CONTENT SPECIFIC MATH VOCABULARY INSTRUCTION TO IMPROVE ENGLISH LANGUAGE LEARNERS' COMPREHENSION OF COMPARISON MATH WORD PROBLEMS

By

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CHAPTER ONE

Introduction

I am studying first grade midwest suburban elementary English Language Learners' comprehension of comparison math word problems. Based on my teaching experience I discovered a correlation between ELL students' vocabulary comprehension and ability to solve word problems. My capstone research project is on the question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?* I will use my research in order to develop math content vocabulary lessons using many, more, and fewer that will support students' comprehension in math comparison word problems.

Overview

This chapter will address why this research question is relevant and important. I will discuss my reasoning for increased support of English Language Learners' (ELLs) vocabulary development, specifically in the area of math and solving comparison word problems. This chapter will also discuss the relevance and audience for this research.

English Language Learners (ELLs)

Throughout this paper I will be using the term English Language Learners (ELLs), which is defined as, "students whose first language is not English and

who are in the process of learning English" (ELL glossary, n.d.). In common practice, English language learners might also be referred to as ESL (English as a Second Language) or ELs (English Learners). To remain consistent I will use the acronym ELL. Some of the other terminology may be utilized during my literature review and when describing my capstone project. Note that I am still referring to the same group of students and learners.

Background

I grew up in a small suburban town in the midwest about 20 miles from a major city. In the schools I attended teachers and administrators were predominantly white. To my knowledge, I did not attend school with any ELLs. I know the population of the community has changed over time, and now there are multiple ELL teachers in the district, but in the late 1990s to early 2000s the population was not there. Reading intervention and special education were the only additional classes offered.

Looking back on my own learning experiences I recognize I was successful with math but struggled with reading. Specifically, in first grade I remember enjoying math because I could do the algorithms and understood how to add and subtract. I assume the reason I was so successful in math was that we did not face word problems. I did not have to comprehend and understand these real world problems. Throughout all of my learning in math the focus was on computation with a very infrequent expectation to solve word problems. While this seemed easier at the time, in reality I was not applying knowledge to the real world situations.

College. I graduated from a four year university in the midwest in the spring of 2012. This school was known both within the state and throughout the midwest for having a very strong school of education. I studied elementary education with the addition of a reading endorsement and minor in math. At the time, students were strongly encouraged to earn a reading endorsement, with professors repeatedly stating that this would set them apart from other applicants. Through my four years of college within the school of education I had little to no exposure to ELLs. My school at the time did not have a major or minor for ELL. I do recall one student at the time getting a ELL teaching degree, but the ELL license was coming from a different university online. The university I attended now offers three Bachelors of Arts degrees classified as Teaching English to Speakers of Other Languages (TESOL), two TESOL minors, and two TESOL Masters programs. In less than ten years the university went from zero ELL programs to having multiple programs. This shows the necessity for ELL teachers as the diversity of student populations continues to change, both in rural and suburban areas. During my student teaching I had my first opportunity to work with ELLs.

I student taught in a diverse suburb of a large metropolitan area in the midwest. This was the first time that I had taught ELLs and worked alongside ELL teachers. I used much of my literacy background to help support these students as best as I could. While reading and literacy interventions allowed me to support ELLs, it wasn't until I began taking classes in my masters program that I realized how much more there was to teaching ELLs.

First teaching position. My first teaching job was as a third grade teacher at a Hmong charter school. The school was located in the middle of a metropolitan area and served students that came from a Hmong and Karen descent. Hmong and Karen people are recent refugees who have settled in the United States from Laos and Myanmar, formerly known as Burma. I taught at this school for two years and worked with a large number of (ELLs). Forty percent of my students were ELLs with two or three each year being new to the United States. While this was challenging for a new teacher I loved the opportunity to learn and co-teach with the ELL teachers in the building. My second year of teaching I worked closely with one of our new ELL teachers during our math block. The vocabulary and language required by our third grade curriculum was surprising to me. I had naively assumed math would be easy for students because they didn't have to read. The vocabulary and structure of the word problems was highly difficult for students. We used multiple strategies, and still students struggled. I learned a lot from our ELL teacher that year and for the first time realized the value in ELL teaching. While I knew that I loved being a classroom teacher, I also had a desire to learn more about ELL teaching and how it could help me to become a better educator.

MAESL. My teaching experiences created a desire in me to learn more about ELL education. I decided to earn a masters in ELL to become a better teacher for all students. That fall, I accepted a new position as a math and reading intervention teacher in a large suburban public school district, where I would work with a large population of ELLs. My previous experience working with

ELLs was a strong factor in my being hired for this position, as was the fact that I was continuing my education to earn my Master of Arts in English as a Second Language (MAESL).

I enjoyed the opportunity to learn different interventions in both reading and math in my new position. I also appreciated the opportunity to work with many at risk students, a large percentage of whom were ELLs. We worked a lot with vocabulary, phonemic awareness, sentence structure, and discourse. During this time I started a class in linguistics. I could directly connect what I was learning in class to my students, and this reassured me that I made the right decision in getting my MAESL. It was gratifying having students new to the United States come in not saying a word and end the year speaking and asking questions. Unfortunately after my first year of teaching intervention our funding was cut and my position was no longer available. My principal saw a need for the district to retain a skilled teacher who was getting a MAESL. The district had a changing population of students that made having an MAESL a valued tool. I was offered and accepted a first grade position to teach in a classroom that had a large population of ELLs.

I have loved being back in the classroom and applying my knowledge from my masters program directly with students. My understanding of learning a language has not only helped my ELLs but also my native English speaking students. I had the opportunity to student teach with our ELL teacher. During my student teaching I planned curricula with our ELL teacher and we had a lot of discussion and practice with language in different content areas.

One of the biggest challenges for both ELLs and native English speaking students was the unit on comparison math word problems. Both the ELL teacher and I noticed that students were not able to properly set up equations to go with the word problems and often added when they needed to subtract or subtracted when they needed to add. After implementing a variety of strategies including: acting it out, drawing pictures, setting up graphs, and underlining or highlighting key words, we found that the strategies we were using did not consistently help students with their understanding and comprehension. This led to my capstone project of asking the question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?*

Math instruction. Math instruction has changed over the years and language knowledge is crucial in being able to understand and solve real world math problems. To understand first grade math you need to know more than just how to simply add and subtract. A significant amount of math is based on reading comprehension and vocabulary knowledge. My first grade students do not just have a few word problems thrown in at the end of a unit. They are expected to be able to solve various types of word problems and to write their own. A challenging aspect of teaching math is the curriculum that school districts are given and making sure state standards are being met through the curriculum. Curriculum is often designed using Common Core math standards. States that do

not implement Common Core standards have the challenge of including state standards into a curriculum that addresses Common Core standards.

Math Expressions. Math Expressions is the curriculum that is currently being used to teach first through fifth grade math in my school district. This curriculum meets many of the state standards for mathematics and goes above our first grade standards. This curriculum is missing elements in which supplemental materials need to be used. As a first grade team, we felt that Math Expressions was missing lessons on number sense and was not giving first grade students enough opportunity to practice and understand place value and number meaning. While we use Math Expressions as our math curriculum, we often use teacher-made materials to give first grade students the opportunity to develop understanding before moving on to new mathematical topics.

Future Teaching. My hope is that this capstone project illustrates a way to support both ELLs and native English speakers in the math content area. This will change my teaching practices and put a better focus on how to teach vocabulary correctly and in ways that support different content areas. This research will support not only my own students with their comparison math word problems unit but also my first grade colleagues. If the lessons go well, it will change our approach to teaching math vocabulary and the language that is used in real world math word problems.

Importance and Rationale

Math content area language instruction is important for all students because students can have varying levels of exposure to mathematical concepts. Stated in, *¡Colorí colorado!* is the following information:

> Math can be a helpful bridge for English language learners (ELLs) that have studied math in their home countries or in other schools. Nevertheless, some students will have limited math experience, and all ELLs will need practice mastering the language of math and learning how to understand word problems and use language in math class for tasks such as explaining their answers (Math instruction, n.d.).

With specific vocabulary development focusing on comparison word problems, ELLs will be able to solve word problems and also explain how they solved them. Many of my ELLs and native English speaking students struggle with word problems because they aren't understanding the vocabulary and language of what the question is asking. When looking at comparison problems they see the word "more" and instantly think they need to add. Specific vocabulary lessons and different types of word problems will help support students' understanding and increase their ability to understand and solve word problems.

Summary

This chapter provides the background for my research question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?* It explains the relevance of

needing specific vocabulary instruction in math and how the project will benefit both ELLs and native English speaking students.

In chapter two I will discuss the literature supporting my research question. This second chapter will focus on the background of ELLs, why the language of math is difficult for them to learn, and what strategies are most effective. It will also provide research regarding comprehension and how comprehension within different language structures varies. Chapter two will then discuss the structure of math word problems. Specifically, I will examine comparison word problems Finally, the chapter will show how vocabulary is used in the language of specific content areas, specifically the subject of math.

Chapter three will focus on the methods I will use to create mini-lessons that will help to answer my research question. It will state the setting and participants that will be using the created lessons. It will explain the process of designing the unit of lessons and a timeline for its completion as well as a scope and sequence of when the lessons will occur.

Chapter four will address the conclusions of this capstone project. I will go over major learnings, implications and limitations of the project, and recommendations for future work.

CHAPTER TWO

Literature Review

Overview

I am studying first grade midwest suburban elementary English Language Learners' comprehension of comparison math word problems. This research will be used to develop math content vocabulary lessons using the terms "many," "more," and "fewer," and will support students comprehension with math comparison word problems. This chapter will look at the research that helps to understand the question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?*

This chapter will first discuss ELLs' background in academics. The research will look at social English and academic English and how ELLs' learn language. The research will show the growth of ELLs' population in the United States and their achievements in academics. Next the literature review will provide evidence on ways students can build comprehension. This section will demonstrate how reading strategies and data can relate to comprehension of mathematical word problems. The understanding of comprehension in mathematics will lead into a section on math word problems. This research will show how word problems are structured, specifically looking at comparison word problems in Math Expressions first grade curriculum. Finally the literature

review will focus on vocabulary instruction. This research will examine specific vocabulary strategies to use when building academic language and how to address content specific vocabulary in math.

English Language Learners

The population of ELLs in the United States has grown by sixty percent in the last ten years; ELLs are currently the fastest growing student population in our country (Grantmakers for Education, 2013). In more recent years the midwest has seen a rapid growth in the number of ELLs in the school system (Breiseth, 2015). There are one-hundred and fifty different languages spoken by ELLs in the United States with the largest population being Spanish speakers (Breiseth, 2015).

Most ELLs in the United States are not immigrants but United States citizens (Breiseth, 2015). According to Breiseth (2015), "eighty-five percent of pre-kindergarten to fifth grade ELL students and sixty-two percent of sixth to twelfth grade ELL students are born in the U.S." Nearly sixty percent of ELLs living in the United States come from low income families with parents who have limited education themselves (Grantmakers for Education, 2013).

When looking at the general academic achievement of ELLs compared to non-ELLs based on standardized tests, ELLs perform significantly lower than their non-ELLs peers (Vandan Plas, 2009). ELLs have a variety of strengths and challenges and these strengths and challenges can vary depending on students (Breiseth, 2015). Some strengths include: literacy skills in their native language, academic and content area knowledge in their native language, family support, interest in education, high levels of responsibility, resilience, and commitment to

their education. Challenges include: limited formal schooling, mobility between different schools, limited access to consistent language instruction, limited practice in using academic language, and responsibilities that distract and use time outside and during the school day (Breiseth, 2015).

Social English is the language that is used for everyday occurrences in both written and oral language (What is the difference, n.d.). Academic English is the language that is required to be successful at school and includes language skills in the content areas of math, social studies, science, and English language arts. It takes less time for ELLs to develop social English compared to academic English. Social English can take as little as a few months for students to start developing. "Under ideal conditions, it takes the average second-language learner two years to acquire Basic Interpersonal Communication Skills (BICS)" (Roseberry-McKibbin and Brice, n.d.). Social English includes communicating with friends on the playground, informal face-to-face conversations with teachers, and making lists and reading them at a grocery store (What is the difference, n.d.).

Academic English may take several years to develop (Roseberry-McKibbin and Brice, n.d.). "Cognitive Academic Language Proficiency (CALP), or the context-reduced language of academics, takes five to seven years under ideal conditions to develop to a level commensurate with that of native speakers" (Roseberry-McKibbin and Brice, n.d.). Barrow (2014) discussed that ELLs that have not received math instruction in their native language may take ten or more years to acquire mathematical academic English. Academic English is more

demanding compared to social English (What is the difference, n.d.). ELLs who have acquired social English will not necessarily be proficient in academic English.

It is important for ELLs to be proficient in academic English in order to perform well at school (What is the difference, n.d.). ELLs lack the knowledge of academic vocabulary that is needed to understand the content. Without being proficient in academic English, ELLs are not able to understand the standards based curriculum that is being taught. English language learners also have a lack of depth in their understanding of vocabulary they do know (Barrow, 2014). In math instruction many of the words used have a different meaning from their core meaning (words used in everyday context) and what students initially learned.

Vanden Plas (2009) conveyed that students' background and importance of concepts can vary based on their personal experiences. For example, ELLs coming from countries that use the metric system may not emphasize fractions in the same way as they are emphasized in the United States. ELLs may come from a cultural background in which computation has a greater importance than analysis and conceptual understanding.

This research explained the background of ELLs including what benefits and struggles ELLs have when learning academic Englsih. This research suggested that vocabulary is a key component in having success in school where academic English is primarily used across content areas. ELLs' background in education and their language process leads to the next section on comprehension.

The schema or experiences they have influence the way they understand what they read (Vanden Plas, 2009).

Comprehension

It is common for students to struggle with reading comprehension (King, 2016). There is a correlation between struggling with reading comprehension and struggling with comprehension in other subject areas, including mathematics. A student can read with as much as ninety-five percent accuracy when reading literature and be able to understand what she or he has just read (Sherman & Gabriel, 2017). However, in math, if a student makes the tiniest error in his or her reading, it can change the outcome of an entire problem. This shows that in math, reading comprehension needs to have one hundred percent accuracy in order to have understanding. Students' comprehension skills can be correlated with their vocabulary knowledge (King, 2016). If students are not understanding the vocabulary words they come across, they will not be able to understand what they are reading.

Successful reading in math is related to the development of math skills and concepts (King, 2016). In math students need to have fluency with symbols, terms, and words in order to show comprehension. In order to interpret the meaning of math words and symbols, students need extensive content knowledge. According to Pierce and Fontaine (2009), "the depth and breadth of a child's mathematical vocabulary is more likely than ever to influence a child's success in math" (as cited in King, 2016, p. 239).

In stories and when looking at different forms of literature, ideas are communicated in multiple ways throughout the text (Azad, 2008). When students do not understand an idea the first time, they have opportunities for later understanding through the context or a later paraphrase. In mathematical texts, such as word problems, students have one opportunity to comprehend and show understanding. This makes comprehension of the language of mathematics more demanding and challenging for students.

Barrow (2014) discusses the comprehension gap that ELLs have when learning academic language. This is because of the complex vocabulary and sentence structure of academic language. It is suggested that ELLs receive pre-taught vocabulary lessons to help build academic language. Barrow also suggests letting students have opportunities to use language through language modeling. Barrow (2014) noted that when building comprehension in a specific content area, it is reasonable to provide words in the student's first language. Research has suggested that students who have studied for two to three years in their home language had an easier time developing academic language. Students are able to transfer their home language knowledge and skills to learning English (Barrow, 2014).

When understanding written discourse (mathematical word problems), the reader must use a combination of processing strategies (Azad, 2008). Azad displayed the use of both bottom-up and top-down processing strategies. Bottom-up processing is a combination of reading strategies and language knowledge including vocabulary, grammar, and punctuation. Top-down processing looks

more at the purpose of reading. In top-down processing readers connect with their background knowledge and knowledge of genres or material and look at their purpose in order to comprehend. A combination of these two processing strategies leads to better understanding and comprehension of the material. When using both bottom-up and top-down processing strategies, readers lacking in one type can rely on the other strategy to help them. ELLs can struggle with these processes and with comprehension. ELLs may not have the amount of language knowledge necessary to utilize the bottom-up processing strategy. Similarly, the top-down processing strategy requires more background knowledge than most ELLs have. This can lead to limited comprehension (Azad, 2008).

Azad (2008) discovered that in order for elementary age students to comprehend mathematical word problems, they needed to have language skills that were two grade levels ahead of the students; third grade student would need to be reading at a fifth grade reading level in order to understand third grade mathematical word problems.

Orosco and Abdulrahim (2018) looked at third grade ESL students' comprehension when solving math word problems. They came up with an intervention that included a restatement of the question, relevant information, irrelevant information, collaboration to find a solution, and independent practice. Orosco and Abdulrahim (2018) found that there was a significant effect on this intervention and that students integrated reading, language, and mathematical concepts to better understand and problem solve. Orosco and Abdulrahim (2018) discussed why students struggle with reading mathematical

problems. The struggles included: syntax structure and knowledge of vocabulary. They found that teachers needed more training on content specific reading skills for students to better understand math word problems.

This section analyzed the research regarding literacy comprehension and how it is related to comprehension in different content areas, specifically math. The vocabulary and sentence structure are areas that can make learning content specific academic language difficult for ELLs. The research suggested that comprehension concepts and ideas used in literacy can be carried over to the context of word problems (Orosco & Abdulrahim, 2018). The structure and importance of comprehension of word problems is addressed in the next section.

Word Problems

Minnesota first grade math standards include knowledge in the three areas of algebra, geometry and measurement, and number and operations (Minnesota Department of Education, 2015). Word problems or real-world and mathematical problems fall under the area of algebra. Below is the first grade standard in regards to solving word problems, as adapted from the Minnesota Department of Education (2015).

Table 1

Minnesota First Grade Math Standard

Strand	Standard	No.	Benchmark
Algebra	Use number sentences involving addition and subtraction basic facts to	1.2.2.1	Represent real-world situations involving addition and subtraction basic facts, using

	represent and solve real-world and mathematical problems; create real-world situations corresponding to number sentences.		objects and number sentences. *For example: One way to represent the number of toys that a child has left after giving away 4 of 6 toys is to begin with a stack of 6 connecting cubes and then break off 4 cubes.*

Adapted from "2007 Minnesota K-12 Academic Standards in Mathematics by Progressions with Benchmark-item Difficulty," by Minnesota Department of Education, 2015, *Division of Academic Standards and Instructional Effectiveness* p. 18.

Benedict (2017) explained that math word problems allow students to problem solve real-world math and apply those problem solving skills into the real world. Math word problems are more difficult to solve compared to mathematical equations. Word problems indicate why and how math is used in the real world. Benedict (2017) discussed that not all students will have careers in mathematics but word problems help students become problem solvers to the math they will encounter.

Word problems have been compared to riddles (Benedict, 2017). Word problems, like riddles, require students to use information they are given in order to find an answer. Word problems have three parts: a set-up/background story, information to solve the problem, and a question. The background story of word

problems can confuse students and make it difficult to distinguish the important and not important information.

Research has found that as math word problems show more complexity in linguistics, there is a greater difficulty for ELLs' proficiency compared to non-ELLs' (Martiniello, 2008). As discussed by Vandan Plas (2009), "the general academic achievement of ELLs as measured by standardized tests is significantly lower than that of non-ELLs."

Martiniello (2008) notes,

> Syntactic features include mean sentence length in words, item length in words, noun phrase length, number of prepositional phrases and participial modifiers, syntactically complex sentences, use of passive voice in the verb phrase, and complex sentences, which are sentences with relative, subordinate, complement, adverbial, or conditional clauses.

Martiniello found that ELLs struggled with both syntax structure and vocabulary in standardized test word problems. The structure of problems became more difficult for ELLs when there were multiple clauses, long noun phrases, and unclear relationships with syntactic units. This distorted the meaning of linked words in a problem resulting in a misunderstanding of the problem. Word problems with more prepositions, pronouns, and polysemous words were found to be more difficult for both ELLs and non-ELLs. It is also found that longer test problems showed a great discrepancy between ELLs and non-ELLs, while shorter test problems showed less discrepancy in accuracy.

Benedict (2017) looked at the different registers used in math. Students use different thinking processes when solving math word problems. A comprehension challenge can occur when students have to shift between explicit representation to abstract or vice versa. In a study looking at first grade students solving word problems that consisted of different types: change, combine, compare, a majority of students weren't able to solve the problems based on the wording (Benedict, 2017). Part of the problem is students not being able to translate between representations.

Word order affects the understanding that students have of word problems (Benedict, 2017). Students assume that the order that words occur will always match the operations that are needed. This isn't a problem when dealing with addition problems; however, this can affect subtraction problems.

Successful problem solvers focused on the meanings of words, and when errors were made, they were based on literal errors; they had the correct operations but different wording (Benedict, 2017). Unsuccessful problem solvers made errors; they did not have the correct operations. This showed that to be successful with word problems, students need to have understanding and comprehension, not just knowledge of how to use different operations.

Comparison word problems. When students are solving comparison math problems, there is a double focus that is required to make the comparison: "the first amount is x units more than the second, and the second is x units fewer than the first?" (Fuson, 2009). Students need to be able to see comparisons can happen both ways. When students are looking at more than one set of data to

compare, students are then asked to find the greatest and least quantity. Students then need the skills to make a general comparison instead of a restricted comparison. When looking at more than one set of data, students also need the skill of selecting relevant and irrelevant information.

Benedict (2017) shows an example:

> An example of this is comparing the prices of two kinds of cereal. One could say that box A is $3.00 and box B is $.50 more (consistent), or that box A is $.50 less than box B (inconsistent because the wording sounds like subtraction).

Fuson (2009) shares the problem: *"Daniel has 6 apples. Abby has 4 apples. How many more apples does Daniel have than Abby?"*. In this type of problem the language can be challenging because of the language of comparing and equalizing (Fuson, 2009). These types of questions required three different questions to be answered: "How many apples does Daniel have?"; "How many apples does Abby have?"; "What is the difference?" (Fuson, 2009). Stair-step manipulatives or picture graphs help focus students on each of the three questions. Below are examples of different comparison word problems from Fusons (2009) Math Expressions curriculum.

Table 2

Comparison Word Problems

Emily made 6 pancakes. Luis made 4 more than Emily. How many pancakes does Luis make?	Ana wrapped 7 gifts. Dan wrapped 5 gifts. How many fewer gifts did Dan wrap than Ana?	Cory's cat has 8 kittens. Eva's cat has 3 kittens. How many more kittens does Cory's cat have than Eva's?

Note. Adapted from "Math Expressions: Teacher Edition," by K. Fuson, 2009, *Math Expressions: Teacher Addition* p. 2009.

Research showed multiple areas that demonstrate the complexity of word problems. Syntactic structures and vocabulary are two areas that indicate challenges for ELLs' understanding (Martiniello, 2008). Vocabulary has been a prominent indicator throughout the research of ELLs' success and challenges with academic language, comprehension, and knowledge of word problems. This last section focuses on the research around vocabulary instruction and strategies used for learning content specific vocabulary that can be related to mathematics.

Vocabulary

Vocabulary knowledge is crucial to reading comprehension (Vocabulary development, n.d.). The more words a student knows the better he or she will understand a piece of text. Vocabulary can be taught directly or indirectly. It is best when a variety of strategies are used when teaching students new words.

It is known that English Language Learners have a lack of knowledge of vocabulary (Barrow, 2014). Vocabulary development (n.d.) states,

> 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.

Vocabulary instruction. The best instruction for teaching native English speakers vocabulary is often the best practice for teaching ELLs (Grove, 2017). Vocabulary development (n.d.) suggests a variety of strategies that include: pre-teaching vocabulary, use of cognates, scaffolding, computers, televisions, audio books, word wizard box, modeling, and encouraging language use.

Barrow (2014) suggested talking as a way to encourage ELLs to restate the new vocabulary and give opportunity for students to use words in discussion. Vocabulary development (n.d.) notes that students are going to learn academic language in the classroom. Structure the language around academic concepts. Barrow (2014) gives examples of scaffolding sentence frames to help support ELLs' use of language and discussion.

King (2016) discussed the strategy of creating an interest in words, which could help increase ease in student reading. King (2016) suggested the following as strategies to increase students' interest in words:

- real objects and demonstration (beans, buttons, marbles, M&Ms®, patterned blocks)
- children's literature related to the concept

- relating words/concepts to prior knowledge and background, interdisciplinary subjects, and cross-cultural backgrounds
- skits, journal entries, and other writing assignments
- writing students' own word problems to exchange with classmates
- field trips (even internet virtual field trips)
- games
- cartoons
- songs, poems, and raps
- drawing to visualize words in word problems
- relating concepts to real-world or everyday life experiences (pp. 67-68)

Cognates are words that are phonologically and semantically similar in two languages (Barrow, 2014). These words sound similar and have similar spelling. An example of this includes the Spanish word *diferente* and the English word *different*. Both words sound the same and are spelled similarly with the same meaning. A study with fifth grade students found that when students used cognates as a strategy, they more easily were able to understand unfamiliar words when they came across them while reading.

Isabel Beck is a theorist in vocabulary instruction. Beck developed a model of vocabulary looking at three tiers. "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." Tier Three words are

"content specific terms." Beck's model was not developed for teaching ELLs vocabulary but can be applied (Grove 2017).

Mathematical vocabulary has a high number of Tier Three words (King, 2016). These words are often only found in the context of math. These words have a low frequency and often only one meaning; however, they are important when learning the content.

Content specific vocabulary instruction. Math vocabulary can be challenging for numerous reasons. Math vocabulary has more uncommon words (King, 2016). Fifty percent of words found in a mathematics textbook are words that are infrequently used in reading. Math vocabulary includes many technical terms not found in everyday language (Azad, 2008). When students don't know and comprehend the words that come up in word problems, they aren't able to understand what mathematical operation to use or select a correct answer when multiple answers are given (Grove, 2017).

Math vocabulary needs to be explicitly taught (Orosco, Swanson, O'Connor & Lussier, 2013). Students should be pre-taught math vocabulary and have the vocabulary words be used and reviewed throughout the unit. Math vocabulary needs to be defined and written somewhere for students to access (Ediger, 2018). King (2016) laid out the strategy of posting Tier One and Tier Two words on a word wall. This allowed for students to visually see the words and their definitions.

Many words in math can have different meanings if in a different context (Barrow, 2014). As noted previously by Barrow, this is particularly challenging

for ELLs. Students need to know and understand the definition of the word when being used in math. Many words used in math are polysemous, meaning their meaning is related to the context they are being used in (Vanden Plas, 2009). "For example, students may understand a word such as *table* in a non-mathematics context, but they will not necessarily understand its meaning in a mathematical sense" (Rubenstein & Thompson, 2002). Math vocabulary also has synonyms. We use multiple words to indicate whether we are adding or subtracting. Azad (2008) showed examples of words that have the same meaning as subtraction and addition. Subtract, minus, less than, or take away all indicate subtraction. Add, plus, sum, and combine all indicate addition. King (2016) explored the strategy of differentiating definitions of words with different meanings. King addressed that words can have one meaning in mathematics and a different meaning in other contexts. Having students practice writing the different meanings of words in sentences is a strategy to help differentiate the meanings.

Smith and Angotti (2012) came up with a format to learning content vocabulary referred to as The 5C's (a focus on concepts, content, clarify, cut, and construct) as a way for planning content specific vocabulary. Smith and Angotti (2012) start with concepts and identify the words that are in a lesson. These are words that are crucial for understanding. These words could be new words or familiar words with a new meaning in the context of a specific subject area. Content is identifying words that are subject matter words that may not be specific terms but are needed for understanding. Clarifying is taking the words

identified from concepts and content and selecting the words that could cause confusion but are not crucial to the understanding of the content. This part of The 5C's addresses synonyms. Smith and Angotti (2012) suggested cutting words to minimize the complexity. Smith and Angotti pointed out that words cannot be eliminated from permanent materials, such as textbooks. Teachers are able to eliminate words from assessments and created materials. Finally the construct portion decides what words will be taught. It is suggested to not teach more than six vocabulary words. These are identified as the most crucial and important words to show understanding of the content. These words are then explored with interactive vocabulary strategies. Below is a table that lays out The 5C's for planning from Smith and Angotti (2012).

Table 3

Planning For 5C's Instruction

Vocabulary: 5C's of Planning for Instruction		
1. Concepts: What mathematical words are in the lesson? 2. Content: What subject matter words are in the lesson? 3: Clarify: What words should I mention to clarify? 4: Cut: Which words should I rephrase or eliminate? 5: Construct: What words should I teach?		
Word	Definition or Context	When to Teach

Note. Adapted from "Why are there so many words in math? planning for content-area vocabulary instruction," by A. Smith, and R.Angotti, 2012, *Voices from the Middle* p. 46. 2012.

There are many strategies to help support the learning of vocabulary. Orosco, Swanson, O'Connor & Lussier (2013) took the approach of reviewing vocabulary on index cards. Barrow (2014) suggests and uses a combination of cognates; chunking vocabulary words, meaning teaching multiple vocabulary words that support the understanding of one another; using different gestures when teaching different vocabulary words; and having students journal about the words.

Summary

This chapter looked at previous research that helped to answer the question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?* The research showed that ELLs have a challenge when learning academic English. These challenges are caused by the complex vocabulary and language structure that appears in academic English.

When analyzing comprehension the literature showed that reading comprehension is an indicator of content-area comprehension. It also showed how the area of mathematics and its complex structure and vocabulary is more challenging to show understanding, specifically with word problems. Word problems have a structure that requires students to use a combination of complex language skills along with content specific vocabulary.

Finally the research addressed vocabulary and the need to specifically teach vocabulary. Some of the challenges that come with math-content

vocabulary are the multiple meanings that change from everyday use to different mathematical meanings. The research shows that vocabulary is crucial for ELLs' language development. In order for students to show comprehension of what they are reading, they need to have knowledge of the vocabulary.

Throughout this chapter researchers found a variety of methods for teaching vocabulary. This leads into the following chapter that will focus on the methodology of answering the research question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?* In chapter three, the research on vocabulary methods will be applied to the development of a vocabulary unit to improve comprehension of comparison word problems.

CHAPTER THREE

Methodology

My capstone project involved developing focused math-content vocabulary lessons based on the vocabulary words "many," "more," and "fewer," and combinations of these words to improve first grade ELLs' comprehension of comparison word problems. These lessons helped answer my research question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?*

Overview

This chapter will discuss the design process for creating vocabulary lessons that will be used to help students with comparison word problems. The vocabulary lessons used a variety of instructional methods that were reviewed in chapter two. I will discuss the process of developing the vocabulary lessons. For this project I used Understanding by Design (UbD) methods while developing lessons. The lessons were designed with the intention of improving ELLs' comprehension and understanding of comparison word problems in math. In this chapter, I will lay out the setting and participants for these lessons, the theory for the best vocabulary practices, a description of the project, how data will be collected, and the unit plan.

Theory (vocabulary best practices)

Chapter two reviewed the best practices for teaching vocabulary. Grove (2017) illustrated that ELLs learn new vocabulary in the same way that native English speakers learn vocabulary. In this unit design the vocabulary included: "more," "fewer," "many more," and "many fewer." According to Beck's model of tiered words, these would be considered Tier One vocabulary (Zwiers, 2008). Tier One words are words that are used in everyday language. While these demonstrate examples of everyday vocabulary words, when placed in the context of math, their everyday meanings can change, specifically when a combination of the words are used, like "many more" versus "more."

When looking at best practices for teaching content specific vocabulary, the research suggested using a variety of strategies. Using language and talking in class with the use of sentence frames, having a vocabulary journal and defining specific math vocabulary, using real objects for demonstrations, acting out problems, and drawing are ways to support students with building academic English through vocabulary. When developing the lessons within this unit plan, I focused on the strategies listed above, with the expectation of supporting students' comprehension of comparison word problems.

Next I will share the process I used to create my vocabulary unit of mini-lessons. I used the practice of Understanding by Design or UbD; this design process was developed by Wiggins and McTighe (2008).

Understanding by Design

While deciding my capstone project I used an approach designed by Wiggins and McTighe (2008) called Understanding by Design (UbD). UbD combined curriculum writing with research and learning that focuses on assessments for understanding (Wiggins & McTighe, 2008). I had previous experience using UbD when writing a science curriculum for my school district. We oftentimes refer to this approach to curriculum writing as the "backwards" design process. Designing curriculum using UbD starts by looking at standards and what the end goal for students will be. When planning this ten-day vocabulary unit I started by looking at the first grade math standards and how to assess the standard. I asked the question, "what do I want students to understand and be able to accomplish at the end of this unit?" This ensured that my teaching and lesson plans went along with what I wanted students to be able to do and understand at the end. It was frustrating at times because I wanted to get to the lesson planning aspect of the unit sooner but the overall unit plan was a success. Standards were addressed, assessments were created that addressed students' understanding of the standards, and lessons were linked to the end goal. I started my capstone project by addressing the following math standard.

Table 4

Minnesota First Grade Math Standard

Strand	Standard	No.	Benchmark
Algebra	Use number sentences involving addition and	1.2.2.1	Represent real-world situations involving addition and

	subtraction basic facts to represent and solve real-world and mathematical problems; create real-world situations corresponding to number sentences.		subtraction basic facts, using objects and number sentences. *For example: One way to represent the number of toys that a child has left after giving away 4 of 6 toys is to begin with a stack of 6 connecting cubes and then break off 4 cubes.*

Adapted from "2007 Minnesota K-12 Academic Standards in Mathematics by Progressions with Benchmark-item Difficulty," by Minnesota Department of Education, 2015, *Division of Academic Standards and Instructional Effectiveness* p. 18.

Setting

The setting for this ten-day unit is in a suburban first grade classroom. The school is a kindergarten and first grade elementary school outside of a metropolitan city in the midwest. The following will be considered as part of the setting: community, district, school, and classroom.

Community. The community is in a second ring suburb with a rapidly growing population. The community has become socially and economically diverse as the population growth has been occuring. Rapid change has occurred with additions of townhome developments, Habitat for Humanity homes, luxury developments, and mobile home parks.

District. The district has sixteen schools, including nine elementary schools, two middle schools, two high schools, an Area Learning Center, an early childhood center, and a transition education center. The student population in the district is approximately 8,500 students (School digger, 2019). This district is ranked 196th out of 440 school in the state in student numbers (School digger, 2019). The nine elementary schools use the same math curriculum and scope and sequence for the year. This project was developed based on the first grade Math Expressions scope and sequence.

School. The school is unique in that it is a kindergarten and first grade campus that later feeds into a second through fifth grade campus. While this school has only two grade levels there are still many students. The population is approximately 335 students, divided into eight kindergarten classrooms and seven first grade classrooms. The school houses multiple pre-school classes as well. The school has a low ELL population, with less than five percent of the students receiving ELL services. The school has 14.6 percent of the population receiving free and reduced lunch. The racial breakdown includes: 84.5 percent white, 7.5 percent two or more races, 3.3 percent Asian, 2.7 percent Hispanic and 2.1 percent African American. The schools follow the ideals that all students should be respectful, responsible, and safe, and have the core values of respect, responsibility, service, integrity, and compassion.

Classroom. The classroom consists of 24 students and one teacher. During core writing and math instruction, para support is also included. The classroom math curriculum consists of Math Expressions with

supplemental materials used that have been researched by district curriculum leads.

Participants

The data for participants is an approximation based on classroom demographics in past years. There were approximately 24 first grade students ages six and seven. In past years there have been roughly twenty-five percent of classroom students participating in our ELLs program. Typically there were three to five students that receive special education services, and less than five students that receive reading and math intervention outside of the classroom instruction. The participants used Math Expressions curriculum for five months prior to the project curriculum being introduced. They have completed five units of the Math Expressions first grade curriculum.

Project Description

This project included a unit plan of ten mini-lessons that focused on math vocabulary. The vocabulary focus will be on the words "more," "fewer," "many more," and "many fewer." This vocabulary will be crucial for students' understanding of comparison word problems. Students will be given a pre-assessment and post-assessment on comparison word problems that use the vocabulary words "more," "fewer," "many more," and "many fewer."

Scope and sequence. The ten vocabulary lessons in the project were aligned with chapter six in the Math Expressions first grade curriculum. This chapter focuses on comparisons and data formats. This unit will approximately occur in the beginning of February, 2020. The Math Expressions chapter six includes sixteen lessons. The first six lessons are on comparisons with graphs.

Starting with lesson eight, students will be solving comparison word problems. The unit of mini vocabulary lessons will start at approximately lesson number three. Starting the vocabulary mini-lessons at lesson five will allow for some pre-teaching of vocabulary.

Timeline. This project was completed in August, 2019. I started developing the project in June of 2019 and worked with a capstone advisor and peer reviewer to complete the project on time. The project will be implemented in my classroom during the 2019-20 school year.

Unit Plan

The unit plan consisted of a series of mini-lessons that will be taught throughout the Math Expressions unit six first grade curriculum. Unit six in Math Expressions includes, graphing, measuring, comparison word problems, three dimensional shapes, and patterning. The vocabulary mini-lessons I created will be taught before the unit lessons on comparing as a way to pre-teach vocabulary. During these lessons I will be using a variety of different vocabulary teaching strategies from research in my literature review. I will use two strategies during each lesson for teaching each day. The reasoning for using mini-lessons in my project is to gradually and explicitly teach vocabulary to improve comprehension and understanding of comparison word problems.

Assessment Tools

For this project there was a variety of tools used for assessment purposes. The project included both a pre-assessment and post-assessment, found in the appendices of this project. The pre-assessment and post-assessment will give teachers the option to look at quantitative data based on student scores on

each assessment. Mills (2000, p. 133) described teacher-made assessments as common quantitative data collection that assists with both monitoring and adjusting instruction. I created a checklist of vocabulary strategies that was used throughout the lesson planning process to ensure I used a variety of researched strategies.

Pre-assessment. I created a short pre-assessment of four word problems. These word problems utilized the vocabulary that will be taught in the lessons. Each problem shows a different variation of the vocabulary "more," "many more," "fewer," and "many fewer." This assessment will provide me with an idea of which vocabulary is difficult and which vocabulary comes easily for students when looking at each question. You will find an example of this informal assessment under appendices in my project.

Post-assessment. I created an informal post-assessment of five problems, four word problems and one problem in which students write their own comparison word problems. Similar to the pre-assessment, the post-assessment used the vocabulary words "more," "many more," "fewer," and "many fewer." I had wanted to use the chapter six math test for the post-assessment to reduce the number of assessments that first grade students need to take. Due to copyright I was not able to use that assessment for the purpose of this capstone project. I will be able to compare the pre-assessment and post-assessment and see how students improved. These assessments will correlate to the language lessons taught. The post-assessment is under appendices within my project.

Checklist. During my lesson planning I used a checklist to ensure that I included all important vocabulary strategies throughout the lessons in the unit. Making this checklist allowed me to make sure I used best practices and multiple strategies to support vocabulary development. I used a minimum of two different strategies each day to work with the vocabulary that is being taught.

Summary

This chapter went over the methods I used when completing my capstone project. I created a vocabulary unit that encompassed mini-lessons while using the UbD approach. In these mini-lessons I used a variety of vocabulary development strategies that have been researched and explained in chapter two. I went over who the participants will be and the setting in which my project will be taking place. All of this information goes over my methodology that will help answer my research question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?*

The following chapter provides conclusions. This chapter will discuss the major learnings from this project, including learnings from the literature review and developing the vocabulary unit using UbD. This chapter will review the implications and limitations of this project. Finally, it will provide recommendations for future work and emphasize the benefits to the education profession.

CHAPTER FOUR

Conclusions

Introduction

The purpose of this capstone project was to develop a vocabulary unit that supports ELLs' understandings of comparison word problems by utilizing the research question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?*

Overview

In this chapter I will discuss the important outcomes I learned through the process of creating my project, a ten-day vocabulary unit assisting first grade students in their comprehension of comparison word problems. I will discuss aspects of my literature review that were significant in the development of my vocabulary unit and other major learnings that have occurred throughout the process of creating this capstone project. I will explain the implications of this project and the effects it had on me, students, and fellow teachers. I will review the limitations that this project has on stakeholders and the limitations I experienced when creating this project. Next I will explain the recommendations I have for this project, including ways to further expand on what I have developed. Finally I will go over the results of the project and the professional benefits I experienced through this capstone process.

Major Learnings

Benedict (2017) explained that not all students will have careers in mathematics but word problems help students to become problem solvers to the math they will encounter. This was a major driving force when creating this project and Benedict was able to explain why this project was important to me, wanting my students to be problem solvers.

Throughout the process of creating my capstone project there were two areas that had a large impact on my learning. The research for my literature review and using the Understanding by Design (UbD) process when creating my vocabulary unit. Both the research and the design process were crucial to creating my project.

Literature Review. Throughout the research I analyzed in my literature review, the common theme was the importance of vocabulary knowledge on learning academic English, being able to have comprehension of what students are reading, and the understanding of word problems. This influenced why my capstone project became a ten-day unit focusing on specific content vocabulary.

Barrow (2014) noted that ELLs have a lack of depth in their understanding of the vocabulary that they know. This impacts ELLs' performance ability at school with academic English. ELLs lack the knowledge of academic vocabulary that is needed to understand the content (What is the difference, n.d.). Without being proficient in academic English, ELLs are not able to understand the standards-based curriculum that is being taught.

This research confirmed that vocabulary is a crucial part of learning academic English and that ELLs are missing aspects of vocabulary that are necessary in having success. This leads into the impact vocabulary has on comprehension.

King (2016) noted that it is common for students to struggle with reading comprehension and that there is a correlation between reading comprehension and comprehension in other subject areas. Azad (2008) found that in order for elementary-age students to comprehend mathematical word problems, they needed to have language skills that were two grade levels ahead of the students; third grade student would need to be reading at a fifth grade reading level in order to understand third grade mathematical word problems. Orosco and Abdulrahim (2018) discussed why students struggle with reading mathematical problems. The struggles included: syntax structure and knowledge of vocabulary. They found that teachers need more training on content specific reading skills for students to better understand math word problems.

This confirmed that vocabulary is crucial when it comes to being able to comprehend what you are reading. It also showed the need to have content specific training and teaching on vocabulary to prepare students for the content they are trying to reach. This project is designed around the content of comparison word problems in first grade mathematics.

Research showed multiple areas that demonstrate the complexity of word problems. Syntactic structures and vocabulary are two areas that indicate challenges for ELLs' understanding (Martiniello, 2008). Vocabulary has been a

prominent indicator throughout the research of ELLs' success and challenges with academic language, comprehension, and knowledge of word problems.

My literature review provided knowledge of ELLs, academic English, comprehension, word problems including comparison word problems, and the importance of vocabulary. This research impacted my unit planning, and the importance of specific vocabulary lessons can play a part in solving comparison word problems.

Understanding by Design Process. When creating my ten-day vocabulary unit I used Wiggins & McTighe (2008) process of Understanding by Design (UbD). This helped with narrowing down the focus of my unit. I started planning by first looking at the state standards and what desired results I wanted students to have at the end of the unit. As shown in my curriculum unit, my desired results included having students understand how to compare and be able to compare two items whether in a word problem or found in other everyday areas (graphs, measuring, etc.). It is important when using the UbD methodology in curriculum planning that teachers understand what they want students to be able to do and understand before they develop individual lessons and activities. After developing my desired results, I next looked at different forms of assessment and how I would interpret evidence of students' understandings of my desired results. For this unit, I chose to use a pre-assessment and post-assessment using the vocabulary I focused on and its use in comparison word problems. The final process with using Wiggins & McTighe (2008) approach with UbD for this unit was creating the lessons and appendices. When developing the activities in each

lesson I used a checklist of strategies from my literature review. This allowed me to ensure I was using a variety of researched strategies throughout the unit plan.

This process taught me how to plan based on standards and focus on the end results. Through the research in my literature review and using the UbD process, I learned valuable information that I can take with me in my teaching and curriculum planning and share with colleagues. Research collected and prior teaching experience assisted in knowledge of the implications and limitations of this project.

Implications

By designing this unit on specific vocabulary instruction, I provided an outline for future curriculum development to support ELLs' academic English throughout different content areas. I and fellow educators can use the UbD format to create additional math vocabulary lessons that can be used throughout the curriculum.

The project intends to give support to ELLs through vocabulary that will build comprehension and improve academic English in the area of math. This ten-day vocabulary unit is built on content specific vocabulary in a way that will allow students to better understand and have success in solving comparison word problems.

While the focus of the vocabulary unit is on comparison word problems, the intent for students is to be able to transfer this knowledge and show understanding in other forms of comparisons. It is my hope that students are able

to make comparisons in everyday life circumstances as well as through reading different forms of graphs and in measurements.

This project was created the summer of 2019 with the intent to be implemented during the 2019-20 school year. Desired results of this capstone project are projected based on the research collected and past experiences in the educational field.

Limitations

This project was developed to be taught parallel with the Math Expressions curriculum. The vocabulary selected was based on chapter six in Math Expressions that correlates with first grade state math standards. These standards are not based on common core; educators would need to make modifications to this unit based on the math standards in the state they are teaching.

The vocabulary that was used is very specific to comparison word problems; however, there could be circumstances when other languages would be used in a comparison. For example, in the unit focused on the word many, there are comparison examples that would instead utilize the word much, specifically when comparing items that are being measured. I would consider adding a lesson now that introduces the word much with comparison word problems. This next section goes over additional recommendations for future work with this project.

Recommendations for Future Work

For future work with the project I recommend expanding on the ten-day unit to create vocabulary units to go with each chapter of Math Expressions

curriculum. This layout and design process could also be utilized with other math curriculum or used to enhance understanding of vocabulary in different content areas such as science, social studies, or language arts.

While in the process of creating this project I was informed that my school district would be changing its curriculum and no longer using Math Expressions. I am optimistic that I can use my knowledge of vocabulary instruction and mathematical word problems in order to make minor changes to this unit and use with future curriculum. I am certain that using the UbD approach allows for use of this unit outside of Math Expressions because it is based on the state math standards.

Presentation of Project Results

This project will be presented to fellow educators as well as with colleagues. The presentation of the results will consist of a Google slide presentation accompanied by speaker notes. While sharing the results with colleagues I will provide access to the ten-day vocabulary unit through Google docs. I will also provide a blank template of my UbD unit. This will provide the ability to create new units or lessons while utilizing the UbD approach. In formal and informal settings, I will be sure to reiterate the importance of creating specific vocabulary units to support ELLs with academic English and the ability to comprehend learning across curricular areas.

Benefit to the Education Profession

My project has added to the inquiry of vocabulary instruction of ELLs. This is a very broad and large topic that has been researched in numerous

ways. Through this project I was able to narrow the vocabulary instruction to three specific words that can be used in one specific type of word problem, comparisons. I am glad to be able to contribute to the field of teaching ELLs and hope this research project inspires others to look at specific aspects of vocabulary to benefit their students.

Conclusion

Through this experience I was able to develop a capstone project on the question, *how can math instruction and comprehension of comparison word problems for ELL students be enhanced through content specific vocabulary on "many," "more," and "fewer," and combinations of these words?* I created a ten-day vocabulary unit that used researched strategies to better support ELLs' comprehension of comparison word problems. I was able to combine research and UbD to create a project that focused on state standards and provided lessons that supported the end goals for students.

From my research in this project, knowledge from completing masters level classes, and personal teaching experiences, I feel strongly that I have created a project that will benefit students and their understanding of comparison word problems. Through this experience I feel that I am a stronger student and educator and have gained knowledge to take with me that will not only benefit students in the area of mathematics but in all areas of learning.

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