that concept to others within the same category" (Vacca & Vacca, 1996, p. 5). Monroe and Pendergrass (1997) describe the integrity of the combined Frayer Model and CD Model, "the CD-Frayer Model is one effective method for teaching mathematical vocabulary" (p. 3). This study describes the effectiveness of the Frayer model as an instructional strategy. The effectiveness of the Frayer model is likely due to the four detailed, complete quadrants that include the term's definition, characteristics, examples, and non-examples.

Semantic Mapping

Semantic Mapping is an approach that focuses on building connections between prior (previous learning) and new vocabulary. This approach encourages discussions and flow maps that describe connections in the written form. First the student or teacher selects a word, the next step is to write down as many connections to the word as possible (Johnson & Steele, 1996). Words are then organized in a map form (see Figure 7). Semantic mapping and word maps area valuable tool which encourage students to relate new words to words and concepts they already know (Johnson & Steele, 1996).

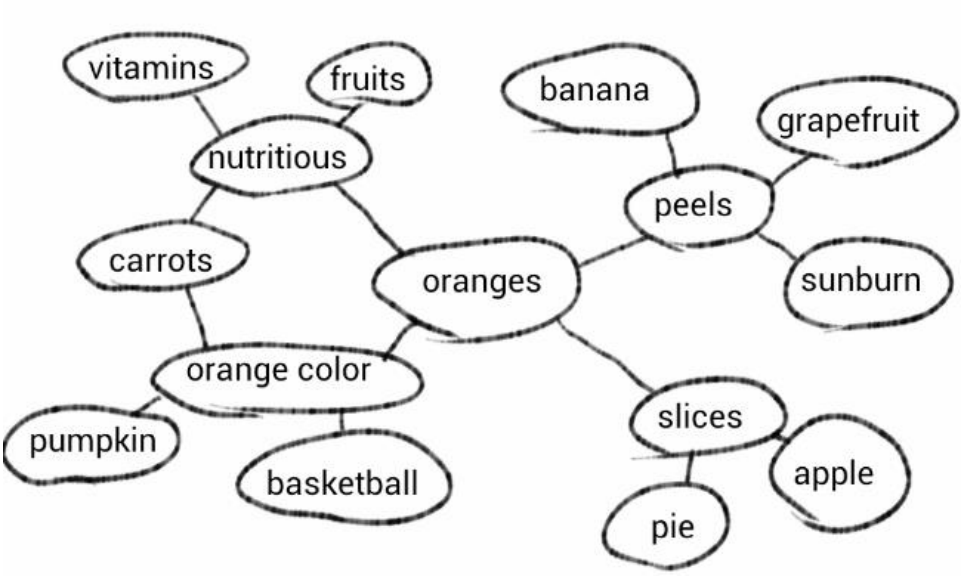

Figure 7. Semantic Mapping example for 'oranges,' by Paul Morris (2012)

The effectiveness of semantic mapping was described by Michael Graves (2006) in terms of previous studies. "The best known and most widely researched techniques (instruction that involves activating prior knowledge and comparing and contrasting word meanings) are semantic mapping" (Graves, 2006, p. 21). Additionally, Graves further described the application of semantic mapping in the classroom through a study with upper elementary students. Johnson, Toms-Bronowski, and Pittelman (1982) discovered that students receiving semantic mapping instruction significantly outperformed their peers who had not received this kind of instruction.

Semantic Mapping stresses the importance of integrating vocabulary into all content areas and into practical life applications when possible. This theory is encouraged by Smith and Angotti (2012). "By thoughtfully selecting words to emphasize, teachers can design introduction to help young adolescents comprehend content-area texts and develop connections between background knowledge and new concepts" (Smith & Angotti, 2012). Semantic mapping provides meaningful cross-curricular and prior

knowledge connections for students (Smith & Angotti, 2012, p. 43). Semantic maps should be used to facilitate the learning of new words is during the vocabulary acquisition (Coady, 1993). Additionally, many vocabulary words are taught in isolation without attempts by the teacher and students to make connections to prior knowledge and to other content areas. Semantic mapping is one way to bridge the gap between new vocabulary terms and prior knowledge, as well as with existing experiences with the term or concept.

Furthermore, researchers Tekin and Ertin (2008) agree on the effectiveness of semantic mapping as a technique to make vocabulary more comprehensible as evidenced by their study. This study centered on the effectiveness of semantically grouping vocabulary words. Their research provides a detailed description of vocabulary study with sixty fourth graders. These fourth graders learned eighty carefully-selected, new vocabulary words. The study described how the words were learned in semantically and non-semantically related families. The results show that students were more accurate and learned the vocabulary more quickly when the word sets were not semantically similar. This is because students were more likely to be confused with semantically similar word sets than with semantically independent sets. Therefore, many researchers including Smith and Angotti (2012), Coady (1993), and Tekin and Ertin (2008), agree on the significance of semantic mapping as part of vocabulary instruction.

Word Walls and Interactive Word Wall

Word walls have been a member of elementary classroom for years. Word walls are displayed on a bulletin boards; they include academic language and vocabulary words. Their intent is to provide visual scaffolding (Jackson & Narvaez, 2013). These terms can be color- coded or in alphabetic-order depending on the grade and intended

use. Words walls can be turned into interactive word walls as described in the science classroom setting by Hooper and Harmon (2015). Interactive word walls increase the daily exposure to keywords with accompanying visual clues this approach helped students develop a deeper understanding of science concepts and vocabulary (Hooper & Harmon, 2015). Hooper and Harmon describe the need to provide engagement beyond the definitional level to create a greater conceptual level of understanding. Students can create these word walls themselves in teams as they interact with this vocabulary. Although this use of interactive word walls is described in the science classroom, it is believed that this approach can be applied to the math classroom. (See figures 8 and 9).

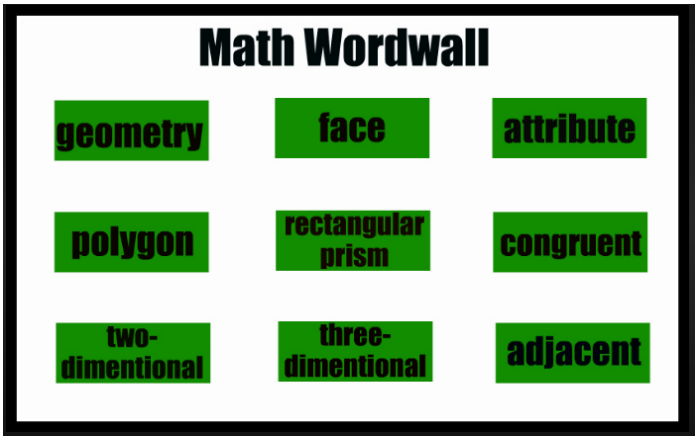

Figure 8. Traditional Word Wall for Math Unit, by Marisa Kaplan (2012)

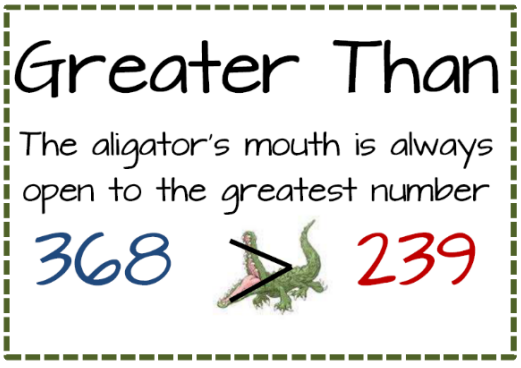

Figure 9. Interactive Word Wall for 'greater than', by Jeri Sandbery (2012)

Interactive word walls can be created and used in a variety of ways. Teachers can pre-generate these word wall words, as shown by the example above. These words can be color-coded by theme and unit to build connections between words. Cognates can also be added to the word wall to increase understanding for ELs. Students can create the interactive word wall; when they create the wall, they take on the responsibility to teach these terms to their peers (Hooper & Harmon, 2015). These words can be described on flash cards including different colors to indicate morphology, and visual clues or symbols around and in the word itself to increase understanding and to build word associations. Students can also create digital word walls, referred to as vodcasts, utilizing technology resources.

Once the word wall is created either in hard or digital copy, by teacher or by students, the teacher can provide additional experiences with the interactive word wall. Students can be asked to create circumstances showing the correct use of the word outside of the usual academic context. For example, the math term *greater than*, can also be applied outside of the mathematics classroom, (e.g., *The president makes a salary greater than I do)*. Similar to semantic mapping, learners can also physically string the terms together showing the connections between them with linking terms. Additionally, students can use the interactive word wall during assessment to encourage using the terms correctly as well as a review tool.

Student Application

Use of cloze reading activities is one technique which has often been used in language arts classrooms. Lee (2008) described the cloze procedure (CP) as text with intentional deletions in content or grammar. Cloze procedure was initially developed as a

tool to measure readability of texts, diagnose reading problems, and check for comprehension. These uses for CP were mainly used in the non-EL classroom. However, there have also been studies showing the effectiveness and usefulness of CP with non-native speakers in addition to native speakers. "In L2 (Second Language) reading research, the CP has been recommended for assessment, although in early L2 reading research, the CP has also been used to measure effects of variables on reading…[such as] background knowledge and text familiarity" (Lee, 2008, p. 650).

According to Lee the use of the CP in classrooms is very effective and can be used to check for background knowledge and text familiarity. "Cloze procedure requires the simultaneous application of vocabulary knowledge, grammatical competence, sentence level decoding, and passage level comprehension [CP creates] even greater degree to the criterion of actual silent reading under normal, contextually constrained, conditions" (Francis, 1999, p. 27). Finally, cloze reading has also been used in the EL classroom as a form of assessment or activity which provides opportunities for additional explicit vocabulary work. See Figure 10 for a cloze reading example with ELs.

Cloze Reading Example: *Friends Fly Together* (text) Instructions: Fill in the blank with a word from the word bank.				
Word Bank				
characters	bus	mood	fly	cellar
away	lesson	alley	sad	air
schoolmaster	cruel	buildings	lonely	friend
bullies	setting	happy	symbol	plot

rocks	Away	

The Red Balloon is a story about friendship. The_____ is in Paris, and the two main_____ are Pascal and his red balloon. The_____, or storyline is very simple. Pascal is a _____little boy. One day as he is walking to school, he is followed by a red balloon. When he tries to put it on the_____, the conductor says, "No balloons on the bus." When it follows him to school the_____ says, "No balloons in school." He even locks Pascal in a _____ because the balloon won't go _____. When Pascal takes the balloon home, his mother shuts it outside. "Go away balloon."

One day Pascal meets a gang of _____who try to take the balloon from him. They chase him down an_____ and over a fence. They are very _____. Some of them throw_____ at the balloon. One hits it, and the red balloon bursts. When Pascal sees his balloon growing smaller and smaller he is very_____ .

Suddenly, all the balloons of Paris appear and to_____ Pascal . He takes their strings in his hands and slowly, slowly he is lifted up into the_____ . Higher and higher he flies over the_____ and into the sky. He has lost his best _____, his red balloon, but he has made many new ones. Pascal is_____ .

The theme, or_____ of this film is *everyone needs friends* , and the balloon is the_____ for friendship. Because Pascal and the balloon love each other, the_____ of the film is happy, too.

Figure 10. Cloze Reading Activity with ELs Example, by Wendy Bell (2008)

The use of translation dictionaries as a strategy to learn vocabulary has also proven effective. However, the learner must be literate in both their first language and English to use a translation dictionary effectively. Gonzalez (1999), and intermediate-

level college professor completed a study involving translation dictionaries for non-native speakers of English as they completed their college classes in American colleges and universities. He had students keep a running journal of words they did not know; they collected these unfamiliar words from current news articles. Fifteen journals were selected and analyzed. The words were categorized into four categories, general utility words, prose, content specific words, and inflected words. Gonzalez (1999) found the use of translation dictionaries as an effective strategy for students. Although this study was completed with college level students, this strategy could also be useful for upper elementary and middle school EL students who are literate in both their first language and in English. This strategy to learn vocabulary is especially useful because the EL students are able to find translations independently, without the need for an instructor.

Summary

This chapter sought to describe and reference previously-completed research and studies involving ELs and vocabulary instruction and classroom application techniques. The relevant research described best practice and effective components of vocabulary instruction, as well as specific vocabulary strategies and techniques which can be applied to the mathematics classroom. Many of the described techniques are borrowed from Languages Arts vocabulary instruction as minimal research has been conducted in the field of mathematics vocabulary instruction.

First, a need for more vocabulary exposure was explored. This need focused on the recognition that ELs need additional and repeated exposure to specific unit vocabulary as well as instructional support from their teacher. Next, the need for content-specific vocabulary was described. Vocabulary should be linked by content rather than

semantically to increase vocabulary comprehension. Content linked vocabulary allows good practice in the classroom. Math vocabulary is already categorized into units which correspond with conceptual units. Finally, teaching practice (direct instruction) and classroom application were explored. Classroom application was broken into two parts, teacher-led activities and application activities which are student-led. Teacher led activities included close reading techniques and Rereading, Isabel Beck's Tier two vocabulary instruction model, Frayer Model graphic organizers, semantic mapping, translation dictionaries (where applicable) and interactive word walls. The following chapter presents and describes the methodology and data collection utilized in this curriculum capstone project.

CHAPTER THREE: METHODOLOGY

Introduction to Methodology and Rationale

Teachers who work with ELs have begun noticing that linguistic complexity is increasingly involved in mathematics. With many pull-out EL math groups, and push-in co-teaching models in use, these struggles have been noticed particularly with regards to vocabulary from the unit as well as the wording of questions and exercises. ELs are learning content material and growing their English simultaneously.

This unit- and content-specific vocabulary plays a crucial role in the understanding and required mastery of the mathematical concepts, and it is often especially difficult for ELs to navigate. They need to learn mathematical concepts, and they also need to be able to read and understand linguistically dense questions and prompts. As a result of limited curricular focus on unit vocabulary, vocabulary instruction was often overlooked by math teachers and is not directly taught to ELs and other students who would benefit from increased exposure to mathematical vocabulary.

As a result of these experiences and analysis, a specific vocabulary instructional guide, including instructional and student application strategies and techniques, has been created as an addition to the current curriculum. Unfortunately, the curriculum did not provide specific guidance to follow to reach the needs of ELs. Therefore, I determined that a curriculum addendum should be created to meet ELs' vocabulary needs.

In reviewing the *Math in Focus- Singapore Math* fourth grade curriculum, the fractions unit was chosen for this curriculum guide because it was particularly dense and rich with vocabulary. Each of the vocabulary terms is very specific and often indicates which mathematical computation to perform to find the correct solution. In my experience working with, and supporting, my pull-out group, I found this unit particularly challenging for my students due to the sheer number of vocabulary terms. The majority of the fractions vocabulary presented in the chapter is not used outside of the fractions unit, and as a result, my students have very limited background knowledge of these terms because they are very specific to fractions work.

I choose to include only using Tier 3 vocabulary terms in my curriculum. This decision was based on fitting the needs of my learners based on their proficiency levels. My student's proficiency levels are 3.5-5, these are upper English proficiency levels. My students need direct instruction on Tier 3 vocabulary terms in their math units. I have seen this need in my pull-out and push-in teaching of these students. The Tier 3 terms I choose were causing difficulty, they did not struggle with Tier 2 words in this situation. The interactive word cards help bridge the gap between abstract vocabulary and concrete concepts. My focus on Tier 3 words is tailored to meet the needs of my higher level proficiency students in a pull out/push in situation. My district EL teachers teach tier 1 and 2 words in pull out stations to support them in their mainstream classes.

According to Koonce (1998) Susana Durto and Carroll Moran, two educational researchers coined the term "brick" and "mortar" to describe types of academic vocabulary words. They use the analogy of building a house to explain the importance of both types of words. Brick and mortar words are needed to build sentences. My students

need help with the brick words (Tier 3) instead of the mortar words (Tier 2). For example, *Circle the numerator*. My students have not struggled with *circle*, or *the*. They struggled with *numerator*. Instead they circled the denominator. This mistake is vocabulary based, there is no mathematical computation needed in this example. The *Math in Focus- Singapore Math* 4th Grade fractions unit includes the terms *fraction, denominator, numerator, equal parts, equivalent fraction, improper fraction, like fractions, unlike fractions, mixed number, simplest form*, and *whole*. Prior to the beginning of this project, an EL curriculum team in the district I am currently working in identified these vocabulary terms as challenging words for ELs.

These terms were selected by the district teacher committee in the summer of 2014. Members of this committee included EL teachers, elementary classroom teachers, and math leads. Math leads are teachers who have received specialized math training in Singapore Strategies, the main component of *Math in Focus*, the math curriculum which this district uses. The terms were selected through careful analysis of language used in the teacher's guide and student workbooks. The committee carefully reviewed the content language ELs would be exposed to and cross referenced this with the terms used in previous grades to select the vocabulary words for this unit. The committee also reviewed released Minnesota Comprehensive Assessment (MCA) math material provided by the Minnesota Department of Education (MDE). The committee determined that all of the fractions words selected from the Singapore Math curriculum are typically used on the MCA assessment. Review of the MCA math test suggested that ELs also be taught the word "number line" so the curriculum team included this term in the recommended fractions vocabulary.

I followed a similar process to select the terms I wanted to include in my curriculum unit. I started with the list generated by the committee. I kept all of the terms selected by the committee minus number line. The term number line was included in the list generated by the committee. I, however, determined to remove this term because students in this district have been exposed to this term since kindergarten starting with the idea of *one more (adding one)* and *one less (subtracting one)* from the number of the day. Additionally each classroom has a number line posted which teachers should be using as a reference.

While having the key vocabulary terms identified by the EL curriculum team was helpful, approaches and specific guidance on how to teach and interact with this vocabulary were not provided. Therefore, I sought to create a curriculum addendum to provide structured guidance and opportunities for additional student interaction with these terms. The ideas and procedures in the addendum could be duplicated with additional unit vocabulary.

The curriculum addendum (presented in Chapter Four) has been created to meet the needs of ELs and to be used in conjunction with *Math in Focus- Singapore Math* 4th grade fractions unit. This chapter provides important context about how and why the addendum has been developed. First, the setting, audience, and necessary materials are described. Next, rationale for the curriculum unit activities, direct teaching techniques and conclusions are described. The goals of the curriculum resource are also referenced. Finally, the components of the curriculum addendum are described in detail.

Setting and Audience for the Intended Curriculum Addendum

The setting for this curriculum addendum is for classrooms where *Math in Focus-Singapore Math* 4th grade Fractions Unit is being used. The primary audience for this addendum is English Language teachers who are supporting their EL students through either the pull-out, push-in, or co-teaching models. However, it can also be used by mainstream math teachers to provide specific support to ELs and other students who need additional vocabulary work and practice. The addendum provides specific activity and practical vocabulary teaching strategies for the fractions unit. These strategies provide a framework that can be altered to fit the vocabulary of other units.

Elementary school ELs in my district are a diverse group of learners. They qualify for EL service due to their scores on the WIDA W-APT screener and ACCESS exams. Most of these ELs are Somali, in addition to a much lower number of Spanish-speaking and East Asian students. The K-6 Somali student population in this suburb is made up of first and second generation immigrants who are not literate in Somali. Consequently, vocabulary instruction strategies that rely on the incorporation of native language (L1) reading and writing skills (e.g., translation dictionaries and providing written native language cognates for English vocabulary words) are not useful for this population. These circumstances are the same for our Spanish-speaking and Asian EL students. They use the L1 in their homes and are largely bilingual in listening and speaking, but are not literate in their first language. Regardless of ELs' language background, the majority of the district's elementary students have attended American schools since kindergarten and have had no formal instruction in their native language. (Applicable strategies and instructional techniques will be further explored later in Chapter Three.)

Goals and Objectives

This curriculum addendum seeks to provide the necessary extra focus on math content vocabulary for ELs through instruction and application. The addendum was designed to meet the needs of ELs through specific direct instruction in the teaching and introductory part of the *Math in Focus- Singapore Math* 4th grade Fractions Unit in addition to specifically added vocabulary exercises which provide additional much needed exposure and opportunities to work with unit vocabulary. ELs need explicit vocabulary instruction as well as additional opportunities to interact with the text. The aim of this capstone addendum was to meet this need. This curriculum addendum is also intended to provide a framework of integral vocabulary teaching and activities which can be utilized in the EL and mainstream classroom. This framework can also be adapted and reused during additional math units and in other vocabulary rich contexts.

Literature Review Implications

In the research and professional teaching literature (see Chapter Two), numerous instructional techniques and components, as well as student application strategies, were described. When deciding what to include in this addendum, these techniques, components, and strategies were analyzed as to their effectiveness with ELs who have similar characteristics to the students in my district (e.g., minimal native language reading and writing skills, limited formal schooling in the native language). This section presents the literature-based strategies that were chosen for inclusion in the curriculum addendum, and those that were not.

Format and Design

The curriculum addendum is separated into four tasks that support ELs' vocabulary acquisition in the field of mathematics. The first three tasks are teacher led activities, including an interactive word wall, the Frayer Model graphic organizer, and semantic mapping. The final task is the cloze reading activity, which is student application. Cloze reading can be done independently or in pairs/small groups depending on the preference of the instructor.

Applied Strategies and Techniques from Literature Review

Scott and Asselin (2003) described the need for additional vocabulary exposure, as a shockingly low amount of the school day is typically spent on vocabulary instruction. In this curriculum addendum, the need for increased vocabulary exposure by using multiple instructional techniques and strategies to reinforce the meanings of words.

Another important concept from the literature that has been incorporated into the curriculum addendum is the use of vocabulary words in context (Mancilla-Martinez, 2010) Context was provided in the addendum through the inclusion of three main components: (a) semantic mapping activities Smith and Angotti (2012), Coady (1993), and Tekin and Ertin (2008), (b) Frayer Model instruction (Ann &Thomas Freedman (2016)) and student discussions, and; (c) Beck's Tier 2 Instructional Approach. Semantic mapping is an activity which activated and connects prior knowledge to new vocabulary terms.

Because there is limited research on vocabulary instruction in mathematics, three vocabulary instructional techniques and student application activities have been borrowed from the language arts literature. First, morphology instruction (i.e., instruction in word

parts; Jackson, 2011), where applicable, will be addressed through the implementation of an interactive word wall. Second, the inclusion of a multifaceted approach to vocabulary instruction that is recommended in the language arts literature is addressed through the multiple activities including: the use of Beck's Model of Tier 2 vocabulary, semantic mapping, the Frayer Model, close reading assessment activity and an interactive word wall.

Non Applicable Suggestions and Techniques from Literature Review

Due to limited native language reading and writing skills among my school's elementary ELs, some of the suggested techniques and strategies from the literature review cannot be included in the curriculum addendum. One such example is the use of translation dictionaries (Gonzalez 1999). The use of translation dictionaries is not applicable because the student population is not literate in their first language. Consequently, the use of translation dictionaries would be not be appropriate for this student group. Additionally, the inclusion of Spanish to English cognates is also not applicable, due to the very limited number of Spanish-speakers among our enrolled students. The Somali language has few cognates with English (A. Khalif, personal communication, December 9, 2016). Furthermore, although these students are socially bilingual, they do not have academic vocabularies in their L1 because they did not attend schools outside of the United States.

Teacher Led Instructional Activities

Frayer model graphic organizers, semantic mapping, and interactive word wall activities are intended to be completed with a large group, or at least introduced and discussed in a whole group setting. The Frayer Model graphic organizers should be used

during the first introduction to vocabulary words. First, the Interactive Word Wall terms will be introduced and taught one at a time. Then, the Frayer Model graphic organizer can be hand drawn or copied and glued into the interactive notebook depending on the preferences of the teacher and students. A graphic organizer with the student-friendly definition is provided in Chapter Four.

After students have completed a few of the initial exploration tasks (Frayer mode and interactive word cards), and have begun interacting with the term, these experiences will lend themselves nicely to the semantic mapping activity. The semantic mapping should be introduced in whole group, when the first vocabulary word, fraction, is introduced. Students will draw the semantic map as guided by the instructor. They are encouraged to list and describe past experiences with the concept of fractions. This format will be repeated to accommodate all of the vocabulary terms for this *Math in Focus- Singapore Math* 4th grade fractions unit.

Student Application

Two student application activities are included in the addendum. First, to activate connections between the fractions unit of study and students' prior knowledge including connections in daily life outside of math, a cloze reading activity has been created. This activity is designed to be used near the end of the unit as an informal vocabulary assessment. Second, a real-world cooking activity is designed to integrate mathematical vocabulary practice by following a recipe.

Conclusion

This chapter has presented the methodology used to create this curriculum addendum. Four specific vocabulary tasks were designed and described indicating how

they would meet the needs of ELs (the need for additional exposure to and direct teaching of unit vocabulary). These tasks were supported by research described in Chapter Two, the Literature Review. The following chapter presents the materials to be included in the with the *Math in Focus* 4th grade fractions unit.

CHAPTER FOUR: CURRICULUM INTEGRATION

Overview of Unit

This curriculum addendum is intended to be used at the beginning of the 4th grade *Math in Focus Fractions* unit. The components are intended to be utilized as introductory teaching elements to teach vocabulary specific to the fractions unit. The interactive word wall terms should be taught first, followed by the Frayer Model organizer, then the semantic mapping is to be completed. The interactive word wall is a teacher led activity, describing the graphics and characteristics of each word card. The Frayer Model and semantic mapping activities are teacher led which include rich student discussions to complete the graphic organizers. Finally, the cloze reading is to be completed last. Cloze reading can serve as an informal assessment that is completed individually by students or in a small group setting depending on the preference of the teacher.

Lesson Design

My focus on Tier 3 words is tailored to meet the needs of my higher level proficiency students in a pull out/push in situation. My curriculum unit was designed to meet the needs of my specific students based on their needs. Brick and mortar words are needed to build sentences. My students need help with the brick words (Tier 3) instead of the mortar words (Tier 2). For example, *Circle the numerator*. My students have not

struggled with *circle*, or *the*. They struggled with *numerator*. Instead they circled the denominator. This mistake is vocabulary based, there is no mathematical computation needed in this example.

I do not advocate for only Tier 3 instruction. Tier 2 instruction should also be taught as described in Chapter 2. My curriculum unit includes only Tier 3 terminology because this caused the struggle for my students. They did not struggle with Tier 2 words.

The purpose of this capstone is to provide a framework utilizing sound teaching theory in vocabulary instruction. To reach this goal several curriculum addendum pieces were created to complement the current curriculum in use. The following paragraphs present the framework and detailed descriptions for each of the curriculum addendum components. Strategies and techniques were collected and assembled to fit the gap in targeted vocabulary design.

There are four components to the supplementary vocabulary lessons for the fractions unit: (a) an interactive word wall, (b) the Frayer Model graphic organizer, (c) semantic mapping, and; (d) a cloze reading activity. Each activity incorporates the vocabulary in a different way. The interactive word wall is the initial introductory activity. The addendum provides fractions vocabulary cards that contain visuals, pictorial representation, examples and clear definitions for each term. These interactive word cards are intended to be introduced and used as a reference point throughout the duration of the unit. Next, the Frayer Model brings in much needed rich discussions. With this graphic organizer teachers and students describe the vocabulary term using a relevant definition,

examples, non-examples and characteristics. The third teaching piece is the semantic mapping strategy. This strategy is used once students have been introduced to the term and have been working with it in context. Semantic mapping encourages connections between terms, and across content areas. The final component of the curriculum addendum is the cloze reading activity. Research describes the merits of building connections between terms and across content areas. With a cloze reading activity students are able to practice and interact with the vocabulary terms in a manner separate from their traditional interactions with the vocabulary in math problems.

Interactive Word Wall Terms

The vocabulary terms for the unit are included below. These terms include the following words: 'fraction, denominator, numerator, equal parts, equivalent fraction, improper fraction, like fractions, unlike fractions, mixed number, simplest form, whole and number line. The terms are included in the order in which they are introduced and used in the fractions unit, and the terms are intended to be taught in this order. To aid in organization, the vocabulary word cards are also numbered in the same order in the bottom right corner. Each term includes a short narrative describing the images, graphics, and color choice used with each card to show and describe the meaning of the word. Figure x shows an example of a word wall card for the word fraction.

The below word wall cards can be used in many different ways depending on their intended use. First, they can be used to introduce new vocabulary. As an introductory tool, they describe the term in student friendly language and provide visual aids which are part of the terms themselves. A copy of the terms should be printed for the classroom word wall. A set of cards can also be printed for student use, as a personal

dictionary of terms in a small ring binder which can continuously be updated. The copy on the classroom wall should be referred to when the term is used in problems as an easy reminder of the word's meaning and visuals to associate with the term. The classroom set can also be presented as an example where students generate their own word cards which are meaningful to them, L1 translations can also be included if meaningful to the student. Finally, a set can be printed for classroom use. The teacher can cut off the definition for each term so they can be used as review tool for both the term and definition.

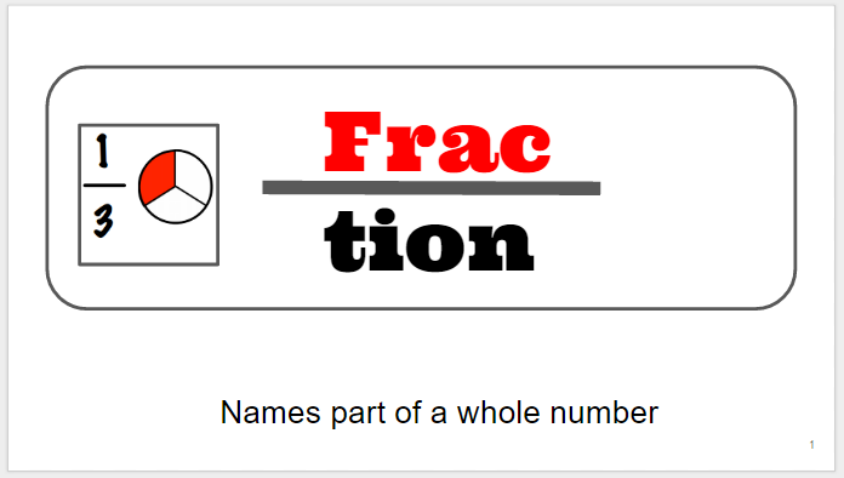

Figure 11. Interactive Word Wall Card 'Fraction', by Emily Grove (2017). Petit, M., 2012 (Left).

The word fraction is broken into two parts illustrating the meaning of the word. There are also two colors, red and black used to indicate the two different parts, numerator, and denominator which are described in later cards.

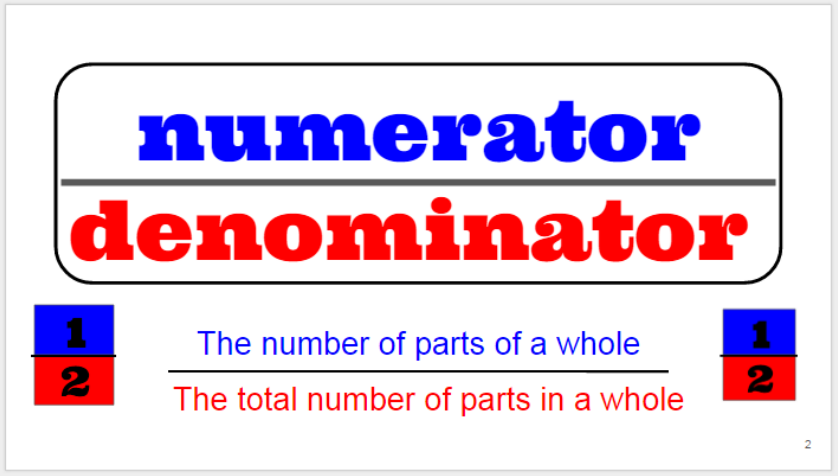

Figure 12. Interactive Word Wall Cards 'numerator' and 'denominator', by Emily Grove (2017)

This card includes two terms, numerator and denominator, in two different colors to show the two different parts of a fraction. At the bottom of the card the definitions are presented in corresponding colors to the names of the parts of the fractions. There is also the ½ fraction included to show where the two numbers originate in a fraction.

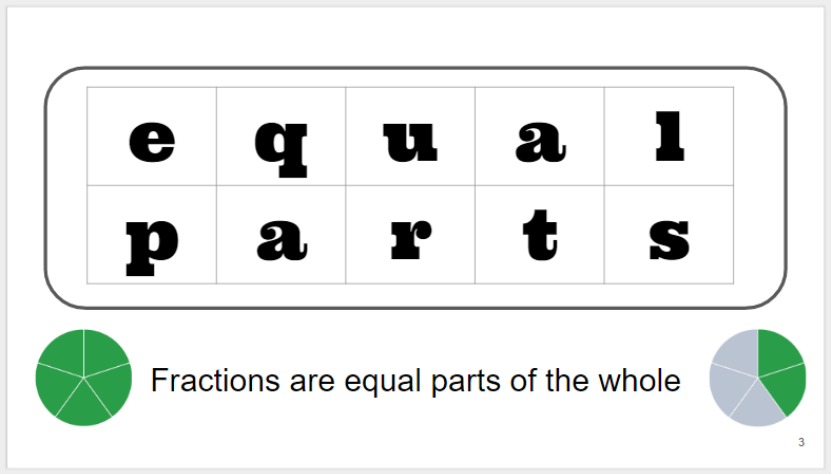

Figure 13: Interactive Word Wall Card 'equal parts', by Emily Grove (2017)

The card for the term 'equal parts' is written in a table to show that fractions are broken into equal parts of the same whole. To create the image the words equal and parts are broken into equal parts on the table.

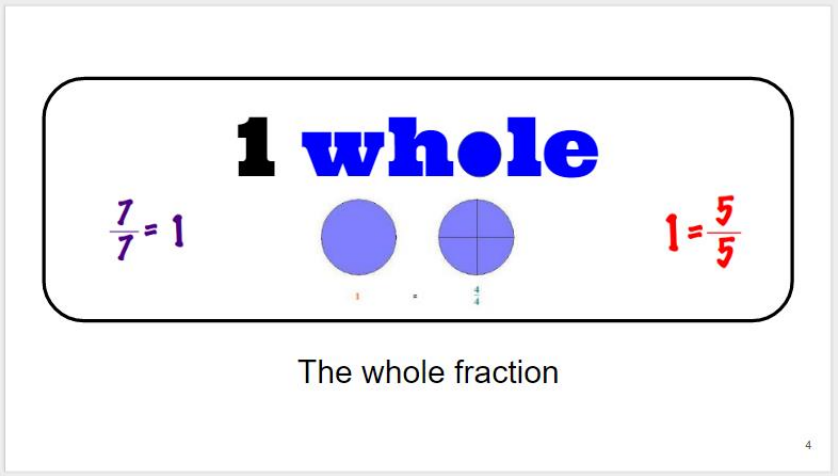

Figure 14. Interactive Word Wall Cards '1 whole", By Emily Grove (2017). (Petit, M., 2012 (Left & Right)),(Miller, M., 2015 (center)).

The term '1 whole' is shown in two different colors, to show that one and whole are two different words and parts of speech. One is a quantifying adjective, while whole is a noun. The card also shows that instead of the letter 'o', a filled in circle is used to show *1* whole pictorially.

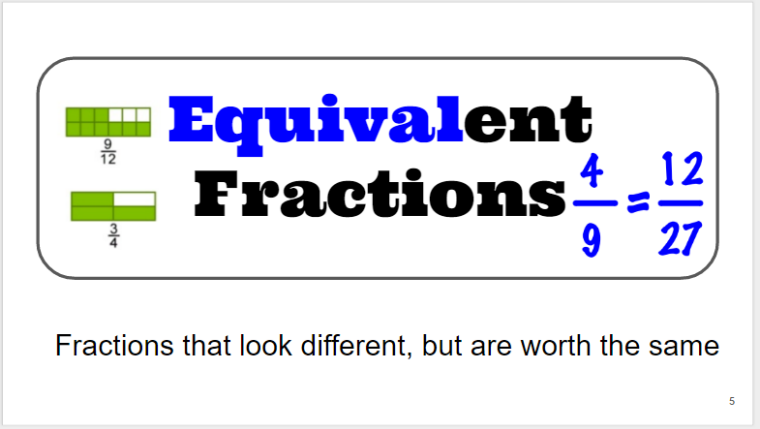

Figure 15. Interactive Word Wall Card 'equivalent fractions', by Emily Grove (2017). (Gill, K., 2016 (Left)), (Petit, M., 2012 (Right)).

In the term 'equivalent fractions', the letters *equival* are in a different font color from the rest of the word. This is because *equival* is similar to the word equal, just in a different morphological form. Students should be told that equivalent and equal have

almost the same definition. Therefore, students should see the word *equal* in *equivalent* to understand that the fractions are worth the same.

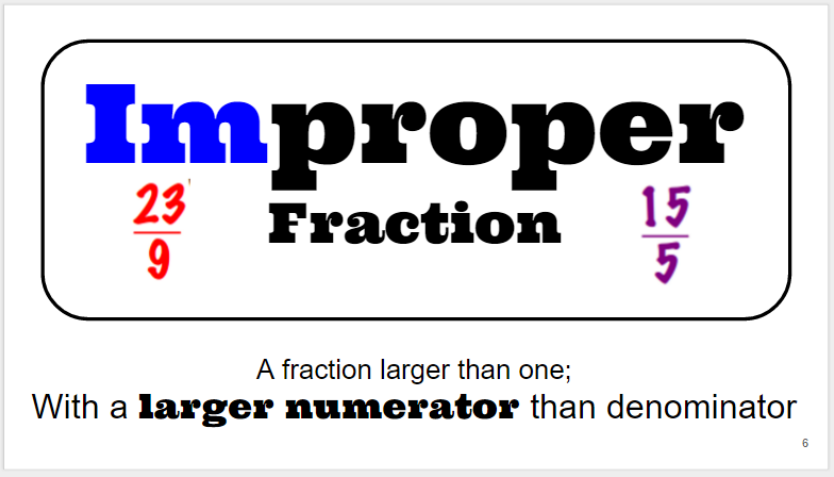

Figure 16. Interactive Word Wall Card 'improper fraction', by Emily Grove (2017). (Petit, M., 2012 (Left & Right)).

The card 'improper fraction' includes two visual clues for students. First, the word improper is much larger than the word fraction. This was designed to show visually that the numerator is larger than the denominator in an improper fraction. Additionally, the prefix, [im] is in a different color from the rest of the word proper. This is intended to highlight that improper is not proper, or correct, with a denominator which is larger than the numerator.

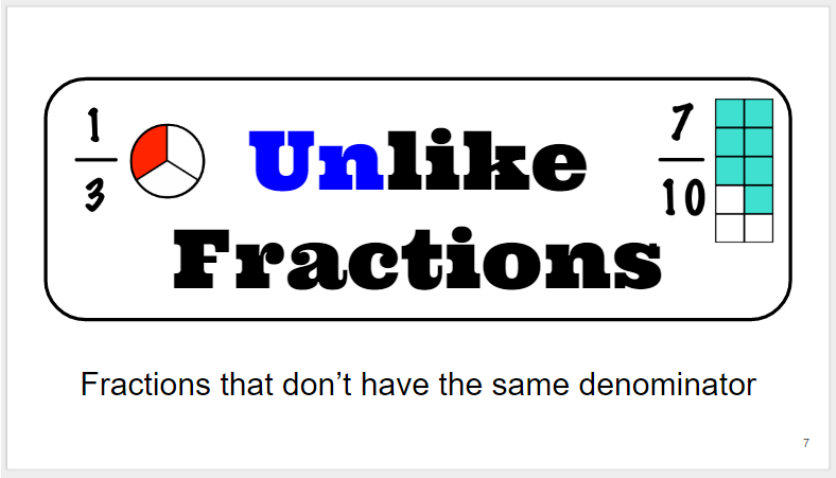

Figure 17. Interactive Word Wall Card 'unlike fractions', by Emily Grove (2017). (Petit, M., 2012 (Left & Right)).

The card for the term 'unlike fractions' includes two different colored fonts. The use of these two colors is to highlight the prefix part /un/ of the term 'unlike fractions'. Because unlike fractions have different denominators, the word meaning should be tied back to the morphological clue /un/.

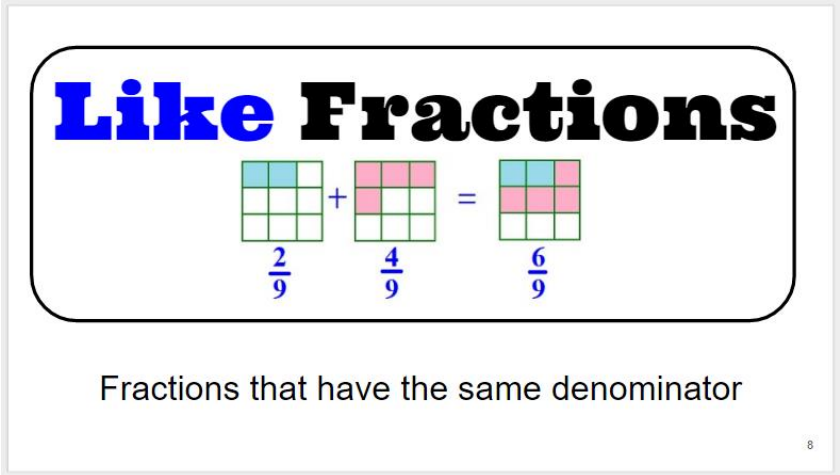

Figure 18. Interactive Word Wall Card 'like fractions', by Emily Grove (2017). (Villec, A., 2016 (Bottom)).

The term like fractions also contains two different font colors. One color is used for the word like and another for the word fractions. These two different colors are used

to highlight the importance of the word *like* in the term 'like fractions'. These fractions are alike because these fractions share the same denominator.

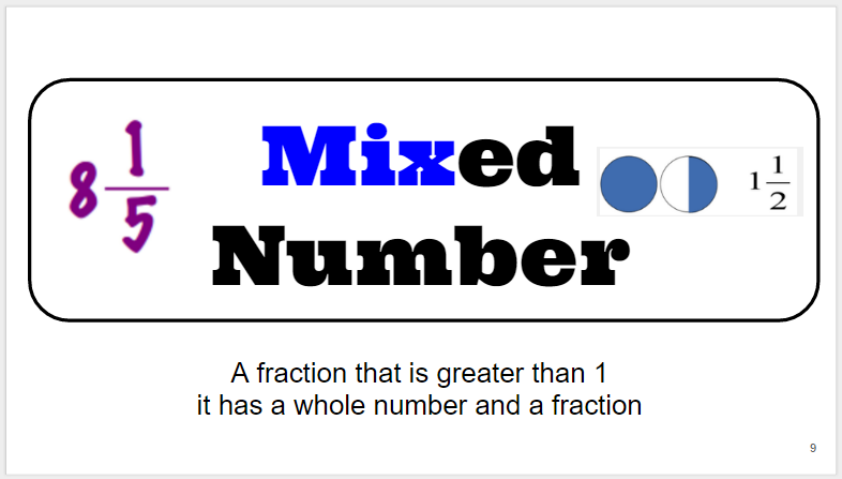

Figure 19. Interactive Word Wall Card 'mixed number', by Emily Grove (2017). (Petit, M., 2012 (Left)). (GRE Math Ninja., (2011) (Right)).

The term 'mixed number' includes two font colors to visually illustrate the morphology of the word mixed. The letters *Mix* are presented in blue to highlight that mixed numbers are a combination of whole numbers and fractions. The remaining letters are printed in black. The graphics show pictorially the components of mixed numbers.

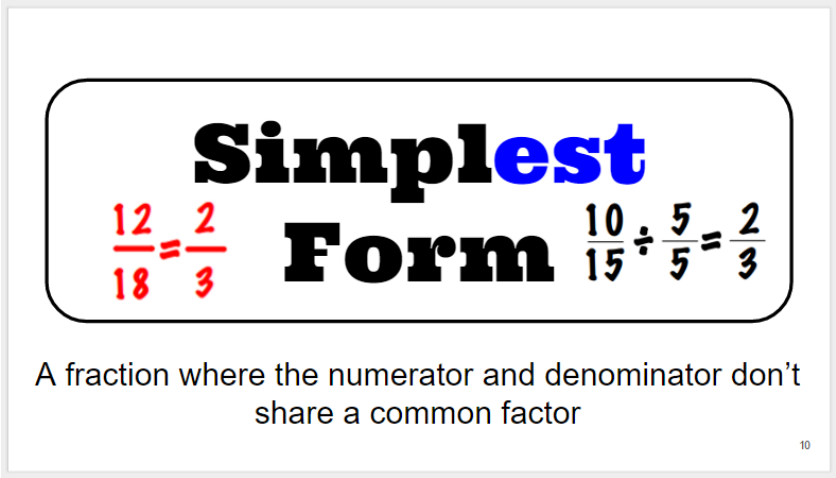

Figure 20. Interactive Word Wall Cards 'simplest form', by Emily Grove (2017). (Petit, M., 2012 (Left & Right)).

The simplest form card includes two different font colors. The base morphological form *simple* is in black, while the superlative (*-est*) is in blue. Using black for the letters *simp-* shows that the fraction is in its simplest form and cannot be reduced further. In simplest form fractions do not share a common factor.

The Frayer Model

An individual Frayer Model graphic organizer is completed for each vocabulary word in the fractions unit. There are four components to the Frayer Model graphic organizer. These components include the term's definition, characteristics, examples, and non-examples. The Frayer Model is similar to semantic mapping, in that a large part of the learning comes from the teacher-student discussion about what to include in each quadrant. Definitions can be the same in the graphic organizers and the interactive word wall to promote consistency within the unit. A Frayer Model graphic organizer has been completed for the term 'fraction' using the definition from the interactive word wall cards (see *Figure* 21). The graphic organizer also includes characteristics of the term, as well as examples (which may include pictures) and non-examples. The non-examples quadrant should include terms which are relevant to the unit or subject but do not describe the term. For example, students may want to include the word *hotdog* under non-examples for fractions. While hotdog is a non-example of fractions it does not describe fractions, not does it describe what a fraction is not in relation to math.

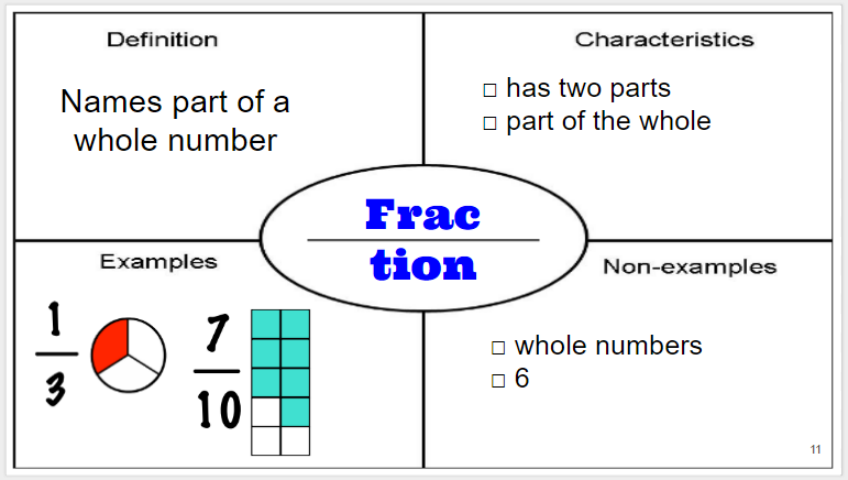

Figure 21. Frayer Model 'Fraction' by Emily Grove (2017). (Petit, M., 2012 (left)).

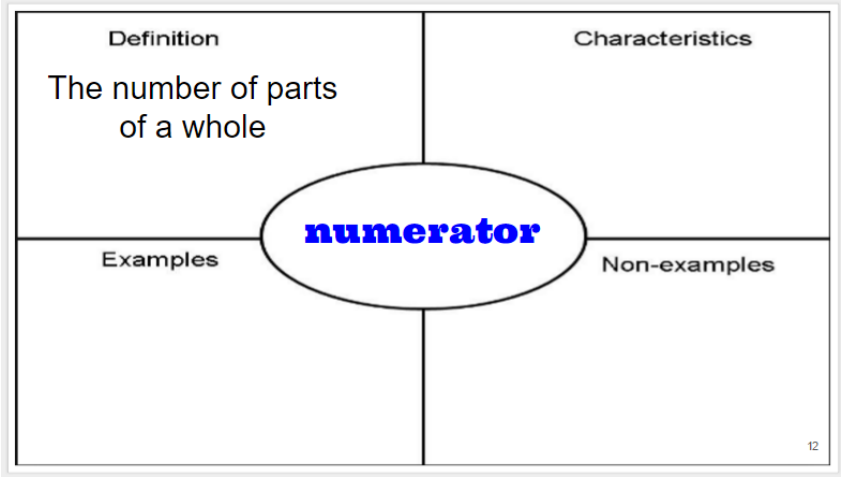

Figure 22. Frayer Model 'Numerator' by Emily Grove (2017).

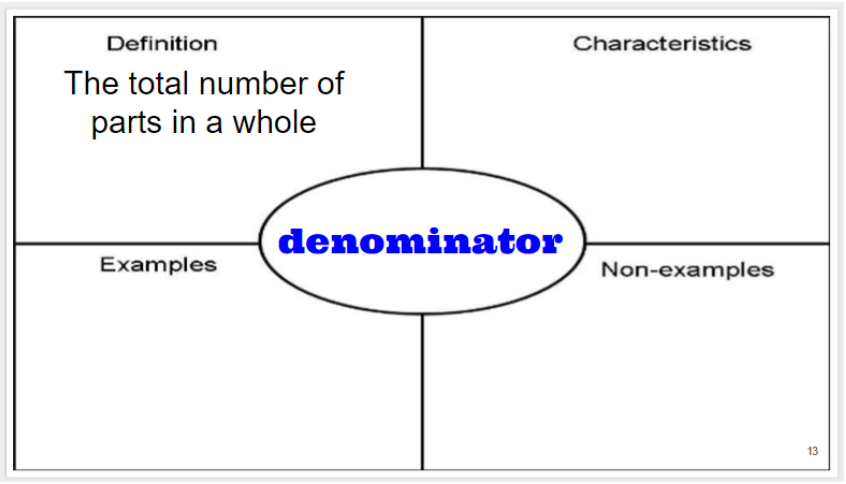

Figure 23. Frayer Model 'Denominator' by Emily Grove (2017).

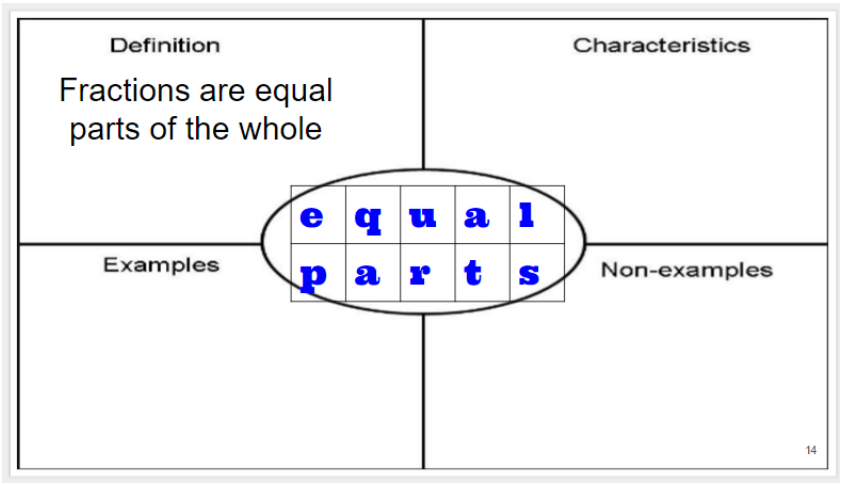

Figure 24. Frayer Model 'Equal Parts' by Emily Grove (2017).

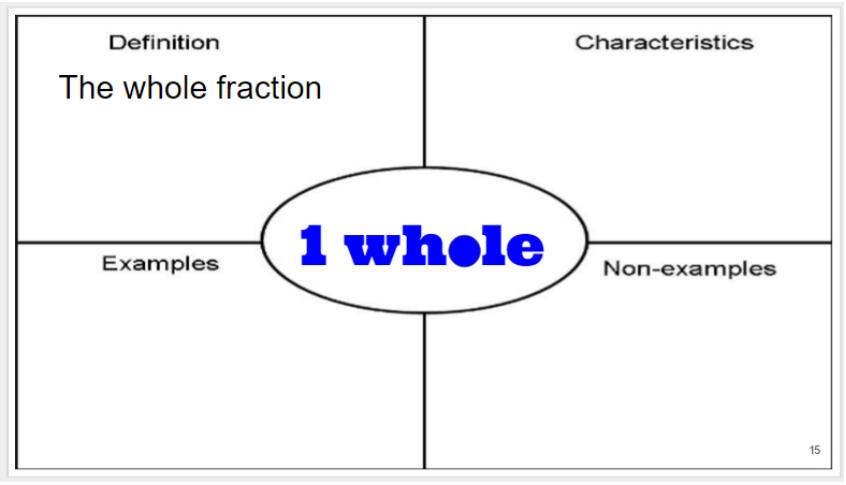

Figure 25. Frayer Model '1 Whole' by Emily Grove (2017).

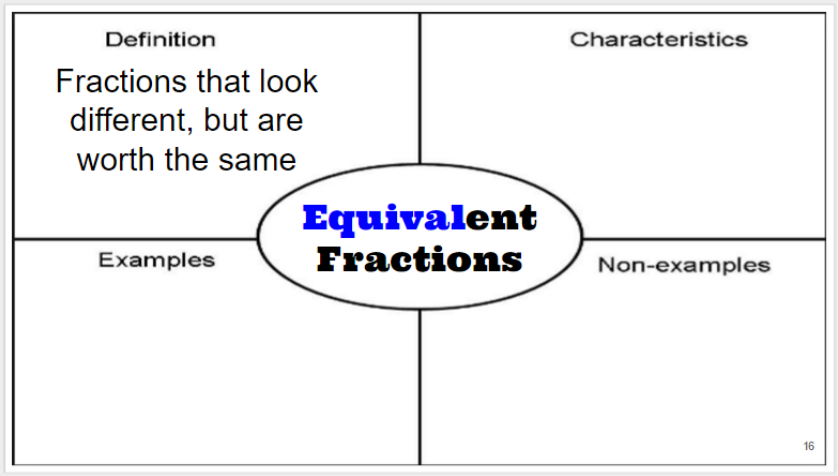

Figure 26. Frayer Model 'Equivalent Fractions' by Emily Grove (2017).

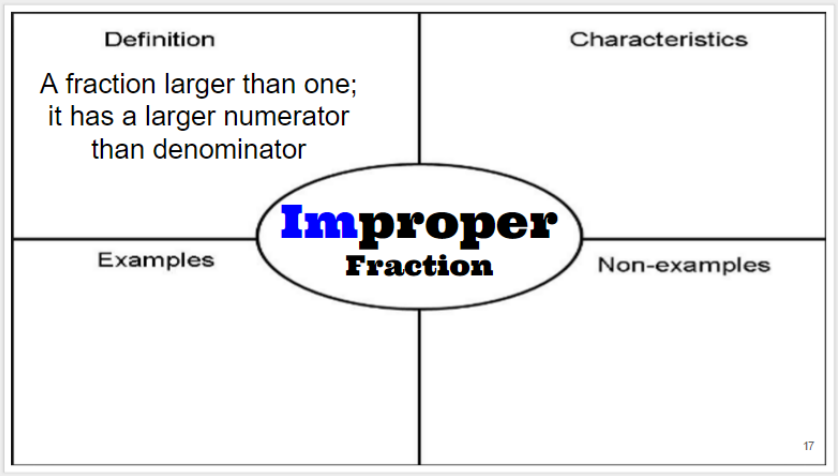

Figure 27. Frayer Model 'Improper Fraction' by Emily Grove (2017).

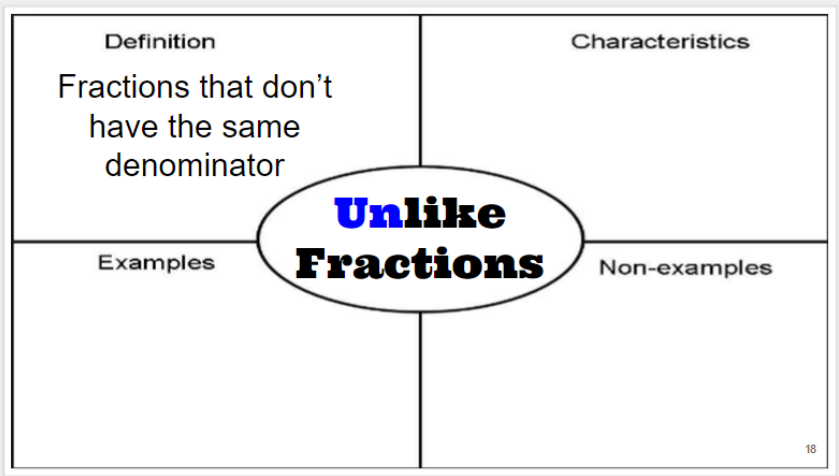

Figure 28. Frayer Model 'Unlike Fractions' by Emily Grove (2017).

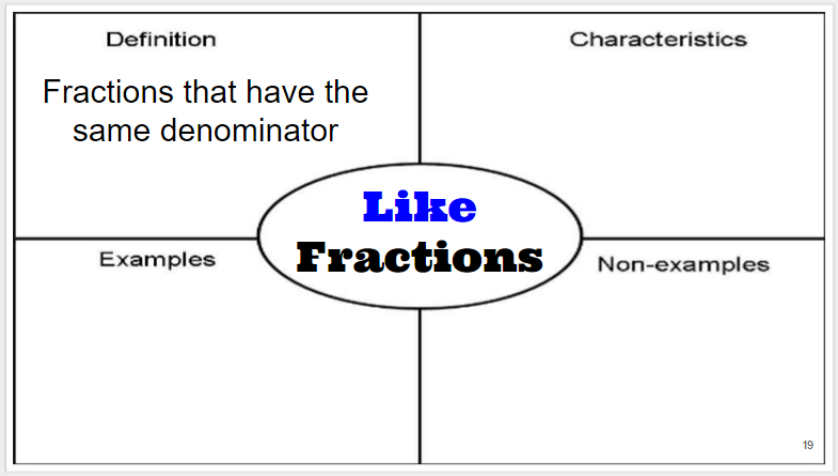

Figure 29. Frayer Model 'Like Fraction' by Emily Grove (2017).

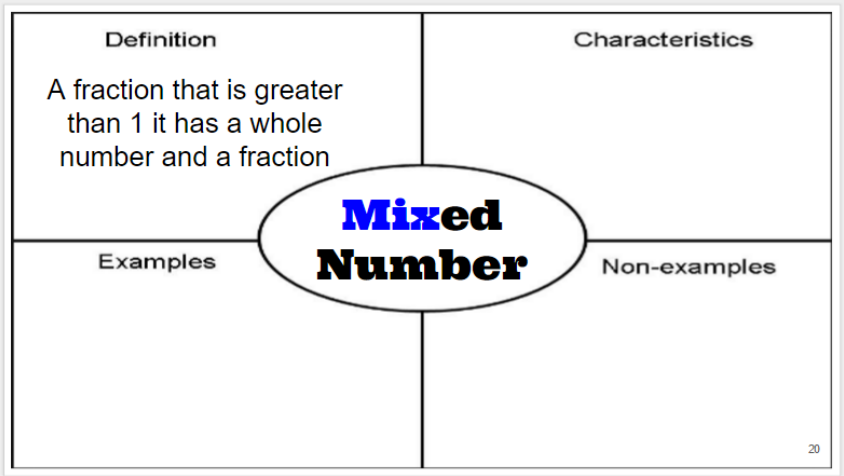

Figure 30. Frayer Model 'Mixed Number' by Emily Grove (2017).

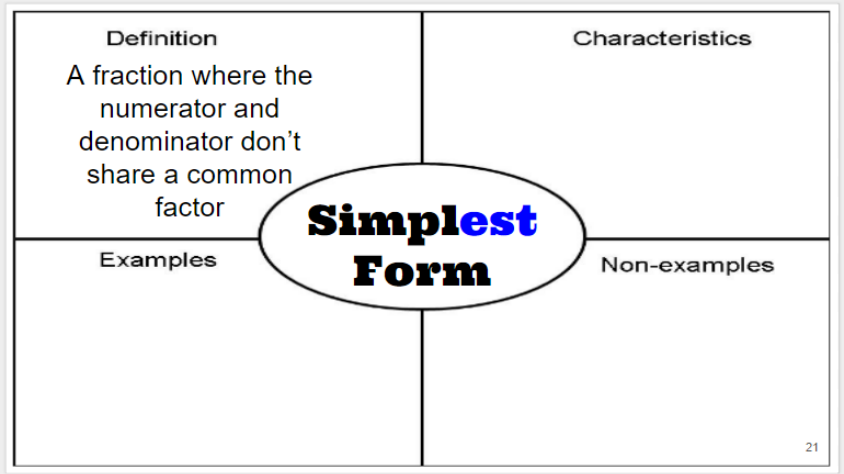

Figure 31. Frayer Model 'Simplest Form' by Emily Grove (2017).

Semantic Mapping

Semantic mapping includes a quick student and teacher discussion. Learning takes place in both the discussion, through negotiation of what should be included in the semantic map, and in completing the map. Students have already been introduced to the vocabulary terms through the interactive word wall cards. The teacher will then distribute the blank semantic maps for each term. Blank semantic maps with each term in the center have been provided as well as a blank semantic map for future use. The semantic maps with the terms already in the center include pictorial images with visual clues from the interactive word wall cards. If semantic mapping has not been used with students previously, use the completed *fraction* semantic map shown in Figure x.

Fraction Semantic Mapping

As can be seen in the fractions semantic map (see *Figure* 32), there are several components included in a semantic map. First, the term is written in the center. Coming out of the center word are spokes with boxes. These boxes should include associations with that term. The point of semantic mapping is for teachers and students to make and draw connections between prior knowledge and word associations with the vocabulary term. Items to write in a semantic map include other forms of the word (morphology), graphics or pictorial representation, connections to other learning and experiences. The fraction model includes pictures, word associations, components of the terms, and a brief definition.

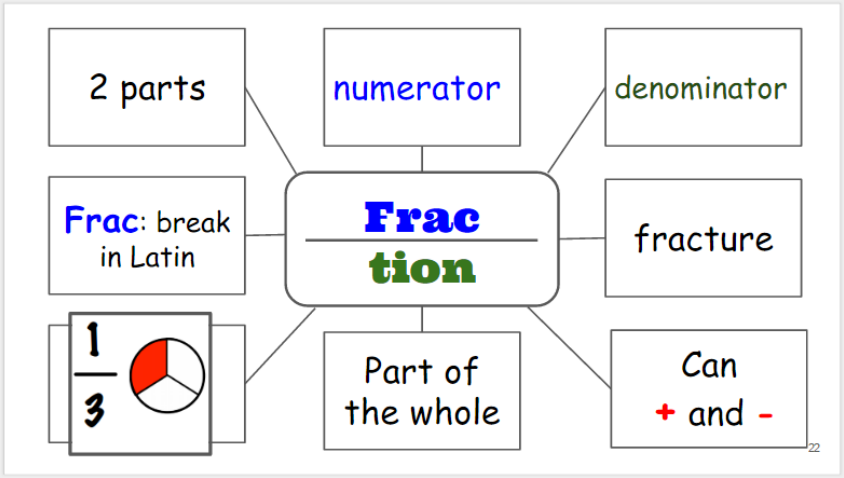

Figure 32. Semantic Map 'Fraction' by Emily Grove (2017). Petit, M., 2012 (Left).

Cloze Reading - Formative Assessment

The final component of the curriculum addendum is the cloze reading activity shown in Figures 33 and 34. This activity can be used as a formative assessment to check for vocabulary comprehension. The cloze reading activity includes the fractions vocabulary removed from the traditional context of the math classroom. Fractions lend themselves well to baking, especially with measuring cups. The included cloze reading activity includes each of the eleven identified fraction vocabulary terms in a story about baking cookies. The assessment is double sided. The student copy is first (*Figure 33*), with the answer key following the student worksheet (*Figure 34*).

Cloze Reading Student Edition

Cloze Reading Baking with Fractions Directions: Read the paragraphs below. Fill in the correct blank with the correct term from the fraction word bank.					
fraction	equal parts	denominator	like fractions	equivalent fractions	unlike fractions
simplest form	numerator	improper fractions	mixed number	1 whole	

One Saturday Ahmed and Hadia went to their Grandma's house. It was a cold and rainy day in March. They couldn't play outside, so Grandma suggested they bake cookies. They decided to make chocolate chip cookies, their favorite.

First, they found the recipe in Grandma's old cookbook. They found the mixing cups, measuring spoons, spoon and bowl. Then they collected the flour, baking soda, salt, butter, white sugar, brown sugar, vanilla, 2 eggs and 1 bag of chocolate chips. Grandma knew Hadia was learning about fractions, so she decided to bring math into their baking fun.

"First we need 2 ¼ cups of flour. What kind of fraction is that Hadia?" Grandma asked. "_____ because there are 2 wholes and a fraction" Hadia replied.

"Ahmed fill the ½ teaspoon with baking soda and add it to our bowl please" said Grandma.

"Hadia 1 is the _____ and 2 is the _____ in the baking soda fraction" Grandma asked." I didn't know _____ were part of baking" Ahmed added.

"I can't find the ¾ measuring cup, can I use the ¼ three times instead?" Hadia wondered. "Well, are those 2 fractions _____?" "Do they have the same denominator?" "Or are they _____ because they don't have the same denominator?" Grandma asked.

"They are like fractions" Hadia replied. They decided Hadia could use the ¼ measuring cup. "Now we need to add ¾ cup of white sugar and ¾ cup of brown sugar." How

many fourths of sugar are we adding Hadia?" Grandma wondered . "Hmm, well ¾ +¾ = 6/4" "But Grandma that is an _____ because the numerator is larger than the denominator." replied Hadia.

"Ok, then how do we fix it?" Grandma asked. "Well, you can make a mixed number with 1 and 2/4." "But 2/4 is not in _____." " 2/4 is an _____ to ½. They mixed in the missing ingredients, salt, butter, vanilla, eggs and the chocolate chips. They mixed and formed the cookies on the cookie pan. They waited for what seemed like hours for them to bake and cool. Finally, Grandma said they could each eat _____ cookie.

Figure 33. Cloze Reading with unit fraction words 'Cloze Reading: Student Edition' by Emily Grove (2017).

Cloze Reading Baking with Fractions - Teacher Edition

Directions: Read the paragraphs below. Fill in the correct blank with the correct term from the fraction word bank.

fraction	equal parts	denominator	like fractions	equivalent fractions	unlike fractions
simplest form	numerator	improper fractions	mixed number	1 whole	

One Saturday Ahmed and Hadia went to their Grandma's house. It was a cold and rainy day in March. They couldn't play outside, so Grandma suggested they bake cookies. They decided to make chocolate cookies, their favorite. First, they found the recipe in Grandma's old cookbook. They found the mixing cups, measuring spoons, spoon and bowl. Then they collected the flour, baking soda, salt, butter, white sugar, brown sugar, vanilla, 2 eggs and 1 bag of chocolate chips. Grandma knew Hadia was learning about fractions, so she decided to bring math into their baking fun. "First we need 2 ¼ cups of flour. What kind of fraction is that Hadia?" Grandma asked. "A ***mixed number*** because there are 2 wholes and a fraction" Hadia replied. "Ahmed fill the ½ teaspoon with baking soda and add it to our bowl please" said Grandma. "Hadia 1 is the ***numerator*** and 2 is the ***denominator*** in the baking soda fraction" Grandma prompted. "I didn't know ***fractions*** were part of baking" Ahmed added. "I can't find the ¾ measuring cup, can I use the ¼ three times instead?" Hadia wondered. "Well, are those 2 fractions ***like fractions***?" "Do they have the same denominator?" "Or are they ***unlike fractions*** because they don't have the same denominator?" Grandma asked. "They are like fraction" Hadia replied. They decided Hadia could use the ¼ measuring cup three times. "Now we need to add ¾ cup of white sugar and ¾ cup of brown sugar." How many fourths of sugar are we

adding Hadia?" Grandma wondered. "Hmm, well ¾ +¾ = 6/4" "But Grandma that is an ***improper fraction*** because the numerator is larger than the denominator." replied Hadia. "Ok, then how do we fix it?" Grandma asked. "Well, you can make a mixed number with 1 and 2/4." "But 2/4 is not in ***simplest form***." " 2/4 is an ***equivalent fraction*** to ½. They mixed in the missing ingredients, salt, butter, vanilla, eggs and the chocolate chips. They mixed and formed the cookies on the cookie pan. They waited for what seemed like hours for them to bake and cool. Finally, Grandma said they could each eat ***1 whole*** cookie.

Figure 34. Cloze Reading with unit fraction words 'Cloze Reading: Teacher Edition' by Emily Grove (2017).

Summary

The curriculum addendum includes several components which should be added to the current *Singapore Math, Math in Focus,* fractions unit in 4th grade. The combination of these added curricular elements and explicit vocabulary teaching will better meet the needs of ELs in fourth grade. The first component is the interactive word wall cards. Each term is clearly defined with picture clues and different font colors indicating specific parts in the words to aid in comprehension. The second element of the curriculum addendum is the semantic mapping. The semantic maps are intended to encourage short classroom discussions about associations with the vocabulary terms. Once the semantic maps are completed, they can be connected with linking verbs and sentences to build and strengthen associations between vocabulary words. The Frayer Model graphic organizer is intended to be used third in the curriculum sequence. Here students and teacher discuss the four quadrants of the graphic organizer, including the definition (which is supplied from the interactive word wall cards), characteristics, non-characteristics, and examples. Finally, the cloze reading activity incorporates fractions

into a baking story. Here, the students can complete a formative assessment using the vocabulary words in a new context. The final chapter presents and describes the implications and final steps in this curriculum capstone project.

CHAPTER FIVE: REFLECTIONS

Redefining the Problem

ELs have the monumental task of increasing their English proficiency while learning content material simultaneously. When students are not familiar with or explicitly taught content vocabulary terms, the content only becomes more challenging. Vocabulary has long been a staple in language arts classrooms; however, this detailed and purposeful instruction should also carry over to the math classroom. The amount of instructional time designated for vocabulary in classrooms is still astonishingly low. According to a 2003 study (Scott & Asselin, 2003) only 6% of the school day is spent on vocabulary, and less than 2% is spent on content-specific vocabulary. These frighteningly low percentages are very concerning giving the increasing number of ELs in schools today. To highlight the importance of explicitly teaching vocabulary, literature on effective instructional strategies and practices was collected. The literature findings were broken into several components including curricular components, teaching strategies, and student application activities.

This capstone project sought to answer two central questions. What are the components of effective elementary vocabulary instruction for ELs? Many researchers and theorists in the field of EL believe in increased exposure and increasing experiences

with new content vocabulary. Additionally, a conscientious selection of which words to include in vocabulary instruction should be scrupulously considered. Term definitions need to be clear and meaningful to students. Another instructional element to consider is the use of L1 cognates when applicable. Instruction should also include morphological discussion relating to vocabulary terms which can aid understanding because of an understanding of root words, prefixes, and suffixes. Finally, sound EL elementary instruction should include a combination of multiple strategies.

The second central question focused on strategies and techniques recommended in teaching math vocabulary in the K-8 setting. Many techniques and strategies from language arts are applicable to the math classroom. A review of relevant literature described the usefulness in incorporating close reading ideology. Direct instruction of the vocabulary words should also follow Beck's Tier Two steps (B. Erickson, personal communication, August 14, 2016) which are also applicable to tier three terms. Specific strategies to employ include Frayer Model graphic organizers (Monroe and Pendergrass (1997) and semantic mapping (Johnson & Steele, 1996); two activities which include rich discussion. These techniques also strive to build and strengthen connections for multiple meaning words outside of the current area of study. Translation dictionaries (Gonzalez (1999) are another prominent resource which can be utilized independently by students. Interactive word walls (Hooper & Harmon, 2015) are a great resource which can be either teacher or student generated incorporating visuals and definitions. They are to be displayed and referred to when possible. Finally, cloze reading (Lee 2008) activities were described. Cloze reading can be used as an assessment or to provide additional exposure to, and interactions with, relevant content vocabulary.

Implications

The Implications of this capstone curriculum unit are applicable to many different types of teaching environments. These strategies are readily reproducible. Blank templates are included in addition to the completed templates for the fraction vocabulary. These templates can be copied and used with other math vocabulary lists.

Additionally, and more importantly, these strategies can be used outside of the fractions unit and math classroom. These strategies and techniques can be used for other math units, as well as outside the math classroom. Close reading, Frayer Model graphic organizers, semantic mapping, and interactive word walls can be applied to science and social studies classrooms. The unique vocabularies in science and social studies can utilize these strategies and techniques. This structure for teaching vocabulary can be used outside of the fourth grade classroom in other areas in the K-8 classroom setting. Finally, the techniques and strategies described have cross-curricular application, including both EL classrooms and general education math classrooms. They can also be used in small group and whole class settings, The activities can be altered to accommodate class work, homework, and as study materials. Teachers should bring these techniques to their classroom and adapt them to meet the needs of their students.

When I began this capstone, I had identified a gap which needed to be filled. This gap for was specific instruction and student practice with math terminology. Furthermore, in my experience, I saw this gap caused confusion and even hindered ELs ability to understand and accurately show what they knew on assessments. While I gathered and read through relevant research I began to see why this may be been a problem and gap in

classroom curriculums. Limited research has been completed on teaching math vocabulary especially in the EL field.

As I continued my capstone journey, I saw connections between the graphic organizers which my school district uses for writing and graphic organizers I saw referenced in relevant literature. These organizers included the Frayer model, and word wall cards. The writing curriculum my district uses includes many different kinds of writing organizers and maps which aids the writing process. This approach is successful with the students I teach. My belief is that the organizers I included in my curriculum unit, the Frayer Model and word cards will also bring structure and routine to help organize mathematical writing and bring an instructional and student application routine to mathematical vocabulary.

Finally, I have always enjoyed making connections within words to their definitions, both as a student and as an instructor. In my middle school Spanish classroom we were learning the Spanish translation for chicken, which is *pollo*. On my word flash card I drew three chicken toes on the two legs of the two /l/s. I have never forgotten the Spanish word for chicken. I knew that as a learner these picture clues helped me to learn terms. I also enjoyed bringing my creativity into study time. As an educator, I have tried to make visual connections or classroom connections to vocabulary whenever possible to aid in the learning of new words. I did not realize I would be accessing this skill in my master's work. I am looking forward to presenting my findings and word cards at a staff meeting in the future. I hope these cards and instructional approach can be brought into classrooms for use.

Dennis, a Spanish speaking EL student in fourth grade summer school inspired a curriculum capstone into math vocabulary instruction and techniques. The implications of this curriculum capstone describe the need for systematic vocabulary targeted teaching. Including student application to build and cement the required content specific vocabulary for Dennis and other ELs.

Future Steps

The findings from this curriculum addendum will be presented to my elementary staff, and shared with my district EL team. While I was creating the interactive word cards I shared samples with the 4th grade classroom teachers. They asked for narratives to explain the visuals and use of colors. This narrative has been included with each of the interactive word cards to provide teachers with some narrative to use when describing the cards to their students. The 4th grade team found the interactive word cards helpful and described looking forward to the staff meeting when I will present this curriculum.

This curriculum is targeted towards the classroom teachers. I will explain and describe how each strategy and technique works and can be employed in their classroom. Teachers can expand upon the model I described, altering it to make it applicable to their classroom. The approach, which brings theory into practice, provides consistent, systematic approach for use and application by K-8 teaching staff.

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Appendix A

Semantic Maps

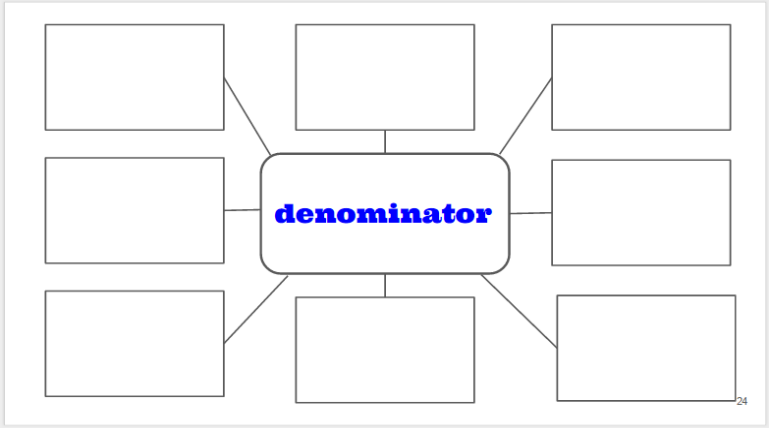

Figure A1. Semantic Map 'Denominator' by Emily Grove (2017).

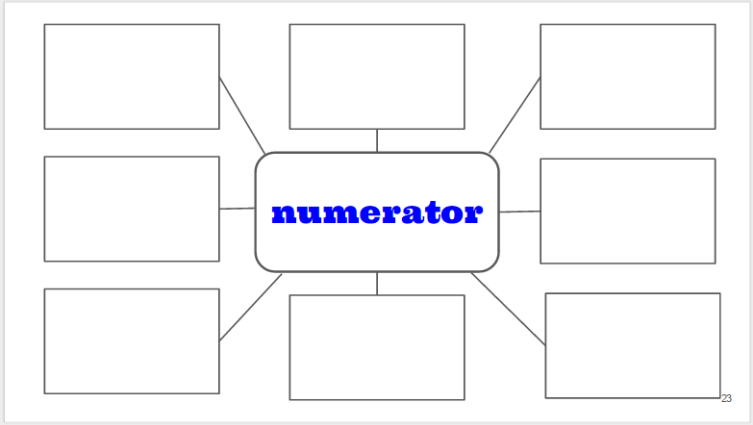

Figure A2. Semantic Map 'Numerator' by Emily Grove (2017).

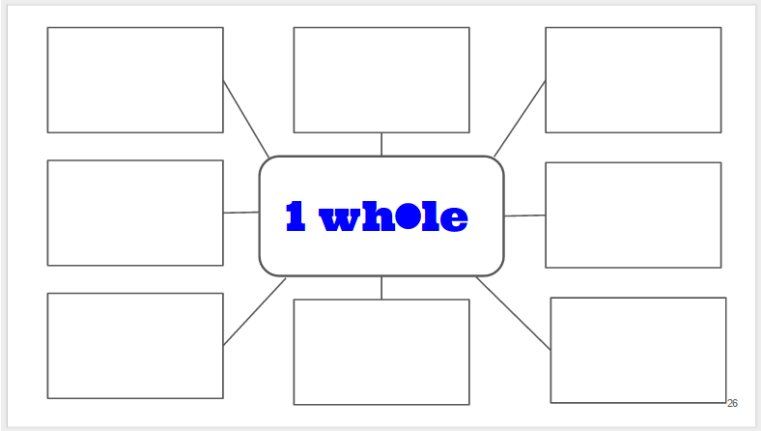

Figure A3. Semantic Map '1Whole' by Emily Grove (2017).

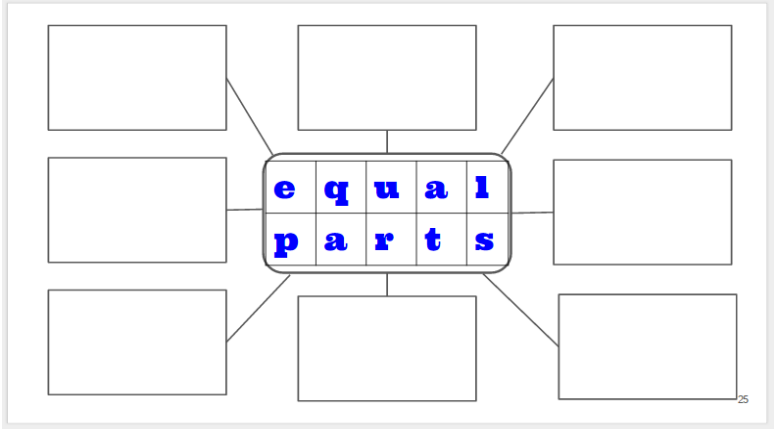

Figure A4. Semantic Map 'Equal Parts' by Emily Grove (2017).

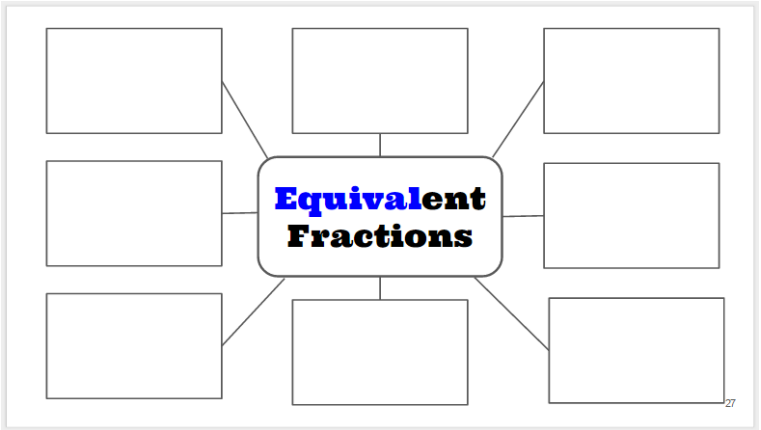

Figure A5. Semantic Map 'Equivalent Fractions' by Emily Grove (2017).

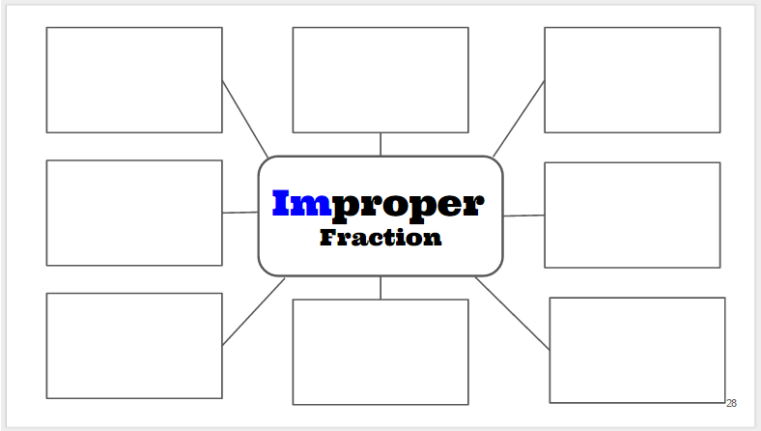

Figure A6. Semantic Map 'Improper Fractions' by Emily Grove (2017).

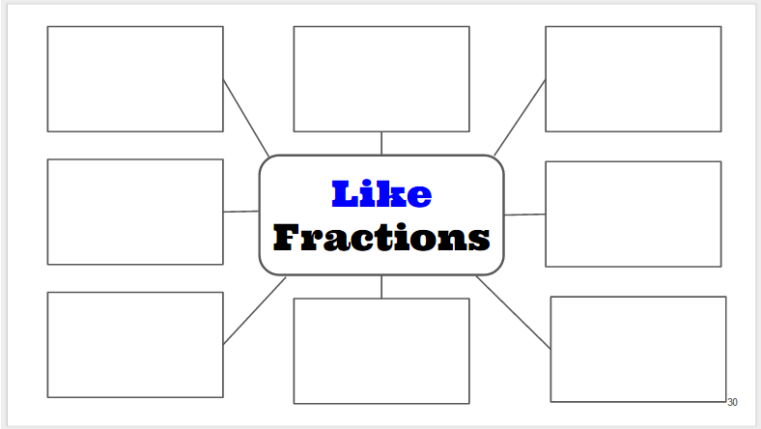

Figure A7. Semantic Map 'Like Fractions' by Emily Grove (2017).

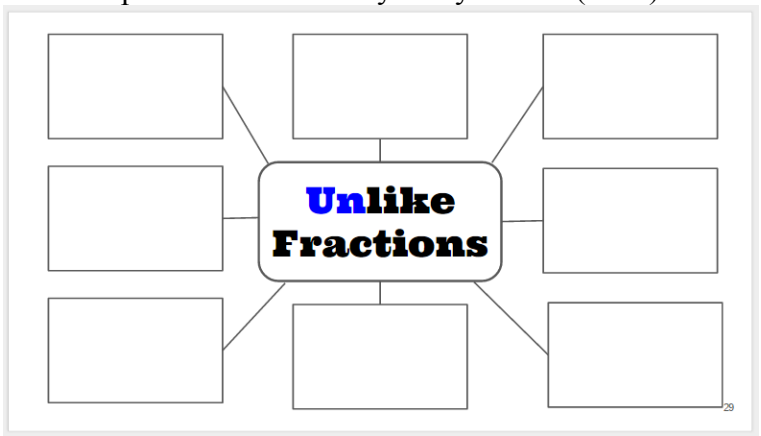

Figure A8. Semantic Map 'Unlike Fractions' by Emily Grove (2017).

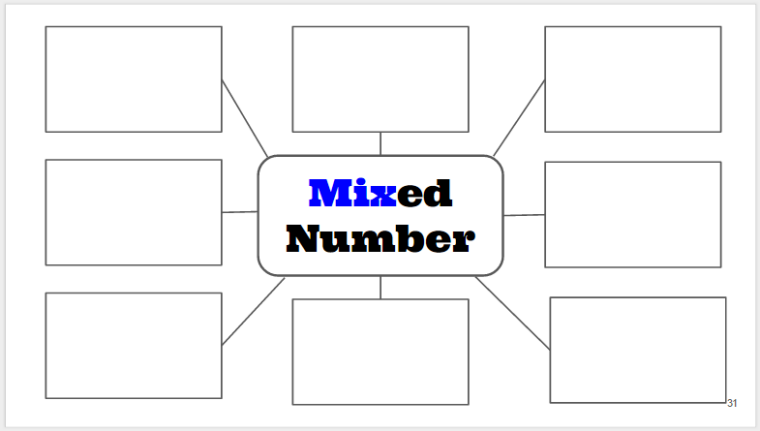

Figure A9. Semantic Map 'Mixed Number' by Emily Grove (2017).

Appendix B

Blank Frayer Model

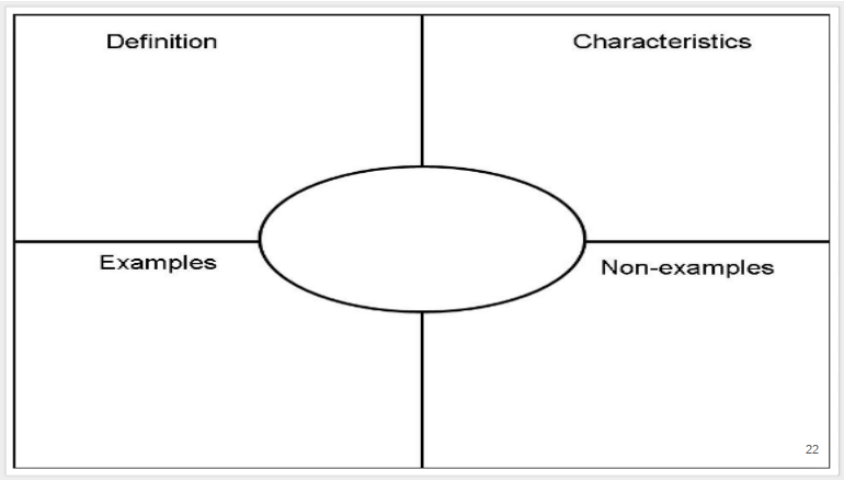

Figure A10. Blank Frayer model 'Frayer Model' by Emily Grove (2017).