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Preparing English Learners for Academic Language Demands of Mainstream Mathematics

Tracie Lynn Cavalli
Hamline University, tcavalli01@hamline.edu

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PREPARING ENGLISH LEARNERS FOR
ACADEMIC LANGUAGE DEMANDS OF
MAINSTREAM MATHEMATICS

by
Tracy Lynn Cavalli

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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Committee:
Kathryn Heinze, Primary Advisor
Ann Mabbott, Secondary Advisor
Sara George, Peer Reviewer
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CHAPTER ONE: INTRODUCTION

Mathematics is considered a universal, non-verbal language, with its numbers, and symbols that span across many languages and cultures (Garrison, 1997). Mathematicians or scientists in one country can interpret data from a mathematician or scientist in a different country without worry about the language barrier, because the numbers have the same value or meaning in many different languages. The current assumption by well meaning guidance counselors is that language minority students should be placed in mainstream mathematics classes because those classes will pose less of a challenge for them to learn the content because of the perceived lack of language in the course (Bresser, Melanese & Sphar, 2009).

The academic language used in mathematics courses is difficult for native speakers as well as language minority students. The academic language of mathematics is frequently limited to the mathematics classroom. Beck, McKeon, and Kucan (2002) delineate words of this technical specificity within academic language as tier three words. These tier three vocabulary words are necessary to build knowledge and understanding in specific academic domains (Marzano, 2004). Integrating learning strategies that incorporate both academic content for mathematics established in the common core standards (2015) and the academic
language standards developed by WIDA™ (2012), which supports academic language for English learners is crucial. Academic content area targets coupled with language standards will enable students to increase their understanding of the mathematics concepts and their ability to communicate and justify their thoughts and ideas both orally and in writing through their second language.

All educators at one time or another will have English learners enrolled in their classes and will be faced with the challenge of how to meet all students’ individual needs. Collaboration of content classroom teachers and language teachers will help facilitate success with ELs. One key aspect is having both content and language teachers look closely at the importance of explicitly teaching academic language. Partnerships between content and language teachers allow students the opportunity to develop receptive and productive language and use the new language numerous times during the course of their lesson or unit. It takes time to acquire language and grasp the concepts being taught. This collaborative format of instruction has the potential to assist a wide range of learners as they are mastering the content standards, not just the language minority or struggling students.

Educators must take into account all the factors that influence a student’s ability to master the content. Today’s English learners come to the classroom with very different backgrounds. Some students have little experience within a school environment in their native language. These students have limited or interrupted formal education (SLIFE) (Walsh, 1999). Others were educated in their native country. Additionally, a growing number of English learners were born here in the
United States but were raised in a home where a language other than English was primarily spoken.

Another factor that influences student learning is the use of technology. Students have become technologically savvy at a very young age, and want to utilize this tool in their learning process. Even the way teachers deliver instruction has changed. Learners are often required to communicate in many different collaborative classroom environments in English. It is imperative that students are given opportunities to interact with the language to become proficient. Given the abundance of cooperative activities that teachers now incorporate into their teaching methods, students need to have linguistic support so they can discuss their thinking process with their peers (Bresser, Melanese, & Sphar, 2009). In this study I want to see if developing teaching methods that support these learners will improve not only their language skills but also their mastery of the mathematics content.

Many language minority students arrive in the United States with varying degrees of social and academic English. The first step is to access their language level. Students are assessed using the W-APT (WIDA™-ACCESS placement test) upon arrival in the United States, and annually using ACCESS for ELs. ACCESS (Assessing Comprehension and Communication in English State-to-State for English Language Learners) is a large-scale assessment that is based on the model performance indicators of WIDA’s™ five English Language Development (ELD)
standards (WIDA™, 2012). These standards focus on both social and instructional language.

In 2014, about 14 percent of the students who qualified for English language support in the suburban high school where I teach were new to the country. These students were assessed as a level one (entering) on the WIDA™ scale (WIDA™, 2012). About 20 percent have been in the country for between 1 to 3 years and qualify as level two (beginning) or level three (developing) on the WIDA™ scale. According to the WIDA™ performance indicators (2012), level three students can communicate in short sentences and are beginning to grasp content concepts. The majority of the students (60%) in this suburban high school are at levels 3-5 on the WIDA™ scale. They can use technical language, expand their sentence structure and can communicate socially with ease. However, when it comes to mainstream educational courses, they struggle to keep up because of the intense usage of Common Core tier three vocabulary, the formality of the academic register, and complexity of grammatical structures, in all of their courses (Schmidt & Burroughs, 2013). In the course of a seven-period high schools instructional day there are seven different teachers, with seven different teaching styles and seven different vocabulary lists for them to acquire both the receptive and productive language. All while keeping up with homework, learning a new language, adjusting to a new culture and a new way of life. Compounding the difficulty, they are being educated differently than their parents; so, parental support can be limited. These factors impact how much a student learns in the course of an academic day.
ELs and Testing

Education has been viewed as the great equalizer, the gateway to equality. But according to the National Assessment of Educational Progress (2011) approximately 3.4 million EL students remain significantly below average in mathematics. The achievement gap stills exists, and many students, including the English learners, aren’t given the same opportunities as their language majority counterparts (Schmidt & Burroughs, 2013). Many English language students are tracked into lower level courses because of their language ability and are receiving different learning experiences, thus limiting their exposure to the higher level concepts and academic register required by standardized tests (Schmidt & Burroughs, 2013).

The majority of the English language learners in the United States are failing their math courses and lagging behind their language majority peers in standardized testing (Echevarria, Short, & Powers, 2006). Considering the high stakes that the state comprehensive assessment mathematics exam and college entrance testing has on students’ futures, all teachers need to think about why the students are not passing these tests they need to receive a high school diploma or gain entrance into college. Teachers need to implement new strategies to help students gain the knowledge and academic experiences to succeed in class, on tests, and in life (Bresser, Melanese, and Sphar, 2009).

This idea brings into question the validity of the tests that are given to English language learners in their L2 (English). Are schools testing the students
understanding of the math concept, or are they testing students’ grasp of the academic register of mathematics? The landmark Supreme Court Case of Lau vs. Nichols (1974) found that all students, despite their first language, should be provided the opportunity for a meaningful rigorous education. To make sure that this happens, English language learners need direct academic vocabulary instruction in mathematics (Marzano, 2004; Zwiers, 2012). According to Marzano, increasing student’s academic vocabulary will improve test scores (2004).

Developing Academic Language

According to the American Association for the advancement of Science (as cited in Jarrett, 1999) “The ability to speak English and a second language combined with strong skills in mathematics and science will provide unlimited opportunities”. Solving algebra problems can be difficult even when the math content language is being taught in class. If teachers add the academic math vocabulary and academic language structures into their math instruction without explicit vocabulary support or instruction it can compound students’ difficulties.

While the majority of EL students whose WIDA™ levels are two and higher are able to communicate about day-to-day things, the students are often not yet able to work in cooperative groups to share their thought processes or discuss how they solved the problems. The language of how to express the complex thinking processes that they need to discuss topics with their language proficient peers has not been developed fully yet (Cummins, 1974). Marzano investigated teaching
academic language across the spectrum of classes and created Marzano’s six-step process for building academic vocabulary (2004). The steps are:

1. Provide a description, explanation, or example of the new term.
2. Ask students to restate the description, explanation, or example in their own words.
3. Ask students to construct a picture, pictograph, or symbolic representation of the term.
4. Engage students periodically in activities that help them add to their knowledge of the terms in their vocabulary notebooks.
5. Periodically ask students to discuss the terms with one another.
6. Involve students periodically in games that enable them to play with terms.

It is valuable to incorporate these six steps into an effective lesson plan. Vocabulary plays an important role in acquiring language, learning to read, and reading to learn. An increased knowledge base in vocabulary has a direct impact on comprehension and plays a role in students’ success in school.

If all students are expected to succeed in the mathematics classroom, then it is necessary for them to understand the language of mathematics. This can be a challenging task given that the only place a student really uses math language is in the math classroom.

Many school districts introduced the SIOP® model. The SIOP® (Sheltered Instructional Observational Protocol) model addresses the academic needs of the EL
student through building background knowledge, making input comprehensible, incorporating interactive activities and explicitly teaching academic vocabulary. These are key components for improving a student’s chances of understanding how to solve algebra problems, because they are given the knowledge of the language in addition to the math skills.

There are several instructional methods used in my algebra one class to introduce, reinforce, and have students engage with the algebra terms or expressions. The most effective tool has been the mathematics journal or notebook. The students include a heading on each page, sample problems and written explanations on how to solve the problem, in their own words. For the purpose of demonstration, a sample of student’s journal entry can be found in Appendix A. The mathematics journal also includes a vocabulary log, where they write student friendly definitions, and add illustrations or sketches when appropriate. Students work in groups to take the textbook or dictionary definition and create a definition that they created in easy to understand terminology.

Another instructional method used during class is engaging students with small whiteboards. When students utilize the individual whiteboards to review and discuss the new terms by writing out the problem and how they solved it. If asked to graphically represent the word quadratic equation they can write an equation with an $x^2$ or they can draw a parabola on a coordinate plane. Student can then use their receptive and productive language to discuss with their partners the different aspects of their answers, again utilizing the new academic vocabulary. This
discussion element of the lesson was the spark that ignited my interested in increasing my students use of mathematics vocabulary.

Co-teaching in the Mainstream Classroom

A few years ago I was transferred to an area-learning center, this school served students who were at risk and had not had success in a traditional comprehensive high school setting. This program has not enrolled a large EL population; previously, the school had only had enough EL identified students to employ an EL teacher for 20% to 40% of the teacher contract day. The EL teacher would show up at random, unscheduled times from other schools pulling the EL students from their mainstream classroom and working with them on improving their writing skills. The staff of the area-learning center agreed that this model didn’t work. They were excited to have another staff member, but the facility did not have any empty classrooms in which I could teach. I agreed to teach one period a day in the kitchen. I was happy to have some space to work with the ELs. Then, we analyzed the students schedule and decided I would co-teach in classes where the majority of the ELs were. I was not thrilled that I would be forced on teachers who didn't really have a choice if they wanted me in their classroom or not. I taught in several different classes, which including English, science, social studies, and mathematics. In three of the cases, English, mathematics and science, we planned together, taught lessons together, and developed different learning strategies together that we were able to add to the current curriculum. The next trimester I
began teaching two sheltered EL classes, English and civics. I found that co-teaching is beneficial if all parties involved are willing participants.

My experience teaching mathematics to EL students began out of the need for the school to increase their percentage of students passing the state’s comprehensive assessment mathematics test. The staff at the area-learning center thought it would help all students if there were two teachers in the classroom. The staff’s reasoning was not to support the ELs, but to support all students’ vocabulary building skills. The task of vocabulary building was not an approach the mainstream mathematics classroom teacher was eager to attempt. So the principal asked me to co-teach in algebra II mainstream course. I accepted the assignment. It was a perfect fit. I had a math background, experience co-teaching, and a good relationship with the classroom teacher. These components helped create a highly successful mathematics classroom environment where all students gained both mathematics skills and mathematics language.

Our class consisted of twenty-five students, of that about seven students were English learners. I began each class with the warm up questions and short vocabulary lesson. So students viewed me as an equal partner in their education and not as support staff. We quickly learned that the majority of the students, not just the EL students, struggled with the mathematics vocabulary. We felt our co-taught classroom was highly effective because we had covered both the language and the content of mathematics. This successful partnership continued for two
years, until enrollment of EL students declined, and I was transferred to another building within the district.

One aspect of the job that is unique is that the ESL teacher needs to go where the students are, and that means being transferred from one building or grade level to another. When I was moved to another building, I advocated for my students and asked for another co-teaching experience. At my new placement no one knew me; they were reluctant to have me in their classroom. I offered an alternative. I asked to teach a sheltered Algebra 1 course. After discussing the state comprehensive assessment mathematics test results data with the high school principal that was presented to the district at an all staff meeting in August 2011. It was clear that the English learners were scoring far below the district norm in all areas. Seeing this marked discrepancy in students enrolled in ESL and those passing the state comprehensive assessment mathematics exam, the principal researched further and saw that the majority of the EL students were not passing their mainstream mathematics class. The principal realized that my suggestion was a possible solution, and I was allowed to offer a new sheltered mathematics course to the EL students. Since I had already been highly qualified in mathematics through the state-licensing agency, the administration accepted my proposal. I taught this course for three years, and it is catalyst for my research.

Therefore, the goal for this study is to help prepare students for the state comprehensive assessment mathematics exam and college entrance exams by increasing their use of mathematics language and increasing their participation in
mathematics conversations about the topic at hand. I will look closely at how ELs’
students learning experiences, as well as, their academic and linguistic needs are
impacted by explicitly teaching math vocabulary, and exposing them to the
academic register so they can express themselves linguistically in a mathematics
setting. The hope is that direct academic vocabulary instruction improves students’
understanding of math concepts as well as increases their use of mathematics
vocabulary during a class period. I want to show that the more EL students master
mathematics academic vocabulary, the more the students will be able to show the
mastery of the intended content standard through proper form of mathematics
language in both oral representation and written form. I want to show that EL
status does not affect their understanding of the content standard mathematics
concept.

Summary

In this study, I will focus on how to incorporate learning strategies that make
both the academic content, mathematics state standards for algebra 1, and the
academic language, more accessible for WIDA™ level one through level four
language minority high school students. I will determine whether utilizing the
adapted form of Spanos’ Word Problem Procedures and direct vocabulary
instruction help students to gain the confidence and mathematics ability to solve
algebra problems. Spanos’ technique is designed to break each math problem down
by steps, helping the learner to process the steps needed to complete mathematics
problems (2009). ELs struggle in mainstream mathematics courses and educators need to investigate which strategies are best meeting students’ needs.

Guiding Questions

This capstone explores the issues involved in teaching mathematics to students whose first language, L1, is not the language of instruction. My research question asks: How can explicit instruction in mathematics language and problem solving instruction improve ELs achievement in solving positive and negative integer problems in a secondary mathematics instruction? I integrate explicated methods teaching of the academic math language and several learning strategies that incorporate use of the mathematics language. The goal is have students attain mastery of mainstream mathematics concepts while developing their English language skills.

Chapter Overviews

In Chapter One, I explained my passionate interest for researching the link between academic vocabulary and student achievement and why it is important to study. In Chapter Two, I provide a review of several studies completed that relate to the topic. Chapter Three describes the research and methodology of this study. Chapter Four presents the results of the study. The implications of the results are also laid out. This study focuses on one aspect of the complex process of acquiring academic mathematics vocabulary structures. There are many more questions that pertain to this topic that can be covered.
CHAPTER TWO: LITERATURE REVIEW

In this chapter I will examine current research in the field of mathematics that explicitly speak to the strategies that address the needs of language minority students. To begin, I will discuss the many facets that make learning mathematics difficult for EL students. Then, I will examine the current statistics to illustrate how EL students have been performing well below the national average on standardized performance assessments. Finally, I will review current methodologies that explicitly teach math language, implement learning strategies and integrate student talk time into lessons. Looking though this research will provide different avenues to explore in relation to improving math instruction for lower to intermediate level EL students.

Research has focused on how building academic vocabulary improves a student’s ability to comprehend the course content; however, many researchers have overlooked the role of academic vocabulary in mathematics courses. Bresser, Melanses, and Sphar (2008) state that if students are to develop an understanding of math concepts, they have to be armed with the language to discuss mathematics. The purpose of this study is to explore the ways to improve EL students’ comprehension in higher-level mathematics courses by mindfully teaching mathematics language, featuring learning strategies that give language support and
structure, and incorporating communicative opportunities for students to utilize their mathematics discourse. My research question asks: How can explicit instruction in mathematics language and problem solving instruction improve ELs achievement in solving positive and negative integer problems in a secondary mathematics instruction?

Social and Academic Language

In every classroom, language is being conveyed in two different formats: social and academic. Cummins (1979, 2009) has brought these language classifications to the forefront of EL education. BICS (Basic Interpersonal Communication Skills) are skills that are needed in every day social situations such as on the bus, in the lunchroom, hallway discourse, and social media interactions. BICS occurs in social situations that are not particularly cognitively demanding, and does not have a specialized terminology correlated with it. Students can successfully develop BICS in six months to two years (Cummins 1979). On the other hand, CALP (Cognitive Academic Language Proficiency) refers to formal academic language learning that is required for a student to be successful in school. The student not only needs to grasp the meaning of the academic vocabulary but also must be able to use it to synthesize new information. Given the complexity of academic language, on average it takes EL students five to seven years to acquire CALP. Some students take longer due their lack of formal school before arriving in the United States (Collier, 1995; Cuevas, 1984).

Academic English and social English are two different entities and need to be
treated as such by educators. It is important to focus on the direct instruction of the language of mathematics because mathematical problem solving is infused with: explaining, questioning, describing, discussing, checking and sharing results with a partner, teacher or class. With all these opportunities for using the mathematics language students will have a significant chance to increase their academic mathematics language and their English language skills (Jarrett, 1999; Kang & Pham, 1995).

Academic Register

An innovative trend in English as a Second Language programs has been the creation of content ESL classes. These courses combine the curriculum for the state academic content standards and the WIDA ™ (world class instructional design and assessments) standards for English language development, as stated in the WIDA™- English Language Development Standards at www.wida.us/standards/eld.aspx (2012). These courses provide the sensitivity to the linguistically and culturally diverse students while mastering the content needed for success in the mainstream classroom (Spanos, 2009). With the emergence of the common core standards, http://www.corestandards.org/, there has been a push for students to be engaged in communication and discourse within the context of the mathematics course work. For an English learner, this means the student needs to acquire both the language and the content material as well as be able to use academic language appropriately.

Whether you are a native speaker or non-native speaker, mathematics can be a difficult subject to comprehend because mathematics, as all mainstream content
courses, has its own academic language. When learning a new mathematics concept, students who do not understand the words being said will not make a connection to the meaning. Academic language is using vocabulary beyond the everyday social conventions. It requires one to read, write and discuss the new terms in meaningful discourse, typically in an educational setting (Freeman & Crawford, 2008). If students are able to use this new language in meaningful ways, they will have created a deeper understanding of the concepts and be able to apply them in their logical reasoning (Bresser, Melanse & Sphar, 2009). Teachers need to remember that everyday language has context clues and the language is often repeated to help express the meaning, but in academic language students do not have those basic clues that they are used to relying on (Cummins, 1979).

**Academic Mathematics Vocabulary Structures Versus Social Language**

Reading and writing mathematics sentences can pose additional problems for language minority students. The biggest issue is that many mathematics terms have words that have the same spelling and pronunciation but different meaning. Words such as *mean, tree, order,* and *power* (Jarrett, 1999). Another issue is that different cultures write or express mathematical operations in different ways. A student who learned to borrow when adding or subtracting in South America may carry the one and mark it on the number on the bottom of the mathematics problem, whereas students in the United States use the numbers at the top of the mathematics equations. Another example is that a comma is used in the United States to separate whole numbers and show place values, but in some countries a
decimal point is used instead. Also, units of measure can differ from one country to another. Most countries use the metric system: kilometers, liters, and Celsius. The United States uses the English system: feet, inches and Fahrenheit. Adding to the complexity, mathematicians created words from pre-existing words, such as square root. Knowing the language challenges is half the battle (Dale & Cuevas, 1992).

Although mathematics had been considered a universal language, the methodological aspect of it can be very difficult for students to master. Solving mathematics problems is hard for some students. However, the language is what can hinder the EL students further cognitive development and discourage their love of math. Teachers need to take into account new vocabulary; such as, equation, hypotenuse and quadratic, and reintroduce words; such as plane, foot, and face, that students are already familiar with, but alter their meaning for concepts being taught in the mathematics classroom (Rubenstein & Thompson, 2002; Freeman & Crawford, 2008). Once language is mastered then the concept can be developed.

Syntax of Mathematics

Another mathematics linguistic twist is that when communicating a mathematics equation or expression in words, it can differ from the order of the numbers. Syntax, or the arrangement of the words in a sentence, contributes to the understanding of concepts. This is difficult for students when they are trying to decipher problems with words in them (Jarrett, 1999). An example from Rubenstein and Thompson (2002), the number $x$ is five less than the number $y$. This is correctly written as $x=y-5$, but can be translated directly as $x=5-y$. The incorrect translation
would result in the incorrect answer given. This causes confusion for the language-
learning student.

Acquiring the language and mastering content standards can prove to be a
difficult task for limited language students especially if the students have had
limited formal schooling, or disrupted schooling in their native language. The
language aspect of mathematics can become more challenging when addressing
some of the inconsistencies in the terminology and its usage. Rubenstein and
Thompson (2002) address many of these difficulties in a chart that show some of
the vocabulary difficulties and give examples for each difficulty (see Appendix B).

In mathematics, words can be the same but have different meanings; an
eexample is right angle, right answer, or right hand. These words can be tricky
because they have different meanings in everyday English than they do in a
mathematics class. Sometimes words in math have similar meanings, but they are
not exactly the same; difference indicates the same as subtraction and difference can
refer to comparing two or more things.

Different disciplines share words, but they have different meanings. In
science, variable means the part of the experiment that you are testing, which is
similar but not exactly the same as variable, the letter that represents the possible
solution to the equation.

Some students find it difficult that in English the same concept can be said in
multiple ways (Rubenstein & Thompson, 2002). For example $X^2$ is said as either $X$
squared, $X$ to the power of two, or $X$ raised to the power of two. Then students need
to learn that there are different ways to solve $X$ squared on a calculator, use the caret button on the calculator, multiplying the number twice or using the engineering exponent (EE) button to enter $X^2$. When learning fractions, one over four can be express multiple ways: one quarter verses one-fourth. The student might recognize the word *quarter* and think that it is referring to the number twenty-five, as in a quarter of a dollar, but they have to learn why they write a one over four when the teacher says one quarter. Without direct vocabulary instruction and language learning strategies a language minority student might fall behind in both the language and content.

**ELs’ Performance in Mathematics**

The ELs need to learn both English language skills and grade-level content skills simultaneously, and because language plays a significant role in acquiring mathematics concepts this makes the task twice as challenging. (Echevarria, Short, & Powers, 2006) Many components in a math lesson and on standardized tests are language intensive and therefore pose problems in deciphering the concept and decreasing comprehension for the ELs (Cuevas, 1984; Khisty, 1995; Freeman & Crawford, 2008).

The achievement data provided by the National Assessment of Educational Progress (2011) has shown that ELs have fallen significantly below the average score compared to native English speaking students in mathematics. According to the National Assessment of Educational Progress (NAEP, 2011), approximately 10 percent, or roughly 4.7 million student of the United States students are English
language learners and that number is only increasing. NAEP results show that 28% of all students in the United States are below basic in their achievement level for mathematics in 8th grade, whereas, 72% of the ELs in the United States are below basic (NAEP, 2011). This trend has been verified through many other studies with comparable results, with an emphasis on schools Latino population (Cuevas, 1984; Khisty, 1995; Freeman & Crawford, 2008). Freeman and Crawford (2008) referred to the National Center for Education Statistics data from 2002 that reported that the drop out rate for Hispanic youth was almost 30% and that 88% of Hispanic eighth graders nationwide are below basic in mathematics.

This achievement gap shows that the needs of the English language learners are not being addressed in the regular mathematics classroom and that their specific language needs need to be addressed before they can master grade level mathematics concepts (Marzano, 2004). One remedy for this problem is the adoption of the Common Core State Standards for Mathematics (CCSS-M). Several states have recently adopted the CCSS-M and with proper implementation all students will receive equal educational opportunities through these high quality math standards (Schmidt & Burroughs, 2013). The Common Core State Standards for Mathematics do not seem to directly address the needs of the English language learner. The hope is that EL teachers can develop curriculum that aligns with but does not stray from the CCSS-M (Freeman & Crawford, 2008). Another remedy would be implementing Marzano’s six-step academic vocabulary process in mainstream courses (Marzano, 2004).
Math + Language = Knowledge

The language of mathematics is difficult to understand. There are many aspects of acquiring academic language structures in mathematics that make that statement true. Mathematics has academic language that has definitions specific to that mathematics concept, precise semantic and syntactic interactions, cultural elements and specific cultural notations and problems solving techniques that differ from those used in the U.S (Kang & Pham, 1995). These varying concepts in culture and language acquisition directly affect the EL students learning and may impede their understanding of the concepts being taught. Once language is mastered then the concept can be developed.

Students not only need to read and understand the words, they also have to be able to solve the problem and communicate with their classmates to explain the mathematics content (Freeman & Crawford, 2008). In recent years, researchers have become increasingly interested in the relationship between English language learners academic success and their proficiency with academic language. In order to close the achievement gap for EL students, Marzano (2004) suggests that teachers explicitly teach standard based, subject specific, and academic language in a meaningful way. This approach will provide the students the tools to create meaningful discourse with their mainstream peers.

Another key component to language minority students’ success in the mathematics classroom is applying the new mathematics vocabulary into the educational setting through the use of direct instructional strategies that promotes
math talk in the classroom (Spanos, 2009). One recent trend in EL has been sheltered content instruction and co-teaching models. These content-English classrooms allow students to master the academic language as well as the grade level mathematics content at the same time. These methods bring academic vocabulary usage to the forefront of the classroom.

Spanos’ Word Problem Procedures

George Spanos wanted to create a learning strategy to help students break down mathematics word problems into simply steps that could be applied to many different types of problems. In Spanos’ case study, he used the learning strategies that he developed: Word Problem Procedures (WPP). Spanos’ integrated the following steps into his class instruction as steps for students to following while solving word problems. The Word Problem Procedures are as follows:

1. Choose a partner. Write your names above.

2. Choose a problem. Write the problem in the space below.

3. One student reads the problem out loud. Discuss the vocabulary and circle words that you don’t understand. Write the words below.

4. Use a dictionary for help. Ask your partner or teacher for help.

5. What does the problem ask you to find? Write this below:


7. Solve the problem below.

8. Check your answer below.
9. Explain your answer to your partner. Write your explanation here.

10. Explain your answer to the class.

11. Write a similar problem on the back of this page (Spanos, 2009, p. 7-8).

This strategy was specifically designed for mathematics classes. These strategies were utilized in-group settings designed for aiding discussion on the content topic at hand. He showed that over time these strategies improved students' critical thinking and study skills as well as increased their confidence with the language. Another benefit that Spanos found was that classes had better classroom management when utilizing this learning strategy. Spanos felt that his study was lacking in significant increases in their linguistic level. In the study it did not mention his methods for assessing their linguistic level. Educators need to recall that the goal for academic language proficiency is a long-term goal and cannot be reached in one school year. The study indicated that language teachers should be coached to incorporate language and content into their programs.

There have been many researchers, including Cummins (2000) and Marzano (2004), who have explained that cognitive academic language proficiency (CALP) is key to student’s success in the mainstream classroom. Research has focused on how building academic language improves a student’s ability to comprehend the course content. However, many researchers have overlooked the role of using academic language in mathematics courses. Several studies have shown that communication is crucial to successful problem solving in mathematics courses but little research has been done to create learning strategies that will help EL students develop their
language skills and communications skills while solving mathematics problems. It is hoped that this study can help to bridge the gap by uncovering a new way to help EL students communicate, clarify and justify their thoughts both orally and in writing in a mathematics class.

Research Question

My research question asks: How can explicit instruction in mathematics language and problem solving instruction improve ELs achievement in solving positive and negative integer problems in a secondary mathematics instruction?

Summary

In this chapter, I have highlighted significant research done on mathematics vocabulary instruction, the challenges that ELs encounter, and strategies to close the gap in achievement.

In Chapter Three, I will describe the research design, data collection methods and procedures I used in this study of the instructional strategies employed in my sheltered EL Algebra 1 high school mathematics course.
CHAPTER THREE: METHODOLOGY

This study was designed to test learning strategies to improve English learners' ability to communicate and comprehend the mathematics concept of positive and negative integers by showing that there is a direct relationship between overtly teaching math language, and integrating learning strategies that incorporate both academic content and academic language into the lesson plan. In this study, I wanted to know if using different learning strategies, such as, an adapted model of Spanos' Word Problem Procedures, would prove to be effective for ELs as they are learning the complex concepts of positive and negative integers. My research question asks: How can explicit instruction in mathematics language and problem solving instruction improve ELs achievement in solving positive and negative integer problems in a secondary mathematics instruction?

Overview

In this chapter, I will describe the methodologies used in this study. First, the rationale and description of the research design are presented along with a description of mixed method research paradigm. Second, the data collection protocols will be presented. Next, I will present background information on my participants and the school's population. Then, I will describe the procedures that I
used and how I analyzed the data. Finally, I will discuss the ethical steps I took to safeguard the student participants.

**Mixed Method Research**

I have prepared an action-based research project using a mixed method research model. A mixed method research design is when both quantitative and qualitative data are collected in the study. This method was chosen for my research because it encapsulates real classroom-learning environments, which includes observations, document analysis and performance assessments.

**Quantitative Research**

In quantitative studies, data are collected in numerical form that can be analyzed using statistics in an objective manner. Students take many quantifiable assessments, so it is important to study the participant’s growth on positive and negative integers. In this study, I plan on collecting quantitative data through performance assessments. I will evaluate each student's previous knowledge on the topic of positive and negative integers by administering a pre-assessment and post-assessment using Naiku, www.naiku.net.

Naiku is a web-based assessment tool designed to give immediate feedback or benchmark checks through a wide variety of assessment formats (Naiku, 2014). All the mathematics teachers in the high school where the study is being conducted use Naiku. It provides the user the ability to measure, monitor, assess, and rate students’ confidence and allows student and teacher feedback as well as align the assessments with the common core or state standards. As students complete the
assessment, they can rate their confidence on each question, provide justification for their answer and reflect their understanding of the topic. The assessments can be run on any web-enabled device. Naiku provides summary descriptive statistics for each student, and whether or not they met each standard. A student is considered proficient if they receive a 70% or higher rating, an approaching rating for 60-69% proficiency, and are not proficient if they are below 60%. The data received from this assessment will be calculated to indicate the student’s mastery of the topic using Table 1. This data are available immediately, and can be broken down by problem.

Table 1

**Performance Classification**

<table>
<thead>
<tr>
<th>Performance Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proficient</td>
<td>Students who scored higher than 70% across all assessments</td>
</tr>
<tr>
<td>Approaching Proficient</td>
<td>Students who scored between 60% and 70% across all assessments</td>
</tr>
<tr>
<td>Not Proficient</td>
<td>Students who scored below 60% across all assessments</td>
</tr>
</tbody>
</table>

**Qualitative Research**

In qualitative studies, the researcher is the main instrument for data collection and analysis, and as a teacher we want to understand how students process and interpret their educational experiences (Merrium, 1998). Therefore this seems to be a good form of data collection for this study. For the qualitative portion of the data collection, I will be looking at how the subjects respond in written form
on the assessment with the language component (see Appendix C) using the written assessment rubric I created to analyze the data (see Appendix D). I will also be looking at how the participants verbally responded during the presentation problems (see Appendix E) using the rubric I created by adapting the speaking rubric from the WIDA™ consortium (see Appendix F). One of my goals in conducting this study was to find out how the ELs were using mathematics language in classroom communications, verbal and written, so it seemed appropriate to add qualitative research: observation and document analysis.

Data Collection

Description of Participants

In my research, I will be studying a small group of English Learners. The participants have varying language proficiencies from entering (level 1) to expanding (level 4) on the WIDA™ (World-class Instructional Design and Assessment) ACCESS English language proficiency scale. Of the eight students chosen, five students speak Somali and three speak Spanish as a first language. There are five female participants and three male participants. The participants have been in the United States educational system from three months to three years. Seventy-five percent of the participants are on free and reduced lunch. More than half of the participants are SLIFE. Pseudonyms were used to protect the participants’ identity. Table 2 gives more specific information about the students.

These students have repeatedly struggled with mathematics concepts in English since their arrival in the US school system. Two of the participants have
taken the **state comprehensive assessment mathematics exam** and neither one met the minimum requirement for graduation. This is one factor that was looked at when placing them in the sheltered mathematics class. Five of the eight students involved in this study are SLIFE. Since many of the participants were new to the country and did not have any formal assessment information, the mathematics department chairperson created an assessment to get a sense of their mathematics ability for correct course placement. They lacked basic math skills like multiplying, dividing, using fractions and decimals and solving one-step equations. The participants were all assigned to my sheltered EL mathematics class.

Table 2

*Student Information*

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>WIDA™ Composite Proficiency Level</th>
<th>Home Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michell</td>
<td>14</td>
<td>1</td>
<td>Spanish</td>
</tr>
<tr>
<td>Messi</td>
<td>14</td>
<td>3</td>
<td>Spanish</td>
</tr>
<tr>
<td>Nancy</td>
<td>18</td>
<td>4</td>
<td>Somali</td>
</tr>
<tr>
<td>Hero</td>
<td>17</td>
<td>2</td>
<td>Somali</td>
</tr>
<tr>
<td>Asma</td>
<td>17</td>
<td>3</td>
<td>Somali</td>
</tr>
<tr>
<td>Ben-Ni</td>
<td>16</td>
<td>3</td>
<td>Spanish</td>
</tr>
<tr>
<td>Sabria</td>
<td>15</td>
<td>3</td>
<td>Somali</td>
</tr>
<tr>
<td>Sara</td>
<td>17</td>
<td>3</td>
<td>Somali</td>
</tr>
</tbody>
</table>

In my quantitative research, these participants represented a typical sample of EL students at this high school. I had complete access to these participants because they were enrolled in my year-long sheltered Algebra 1 course. A student
may be exited from this program and returned to a mainstream class if she or he can solve problems from grade level content independently. My expectation is that the data collected about these participants might be a true representation of how level one, level two and level three students acquire the language of mathematics.

Location/ Setting

This study was conducted in a suburban high school fifteen miles south of a large mid-western city. I currently teach at this high school. There are approximately 1,800 students enrolled in the school, 70 of those students qualify for EL services. Its student body is primarily of white students, but it is the most diverse comprehensive high school in the district. Presently, 28% of the students in the district are students of color, and approximately one-fourth of the population is receiving free or reduced lunch. Six percent of the student body is classified as English language learners, which is slightly lower than the state average of eight percent (NAEP, 2011).

The research took place in the sheltered EL algebra one class that I teach. The textbooks used are Longman Mathematics and Algebra 1. Longman Mathematics is a mathematics workbook designed for use with English language learners, it is used as a supplement to the Algebra 1 book that is the mainstream district textbook. The state standards are taught and we attempt to follow the schedule set forth by the mathematics department at the high school.

Pilot Study

Over the past three years, I had piloted a study as a part of our required
continuing education program in which I incorporated pre-teaching vocabulary into the mathematics lesson and tracked the students’ pre and post-test scores. This was completed as an informal investigation to help focus this study. The observational results showed that test scores dramatically increased with direct vocabulary instruction. As an observational note, students’ engagement in the classroom discussions and activities increased during the lessons where the vocabulary was clearly taught. To help focus the study further, I continued teaching the language minority students mathematics with an addition to the pilot program. A set of procedures was added that was adapted from Spanos’ Word Problem Procedures (WPP). The students use a specific set of steps or procedures to solve and explain their mathematics assignments (Spanos, 2009). The pilot study showed that the students used informal language when they were in small groups. The informal atmosphere of the small group discussion permitted them to use everyday language and not academic language. When they presented their problems aloud in front of the class at the interactive whiteboard, the percentage of academic mathematics vocabulary increased. Thereby students were demonstrating that they understood not only the mathematics concept but also the mathematics language of the course. This caused me to change the data collection of the present study to focus on the problems presented to the class instead of the students’ discussion while they were completing the problem solving procedures (PSP) worksheet with their group. I clarified my focus and used the procedures adapted from Spanos’ Word Problem Procedures.
My objective was to show that with some vocabulary instruction and collaborative class discussions, EL students might not need to be placed in mathematics remediation classes but that they could master the same grade level standards with the proper scaffolding and language support warranted of a student whose first language is something other than the language of the course instructor.

Procedures and Analysis

My data were collected during the 2014-2015 school year. Previously, I had implemented several different learning strategies in my pilot study to support language develop in the mathematics classroom. The first step was introducing new techniques to teach mathematics language: the Frayer model, four corner notecards, and Marzano’s six-step process for developing academic vocabulary (Roberts & Truxam, 2013). I continued to add interventions to support the use of the language in the classroom such as math journals, group discussion time, partner problems, problem solving procedures, and presentation problems.

I focused this study on the following data collection methods: (1) pre and post-assessment on Naiku, (2) post assessment with a language component (see Appendix C), (3) collaborative group work called PSP (see Appendix E), a method adapted from Spanos’ method, which incorporates the participant orally presenting presentation problems in front of the class. I documented student’s knowledge about the mathematics language and concept in a pretest before administering the Naiku pre-assessment.
Appendix G shows the schedule that I used to teach the lesson, administer assessments, and collect recorded and written data. I used Algebra 1 lesson on positive and negative integers provided by the mathematics department. After teaching the mathematics department’s lesson, I introduced interventions intended to strengthen the student’s knowledge of mathematics language. The interventions include vocabulary instruction, use of a classroom word wall, use of mathematics journals, PSP from Spanos (2009) and presentation problems (Roberts & Truxam, 2013; Rubenstein & Thompson, 2002). After implementing the interventions, I reassessed their language usage in the same fashion with the language post-assessment, altering the numerical values but keep the language and structure of the questions the same.

Data Collection Technique One

To gather some baseline quantitative data about my participants’ knowledge on the topic of positive and negative integers, I administered the first pre-assessment using Naiku. I provided a fifteen question multiple-choice pre-assessment test to the students that was created by the mathematics department administered via the website www.naiku.net. This website is used by every mathematics teacher at high school. The assessment consisted of fifteen problems using positive and negative integers to add, subtract, multiply or divide. The assessment questions corresponded to the mathematics content standards that all students are expected to master in Algebra 1.
For comparison of results, student assessments were administered, at the end of the study, the fifteen question multiple-choice post-assessment via Naiku; the values in the problems were altered, but the operations and the language remained the same. Summary descriptive statistics were provided in a report on each student based on their performance, based on the number of correct responses. The data was compiled for comparison. Table 1 describes the performance categories and quantitative groupings. The cut scores in Table 1 are based on district-accepted proficiency levels in mathematics.

Data Collection Technique Two

To better assess the participants’ mastery of the content and the language, I collected data via a paper and pencil assessment. This assessment was teacher-created for use with EL students. It is modeled after the writing assignments that the students complete in their mathematics journal on a weekly basis, example shown in Appendix A. The assessment has two components: solving the mathematics equation that used positive and negative integers and explaining their thinking in sentence form using correct mathematics language. The quantitative component was based on the correct solution to the equations. The written responses were assessed using the rubric in Appendix D and the participants’ performance classification was described according to parameters in Table 1. If a participant received 70% or higher they were classified as proficient, 60-70% was approaching proficient, and 60% or below is not proficient. The qualitative component measured how the participants explained their thinking, how they used
targeted vocabulary words in the written explanation, and if their explanation was comprehensible. The recorder analyzed the sentences for correct language structures and meaning. Then the recorder placed a circle around the appropriate number on the rubric indicating the effectiveness of the answer.

Data Collection Technique Three

To collect data about my participants’ ability to justify their thinking and reasoning orally, I recorded the participants verbally explaining the solution to an assigned positive and negative integer problem. During class, students were recorded presenting their presentation problems after they had been given time in their small discussion groups to work on their PSPs. A set list of words was targeted during the discourse completion task. This list was partially generated by the participants. The vocabulary words included: *add, addition, subtract, subtraction, multiply, multiplication, divide, division, parenthesis, exponent, integers, whole numbers, same, different, sign, order of operations, positive, negative, big, bigger, biggest, small, small, smallest, change, equals, answer* and *solution*. Participants were graded using the rubric in Appendix F. Once the score had been calculated participants were again classified according to Table 1 to determine their performance classification.

Triangulation

In order to ensure reliability of the study, I asked a mathematics teacher from the high school to also score the language components of the participants’ responses using the same rubric and guidelines set forth in this document. She has been a
mathematics teacher for seven years at the high school where the research was completed and teaches Algebra 1. I wanted to determine whether there was inter-rater reliability. I collected data in more than one format using rubrics to ensure validity and reliability.

Ethics

This study employed the following safeguards to protect informant’s rights:

• Permission was obtained from parents/guardians of the participants prior to data collection.

• Research question was shared with all participants.

• The human subject review was submitted and approved before any research was conducted.

• Research was kept on password-protected computer and in locked files when not in use.

• Names of participants and schools remained anonymous to protect rights and reputations.

• All transcriptions were written word for word to ensure proper representation of the participants in the study.

Summary

In this chapter I explained who the participants in the research were. Then I described the environment that the experiment took place. Finally, I summarized the procedures that I used to conduct my investigation, and how they were
implemented. Appendix G includes a chart showing the timeline for my lesson. In Chapter Four I discuss the results of my study.
CHAPTER FOUR: RESULTS

This study took place in an EL sheltered mathematics classroom during the designated class time. This study was completed in a large mid-western suburban high school with students in grades nine through twelve. My research question asks: How can explicit instruction in mathematics language and problem solving instruction improve ELs achievement in solving positive and negative integer problems in a secondary mathematics instruction? This chapter presents the results of the research based on: pre-test, post-test, oral problem solving procedures and the written integer language assessment.

Through the analysis of the data, I wanted to find out if explicitly teaching mathematics language and allowing students opportunities to use that language would increase their ability to retain the mathematics concept and the mathematics language.

Pre-test Results

The participants in the study began by taking a pre-test prior to any instruction on the topic of adding, subtracting, multiplying and dividing positive and negative integers. I gave the participants an assessment created by the high school's mathematics department using the web-based formative assessment tool, Naiku (2014). Naiku, http://www.naiku.net/, is used district wide and all the participants
had been exposed to this technology at least twice prior to this investigation. The participants completed this during class time in the computer lab. See Appendix H for the pre-test and post test assessment for positive and negative integers.

None of the participants involved in the study received a rating of proficient on the pre-test. The participant Messi clearly has had some background knowledge about this topic, but looking closer at his results, the errors were all based on situations where multiple negative signs were used in the same problem. The other participants showed a great need for instruction on this topic, and had more pronounced difficulties throughout the assessment. The participants’ pre-test scores can be seen in Table 3.

Table 3

Student Pre-test Scores

<table>
<thead>
<tr>
<th>Participant’s name</th>
<th>WIDA™ composite proficiency level</th>
<th>Score (Number correct out of 15)</th>
<th>Performance Classification (Naiku assessment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asma</td>
<td>3</td>
<td>4</td>
<td>Not Proficient</td>
</tr>
<tr>
<td>Nancy</td>
<td>4</td>
<td>3</td>
<td>Not Proficient</td>
</tr>
<tr>
<td>Sarah</td>
<td>3</td>
<td>6</td>
<td>Not Proficient</td>
</tr>
<tr>
<td>Michelle</td>
<td>1</td>
<td>6</td>
<td>Not Proficient</td>
</tr>
<tr>
<td>Ben-Ni</td>
<td>3</td>
<td>2</td>
<td>Not Proficient</td>
</tr>
<tr>
<td>Messi</td>
<td>3</td>
<td>10</td>
<td>Approaching Proficient</td>
</tr>
<tr>
<td>Hero</td>
<td>2</td>
<td>8</td>
<td>Not Proficient</td>
</tr>
<tr>
<td>Sabria</td>
<td>3</td>
<td>4</td>
<td>Not Proficient</td>
</tr>
</tbody>
</table>

Problem-Solving Procedures Results

A mathematics teacher and I conducted oral analyses of participants’ language and math ability while the participants presented individually to the entire
class. Each participant was given an assigned problem to review with the class on the interactive whiteboard. The instructions were to solve the positive and negative integer problem provided on the interactive whiteboard while explaining their thinking, reasoning, using key vocabulary words and phrases as well as providing the correct solution to the mathematics problem. On occasion, prompts were given when a participant needed a reminder to explain what they were doing.

One aspect of language development that was lacking was the use of productive language. The students need more opportunity to use productive language through speaking activities and writing assignments. I wanted to actively engage students in language usage while teaching them grade-level mathematics concepts. I came across Spanos’ word problem procedures and since many of my EL mathematics students are SLIFE and had not been exposed to these higher-level mathematical concepts, I needed a way to break down the mathematics concept while teaching language. Therefore, I adapted Spanos’ Word Problem Procedures to work for the steps of any mathematics problem, whether it was simple or complex. The pre-test results, before Spanos’ intervention instruction, showed that 87.5% of the students were not proficient in the use of positive and negative integers prior to instruction. Clearly there was a need for direct instruction and interventions.

On day five of the study, the class reviewed the mathematics concept by implementing the PSP. See Appendix E for PSP worksheet. We completed three problems together as a model. Students were then assigned one problem to work on using the PSP, they were allowed to discuss their problem with a partner and then
given time to practice with their partner while a parent volunteer and I worked with the participants as needed. I chose problems for each participant based on their language level and mathematics proficiency.

On day six of the study, students individually used the interactive whiteboard to present the problem that they worked on the previous day. Students were instructed to state the problem, explain how they solved the problem, and use mathematics vocabulary in their explanation. The researcher and a mainstream mathematics teacher, using the rubric in Appendix F, scored the participants. I generated this rubric by melding several rubrics that I was familiar with including the Speaking Rubric of the WIDA™ consortium (2012). The two scores were averaged and are shown in Appendix I.

After the entire recordings were complete, I transcribed the oral presentations. See Appendix J for the transcriptions of the oral presentation problems. Next, I looked for patterns that I could use to summarize the information from the rubrics. Finally, I analyzed the two rubrics, the researcher's and math teacher's rubric, for each student and compared it to their language level and their SLIFE categorization.

The participants' scores for the presentation problems (PSP) can be seen in Appendix I. For all students, the scores in the calculations performed sections were higher than any of the other categories. Every participant received a score of four or higher. One factor for this could be the leveling of the questions. Participants with lower language levels were given simpler questions. No major errors in calculations
were evident which shows that students checked their answers with their partners or the teacher, verifying that they had the correct answer before presenting the problem.

Every participant was able to correctly copy the mathematics problem on the board. For the participant, Hero, there were some problems with correctly naming the numbers and signs, reversing the nine and six and positive and negative. Participants, Nancy and Messi, both received a score of five because they incorporated several technical mathematics terms in their problem description.

The mathematical difficulty of the integer problem has a direct relation to the amount of vocabulary needed to explain the problem correctly. So participants with simpler problems needed to use less technical language. In the case of Michell, she is at level one; therefore, she received the easiest integer problem. She used general mathematics words like: *six, twelve, eighteen, big* and *first*. Then she was also able to incorporate *subtract, whole number, answer and negative* correctly. Given her language level, this suggests that there was growth in her developing in the use of mathematics language.

The two components of the oral presentation that received lower scores are more linguistically based: the (1) explanation of the problem solving strategies and (2) linguistic complexity of the discourse. When looking at the results in these two sections, the pattern that I noticed was that 75% of the participants scored above their WIDA™ language level on the adapted WIDA™ rubric. The students developed their vocabulary but not complex sentence structure, organization or
ways to support their thinking further orally. The next step is comparing their language, and their SLIFE classification with their performance on the oral presentation.

The data in Appendix I suggests that all but one the participant’s average scores on the oral presentation exceeded the current composite WIDA™ language level. Ben-Ni’s score was the only one that matched his language level. This is not surprising given the fact that this participant entered the country three weeks before the research was conducted. He had not attended school over the past two years and his eighth-grade grades were below average.

A focus on the students who are categorized as non-SLIFE students, students who had been formally educated in their first language, suggests in Appendix I that two of the three scores are significantly above their language level. Michell and Messi made pronounced gains. Messi has a language level of three but showed oral presentation proficiency skills at 4.4. Michell’s growth was even more noticeable with a language level of one and a presentation score of level three. Participant Nancy showed little growth but given her current WIDA™ level of four, it is not surprising. When speaking, Nancy sounded comparable to a native speaker.

Spanos’ own findings correlate to this trend. He found that more advanced learners showed less growth, but still improved in performance (2009). The non-SLIFE students clearly made gains in the oral use of mathematics language during this unit of study.
The majority of this class was SLIFE students. Each participant had a different background in the amount and type of schooling that they received before coming to the United States. Participant Sabria did not attend school until she arrived in the United States two years ago. She lacked basic number sense and mathematics skills, like addition, subtraction, multiplication and division that some of the other SLIFE students had. Over the course of this academic school year, she has made tremendous strides in all of these areas. When I look at her oral performance in Appendix I, it shows that she made considerable progress. Furthermore, when her lack of schooling is factored in, she would be the participant that exceeded my expectations. She has a language level of three and scored an average of 3.6 on the oral presentation rubric. I was surprised that her score in the problem identification and linguistic complexity categories were not higher because she is an oral learner and typically does a wonderful job explaining her thinking aloud. I feel that placing a recording device in front of her increased her anxiety and may have slightly impacted her presentation skills. This is a natural consequence when asking students to stand in front of their peers, especially SLIFE students.

Participant Sara has been in the United States for almost three years arriving with no English and several years of interrupted schooling at various refugee encampments. She is clearly expanding her language skills from a language level of three to 4.1 on the oral presentation rubric. She was a student of mine last year and is much more comfortable presenting to the class since we used these same strategies last year. One area that I felt she could have improved was vocabulary
usage. While explaining the problem she did not use words like *numerator* and *denominator*, which were taught earlier in the year. Instead she chose less academic descriptions of *on top* and *on bottom*. This shows that reviewing the academic vocabulary throughout the year is important (Roberts & Truxam, 2013).

Hero’s situation is very similar to Sara’s situation. He has been in the United States for less than two years and has received the last few years of his education in refugee camps. He had some knowledge of addition, subtraction and multiplication. He struggles with division and negative numbers. During his presentation he was continually groping for the correct terms, possibly showing some L1 interference. He would confuse *six* and *nine*, forget to say *negative* and he needed more prompting than any other student. Given these difficulties, he was able to orally explain his approach at a level that was slightly higher than his language level.

The remaining two participants, Asma and Ben-Ni, both scored slightly above their language level of three. Ben-Ni had only been in the United States for three weeks prior to this research being conducted. Before that he had not attended school for the past two and a half years. During the research window, he was struggling with getting to school on time, staying awake and staying focused. Asma had been in the United States for about a year and a half. She transferred to our school, from Washington State, about two weeks prior to the research being conducted. She and Ben-Ni were unfamiliar with my teaching style and giving oral presentations. Given their relative unfamiliarity with the learning environment they still preformed adequately on the oral assessment.
**Written Assessment Results**

During the nine class periods that data were collected students received several interventions to aid their learning the mathematics concept correctly. The interventions included direct vocabulary instruction, slower paced lessons, group work to develop oral skills, and oral presentations using the problem solving procedures. After two weeks of instruction on the topic of positive and negative integers students were given the assessment with the language component as seen in Appendix C.

The participants' scores for the written assessment can be seen in Appendix K. For the majority of the students the scores indicate that they performed at levels approaching proficient or proficient in the mathematical skill based categories. These scores suggest that the students increased their ability to solve equations involving positive and negative integers. Ben-Ni continues to struggle with the concept of positive and negative integers. I feel that the added focus on the students' usage of oral mathematics language had positive results.

The one language-based category that the participants excelled in was vocabulary usage. It is clear to me that students that did not have the math language at the beginning of the unit mastered the understanding of the technical mathematics language needed in order to comprehend the lesson by the end of the unit. Allowing students time to learn, and use the vocabulary in meaningful experiences improved their comprehension and allowed them to articulate that in the assessment. For example, participant Michelle wrote, "Addition problem with a
negative number. Subtract the smaller number from the bigger number. Keep sign of bigger number. Answer negatives twenty.” She used seven of the vocabulary words correctly, and explained her thoughts in simple grammatical constructions that are typical of a level one learner. The participant Asma stated in one of her answers, “For this problem, I needed to multiply positive and negative integer. The rule is positive time negative equal negative. My solution be negative.” Asma also used seven vocabulary words correctly, and she showed that she organized her expressions of ideas and utilized some short and some expanded sentences. This writing sample shows that her written language is expanding.

The area on the assessment that still shows a need is the writing component. The majority of the students were not proficient in the written language categories especially in the area of a written explanation of mathematical steps and writing an explanation that is comprehensible. The only intervention that focused on writing was the PSP. I modeled how to fill in the PSPs, but no direct instruction was given on how to write clearer sentences to explain their thinking. This could be one factor that contributed to the students’ deficiencies in the writing categories. The exception to this was participant Messi. He mastered this concept in all domains. Given his language level of three on the WIDA™ scale, I was impressed by his improvements. The mathematics department placed him in the sheltered EL mathematics class because of his language level. He has since been moved to a different math class and is experiencing success in a mainstream classroom.
Participant Ben-Ni did not attempt anything in the writing section for six of the twelve problems. There were numbers written in the sections where sentences should have been. It was clear that he knew he needed to write in those sections because he did so for the other six questions. When I asked the participant about this he said he did not know how to explain it in words and he did not want to leave the spaces empty. It is possible that his limited formal schooling, not being in school for over two years and being a newer student to our class, could partially account for his not proficient status.

Several participants, Michell, Asma and Hero, also struggled with the writing assessment. They rewrote the mathematics sentence in words but did not explain how they calculated their answers resulting in receiving no credit for the explanation categories. Although in their writing, it was clear that they had a grasp of the vocabulary. One factor could have been their language level. Another factor could have been that they were unclear about what the directions were asking them to do, but they had completed smaller assignments like this before with more success.

An interesting observation was that only two participants, Messi and Asma, attempted problem twelve. This was the most difficult problem on the assessment. Even thought the assessment contained only twelve problems, adding the writing component lengthened the time it took to complete the assessment. Two participants, Sabria and Hero, claimed that the assessment was too long and that they were, “... so done,” with the assessment, meaning that they were no longer able
to continue working on it due to mental exhaustion. On my usual assessments, they only need to explain their thinking in writing for one or two problems. This increased linguistic demand may have placed undue stress on their testing environment.

Post-Test Results

In order to show whether or not the participants displayed growth on the topic of positive and negative integers, I administered a post-test using the web based formative assessment Naiku. The post-test assessment was created by the high school mathematics department. The assessment was identical in structure to the pre-test with only the numerical values differing (see Appendix H). The assessment was given on the last day of the unit in the computer lab of the high school after all interventions were completed. Calculators were prohibited on all assessments during this research project.

Comparing the data on performance classifications from the pre-test to the post-test assessments the data shows progress for every student. One participant received a perfect score. The rates of growth varied widely in the class. Participant Sara showed a two-point growth from the pre-test to post-test. But when looking at her oral comprehension of the topic from the problem solving procedures, it shows that she can orally explain her thinking but is still struggling with the mathematics concept. This is not surprising considering she has only received two years of education. Her parents have also said that she struggles in mathematics but is making wonderful gains in language. Participant Asma showed a nine-point growth
in her score by improving from four points on the pre-test to thirteen points on the post-test. The remaining participants fell within the range of growth between 20% and 47%. This is a topic that many mainstream students struggle with after being taught. So it is not surprising that the participants did not master the concept. In Appendix L, each participant is listed with their pre-test and post-test score and their performance classifications.

Conclusion

In this chapter, I have presented the results from my data collection. The data were summarized and displayed in graph format in Chapter Five. In summary, the results showed that 100% of the participants showed growth from the pre-test to the post-test with 50% of the participants receiving a proficient rating, 25% approaching proficient and 25% not proficient yet. The oral presentations of the problems using the problem-solving procedures showed that 100% of the participants scored at or above their current language level. The results also revealed that 88% of the participants were proficient in the vocabulary usage on the writing assessment; conversely only 25% of the participants were about to explain their thinking clearly through writing.
CHAPTER FIVE: CONCLUSIONS

My research question asked: How can explicit instruction in mathematics language and problem solving instruction improve ELs achievement in solving positive and negative integer problems in a secondary mathematics instruction? In this study, I attempted to determine whether adding language-based interventions such as explicit vocabulary instruction (Rubenstein & Thompson, 2002), student oral presentations connected with the use of an adapted version of Spanos’ word problem procedures and incorporating more writing about their mathematical thinking was an effective strategy for improving high school ELs ability to understand the mathematics concept. In this chapter, I will discuss my major findings, limits of this study, implications for teachers and recommendations for further research.

Major Findings

One major finding from the research was that the interventions aided the students’ comprehension and receptive and productive language development on the topic of using positive and negative integers. Cuevas (1984) stated that attention must be given to language skill in order for achievement in mathematics. Every participant showed growth in the categories studied. The participants’ performance on the problem-solving procedures and oral presentations showed the
most significant growth in the category of oral language development. I found that
the repeated use of the academic vocabulary during these times required the
students to use appropriate academic language to be able to complete the steps of
the procedures, communicate with their partner and orally present their integer
problem to the class. The problem-solving procedures and oral presentations are
helpful techniques for students who struggle with the mathematics language and
mathematics skills.

Another interesting finding of this research was that students who were
given proper background knowledge and vocabulary instruction on the topic were
not impeded by their language level when asked to explain the math problems
orally. The participants were able to exceed their language level when the language
instruction was focused on the topic that was being taught. Oral skill are attained
prior to written skills so this result is as expected (Cummins, 1979).

Limits of the Study

One limitation of this study was that participants scored significantly lower
on the writing components of the assessments. This inconsistency could be the
result of the lack of direct writing instruction. I modeled how to fill in the problem
solving procedures, but should have created sentence frames and provided more
examples and practice writing time during the integer unit.

Another limitation is the number of students at each language level that
participated in the study. If I had had more students at each given language level I
could have focused on how students at the same language were able to complete the
language components of the research. This would have provided more focused findings. Since this class is a sheltered mathematics class it also limits students exposure to the language via non-native speakers. If the research took place in a co-taught class there might have been more exposure to higher level, richer language.

My class population tends to fluctuate during the year. This creates a limitation in my eyes because two to three weeks before the research began I had one student leave and three new students join my class. Two of the new students are SLIFE students and were struggling to be students. They had not attended school for the last year or more. The new students had difficulty focusing, working with others in groups, and standing in front of the class to present the information. Since 63% of the participants were SLIFE, factors such as school cultural, knowing how to be a student, shyness when being recorded and their interest in mathematics impacted their performances on all of the assessments.

Implications for Teachers

As I tackled this research topic, I approached many mainstream mathematics teachers for ideas on how to teach the concept of positive and negative integers and make it stick. One implication that I would stress is that mainstream teachers should take more instructional time addressing reoccurring topics and introduce methods like direct vocabulary instruction, problem solving procedures and plan mathematics talking time. This would give students opportunities to use the tier 3 words that are content specific to their mathematics courses (Collier, 1995).

According to Marzano’s research (2004), students need time to be engaged with the
language through activities that will add to their knowledge and usage of the academic vocabulary being used. This would be beneficial to all students’ not just limited language students. If teachers spend more time going deeper into the topic now, there will be less of a need for re-teaching the same topic when it is applied in a higher level mathematics concept.

The observations that I made during the course of this research support instructional approaches in which teachers allow students time to discuss and present their problems. Repeated practice in academic discussion creates students who are more comfortable with getting up in front of class. As our school goes through many STEM (science, technology, engineering and mathematics) meetings, we are continuously being reminded that we need to be teaching students how to express themselves in front of groups in all different circumstances. Presentation problems are a way of meeting that goal.

**Recommendations for Further Research**

After completing my research I realized that I could have pursued some different avenues. One addition I would have made was developing a way to include more writing instruction into the mathematics lesson. I was asking the students to use the language in written form, but did not teach methods to do that during this unit.

Research shows that students need both productive and receptive experiences with language. I feel that another avenue for research would be looking at which modality, oral or written, offers the greater educational benefit when
teaching mathematics concepts. The teacher can then focus on the one method that is most beneficial to students.

In addition to further studying the above concepts. I believe that there must be a focus on ways to help limited formal schooling high school students catch up on the basic mathematics skills while continuing to learn state standards in mathematics. This poses a huge challenge for students and needs further study.
Appendix A

Photo of level 1 student’s math journal: Order of Operations.
First I have to do a multiplication and I got 2. Then I times 210 and got 10 and then I division with twenty and then which is two and then I plus two and I got 6.
Appendix B

Vocabulary difficulties and examples
<table>
<thead>
<tr>
<th>Row</th>
<th>Category of Difficulty</th>
<th>Examples</th>
</tr>
</thead>
</table>
| 1.  | Some words are shared by mathematics and everyday English, but they have different meanings in the two contexts. | Right angle verses right answer  
Right angle verses right hand  
Reflection as flipping over a line versus reflection as thinking about something  
Foot as 12 inches versus the foot on a leg |
| 2.  | Some mathematical words are shared with English and have comparable meanings, but the mathematical meaning is more precise | Difference as the answer to a subtraction problem verses difference as a general comparison  
Even as divisible by 2 versus even as smooth |
| 3.  | Some mathematical terms are found only in mathematics                                                      | Quotient, decimal, denominator, quadrilateral, parallelogram, isosceles                            |
| 4.  | Some words have more than one mathematical meaning                                                          | Round as a circle versus to round a number to the tenths place  
Square as a shape versus square as a number times itself  
Second as a measure of time versus second as a location in a set of ordered items |
| 5.  | Some words shared with other disciplines have different technical meanings in two disciplines                | Divide in mathematics to separate into parts, but the Continental Divide is a geographical term referring to a ridge that separates eastward and westward-flowing waters.  
Variable in mathematics is a letter that represents possible numerical values, but variable clouds in science are a weather condition. |
| 6.  | Some mathematical terms are homonyms with everyday English words.                                           | Sum verses some, arc versus ark, pi versus pie, graphed versus graft                                |
| 7.  | Some mathematical words are related, but students may confuse their distinct meanings.                       | Factor and multiple, hundreds and hundredths, numerator and denominator                             |
| 8.  | A single English word may translate into Spanish or another language in two different ways.                  | In Spanish, the table at which we eat is mesa, but a mathematical table is a tabla (Olivares 1996). |
| 9.  | English spelling and usage have many irregularities.                                                        | Four has a u, but forty does not.  
Fraction denominators, such as sixth, fifth, fourth, and third are like the ordinal numbers, but rather than second, the next fraction is half. |
| 10. | Some mathematical concepts are verbalized in more than one way.                                           | Skip count by threes versus tell the multiples of 3  
One-quarter versus one-fourth |
| 11. | Students may adopt an informal term as if it is a mathematical term.                                       | Diamond for rhombus  
Corner for vertex |

Appendix C

Assessment with language component
Positive and Negative Integers

**Answer** each problem in the box provided. *(BUT WAIT THERE’S MORE!)* Then describe how you solved each of the problems in complete sentences in the box below the problem.

Here are some KEY vocabulary words that might help you!

<table>
<thead>
<tr>
<th>positive</th>
<th>negative</th>
<th>integer</th>
<th>digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>equals</td>
<td>number line</td>
<td>whole number</td>
<td>number</td>
</tr>
<tr>
<td>decimal</td>
<td>simplify</td>
<td>solution</td>
<td>equation</td>
</tr>
</tbody>
</table>

1. 34 + (-21) =
2. -9 - 6 =
3. -23 + 3 =

4. What is negative seven plus four?
5. What is four less than nineteen?
6. Calculate the sum of negative seven and negative 5.

4.
5.
6.
Appendix D

Written Assessment Rubric
<table>
<thead>
<tr>
<th>Problem Assessed</th>
<th>Question is correctly written into math equation</th>
<th>Math steps are shown</th>
<th>Correct Answer</th>
<th>Written Explanation</th>
<th>Vocabulary Usage</th>
<th>Explanation is comprehensible</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>X</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/6</td>
</tr>
<tr>
<td>2.</td>
<td>X</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/6</td>
</tr>
<tr>
<td>3.</td>
<td>X</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/6</td>
</tr>
<tr>
<td>4.</td>
<td>X</td>
<td>1 - 0</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/7</td>
</tr>
<tr>
<td>5.</td>
<td>X</td>
<td>1 - 0</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/7</td>
</tr>
<tr>
<td>6.</td>
<td>X</td>
<td>1 - 0</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/7</td>
</tr>
<tr>
<td>7.</td>
<td>X</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/6</td>
</tr>
<tr>
<td>8.</td>
<td>X</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/6</td>
</tr>
<tr>
<td>9.</td>
<td>X</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/6</td>
</tr>
<tr>
<td>10.</td>
<td>X</td>
<td>1 - 0</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/7</td>
</tr>
<tr>
<td>11.</td>
<td>X</td>
<td>1 - 0</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/7</td>
</tr>
<tr>
<td>12.</td>
<td>X</td>
<td>1 - 0</td>
<td>2 - 1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>1 - 0</td>
<td>/7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Math Steps are shown</th>
<th>2 Steps are clearly shown, cleanly written &amp; all elements are valid or with minor errors that don’t disrupt understanding.</th>
<th>1 Valid approach with multiple errors that impede understanding.</th>
<th>0 Little or no understanding of how to approach the problem.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Answer</td>
<td>1 Numerical value is the exact answer that makes the equation true.</td>
<td>1 Unable to reach a correct answer or this path, or no answer given.</td>
<td>0 Unable to reach a correct answer or this path, or no answer given.</td>
</tr>
<tr>
<td>Written explanation and rationales that translate into words the steps of the solution process</td>
<td>2 Gives a complete written explanation of the solution process used and possibly addresses both what was done and why it was done.</td>
<td>1 Provides minimal explanation of solution process, may fail to explain or may omit information about what was done.</td>
<td>0 Provides minimal explanation of solution process, may fail to explain or may omit information about what was done.</td>
</tr>
<tr>
<td>Vocabulary Usage</td>
<td>2 Usage of specific and some technical language related to the mathematics, lack of needed vocabulary may be occasionally evident, but does not impede the explanation.</td>
<td>1 Usage of general language related to the content area, lack of vocabulary may be evident.</td>
<td>0 Usage of general language related to the content area, lack of vocabulary may be evident.</td>
</tr>
<tr>
<td>Explanation is comprehensible</td>
<td>2 Generally comprehensible at all times, errors don’t impede the overall meaning, script errors may reflect first language interference.</td>
<td>1 Comprehensibility may be often impeded by errors.</td>
<td>0 Comprehensibility may be often impeded by errors.</td>
</tr>
<tr>
<td>Question is written into numerical form (questions 3-6 only)</td>
<td>2 Correct translation from words to math symbols.</td>
<td>1 Errors in translation from words to math symbols.</td>
<td>0 Errors in translation from words to math symbols.</td>
</tr>
</tbody>
</table>
Appendix E

Problem Solving Procedures
Appendix F

Presentation Problem Rubric
<table>
<thead>
<tr>
<th>5 - Bridging</th>
<th>4 - Expanding</th>
<th>3 - Developing</th>
<th>2 - Beginning</th>
<th>1 - Entering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem Identification and explaining the purpose of the problem</strong></td>
<td>Copied problem on board while explaining the steps using correct naming and symbols.</td>
<td>Copied problem on board, limited or incorrect naming of numbers and symbols.</td>
<td>Copied problem on board, no verbal explanation.</td>
<td>Highest frequency vocabulary from mathematics lessons are used.</td>
</tr>
<tr>
<td><strong>Vocabulary Usage</strong></td>
<td>Repeatedly used technical language related to math language taught in class; facility with needed vocabulary is evident.</td>
<td>Specific and some technical language related to mathematics was used; groping for needed vocabulary may be occasionally evident.</td>
<td>General language related to the math concept was used; groping for vocabulary when going beyond the highly familiar is evident.</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Calculations performed</strong></td>
<td>Calculated the correct answer. Work shown and is logical. Diagrams or labeled work support the strategy. Calculations are completely correct and answers properly labeled.</td>
<td>Calculated a correct answer but was unable to explain the strategy. Work shown has gaps. Calculations are mostly correct, may contain minor errors.</td>
<td>Work is partially shown. Major errors may be evident. Calculations contain major errors.</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Explanation of the problem solving strategy/steps</strong></td>
<td>Uses mathematical language, graphs, diagrams, and/or charts appropriately. Solution is presented in a detailed, clear and orderly manner so the listener can follow the flow of the solution and final answer.</td>
<td>Uses mathematical language, graphs, diagrams, and/or charts appropriately. Explanation contained adequate details. Steps are easily followed by listeners.</td>
<td>Uses mathematical language, graphs, diagrams, and/or charts appropriately, could not explain the strategy used. Explanations are somewhat clear, but lacks details.</td>
<td>No attempt or below grade level work shown.</td>
</tr>
<tr>
<td><strong>Linguistic Complexity</strong></td>
<td>A variety of sentence lengths of varying linguistic complexity in extended oral discourse; responses show cohesion and organization used to support main idea.</td>
<td>A variety of oral sentence lengths of varying linguistic complexity; responses show emerging cohesion used to provide detail and clarity.</td>
<td>Simple and expanded oral sentences; responses show emerging complexity used to add detail</td>
<td>Phrases, short oral sentences</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Single words, set phrases or chunks of memorized oral language</td>
</tr>
</tbody>
</table>
Appendix G

Timeline for Lesson on Positive and Negative Integers
Timeline for lesson on Positive and Negative integers

Day 1-
• Pre-assessment on Naiku
• Smartboard lesson (1 day according to math department)
• Homework: Operations with numbers worksheet #1 - due on next day

Day 2-
• Review homework
• Begin discussing word wall words - have students choose words to add
• Homework: complete academic math vocabulary definitions and diagrams/pictures

Day 3-
• Complete word wall cards and review homework
• Re-teach integers with EL teacher created Smartboard lesson with language component added
• Homework: Operations with numbers worksheet #2 - due on next class period

Day 4-
• White board review problems/ quick homework check with partner (talk time)
• Review PSP's (problem solving procedures)
• Pick problems and partners
• Homework: practice your problem at home

Day 5
• Work on your PSP's with your partner
• Have teacher check their progress
• Practice with another group of partners (total of 4 people in the group)

Day 6
• PRESENTATIONS
• Homework: STUDY for test on positive and negative integers TOMORROW!
• Whole class review

Day 7
• Post-language assessment with the math language component

Day 8
• Positive and negative integer card game!
Appendix H

Pre-Test and Post-Test Assessment for Positive and Negative Integers
Pre-Test

Add, Subtract, Multiply, and Divide the following - NO CALCULATORS ARE ALLOWED!

1) \(-7 + 3\) 
2) \(-10 + (-13)\) 
3) \(12 + (-4)\) 
4) \(-6 - 8\) 
5) \(13 + (-5)\) 
6) \(-12 - (-15)\) 
7) \(-5(6)\) 
8) \(-47\) 
9) \((-6)(-9)\) 
10) \(-63/9\) 
11) \(-24 ÷ -4\) 
12) \(32 / 4\)

Simplify the following problems using the order of operations - NO CALCULATORS ARE ALLOWED! Show All WORK and DRAW A BOX AROUND YOUR ANSWERS

13) \(8 - 2[6 + (-4)^2]\)
14) \(12 ÷ 4 • 3\)
15) \(\frac{8 + 6 • 4}{20 - 15 + 3}\)

Post-Test

Add, Subtract, Multiply, and Divide the following - NO CALCULATORS ARE ALLOWED!

1) \(-6 + 2\) 
2) \(-11 + (-14)\) 
3) \(12 + (-4)\) 
4) \(-5 - 7\) 
5) \(12 + (-6)\) 
6) \(-13 - (-16)\) 
7) \(-4(5)\) 
8) \(4 • 8\) 
9) \((-7)(-9)\) 
10) \(-54/9\) 
11) \(-24 ÷ -6\) 
12) \(36 / 4\)

Simplify the following problems using the order of operations - NO CALCULATORS ARE ALLOWED! Show All WORK and DRAW A BOX AROUND YOUR ANSWERS

13) \(7 - [5 + (-3)^2]\)
14) \(16 ÷ 4 • 5\)
15) \(\frac{6 + 4 • 3}{20 - 14 + 3}\)
Appendix I

Oral Presentation Problem Rubric Data
### Researcher’s Scoring

<table>
<thead>
<tr>
<th></th>
<th>Non-SLIFE Students</th>
<th>SLIFE Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Michell</td>
<td>Messi</td>
</tr>
<tr>
<td>Language Level</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Problem ID</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Vocabulary Usage</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Calculations Performed</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Explanation of Steps</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Linguistic Complexity</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Researcher’s Scoring Average</td>
<td>3</td>
<td>4.4</td>
</tr>
</tbody>
</table>

### Math Teacher’s Scoring

<table>
<thead>
<tr>
<th></th>
<th>Non-SLIFE Students</th>
<th>SLIFE Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Michell</td>
<td>Messi</td>
</tr>
<tr>
<td>Language Level</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Problem ID</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Vocabulary Usage</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Calculations Performed</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Explanation of Steps</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Linguistic Complexity</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Math Teacher’s Scoring Average</td>
<td>3</td>
<td>4.4</td>
</tr>
</tbody>
</table>

### Overall Scoring Average

<table>
<thead>
<tr>
<th></th>
<th>Non-SLIFE Students</th>
<th>SLIFE Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Michell</td>
<td>Messi</td>
</tr>
<tr>
<td>Language Level</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Overall Scoring Average</td>
<td>3</td>
<td>4.4</td>
</tr>
</tbody>
</table>
Appendix J

Transcription of the Oral Presentation Problems
Michelle- (level 1)


Sabria- (level 3)

I am doing problem number 10. Negative thirty-five divided by negative seven. I know it is division so I use the board (she drew the tic tac toe method on the board). Thirty-five divided by seven is five. No calculator! Sign is positive. Negative integer divided by negative integer, integer is right, right? Ok... negative integer divided by negative integer is equal to a positive. Solution is positive five! Whew! Thank god that’s over.

Hero (level 2)

Uhm, forty-two negative division nine, oh I mean six. The answer, solution is positive, oh negative seven. (teacher: How did you get that solution? Can you explain it to the class?) I division divide forty-two by six and got seven. (teacher: how did you get the negative sign??) oh, the signs. Negative times a positive equals a negative. Solution negative seven.

Be-Ni (level 3)

Negative forty divided by negative four. Oh I doing number thirteen. This is easy. Forty goes to four ten times. Me answer is ten. (Teacher: is your answer positive or negative? How did you figure that out?) Cause you taught me, miss. Divide or multiply same sign is positive. Answer is positive ten. Thank you.

Messi (level 3)

Ok, ok I got a hard one cause I am smart. First is order of operations! (teacher: Can you read the problem to us?) Of course, of course. Three brackets five parentheses two plus six parentheses. First you have to add two plus six and you get eight. Rewrite your problem. Do inside the brackets. Five times eight is forty. One more thing, multiply three times forty and that is positive one hundred twenty. Everything is positive, so answer is positive. Of course!

Nancy (level 4)

Hi, my name is Nancy and I am going to do number 18. My problem is eight times three minus four raised to power of two. (Messi: that’s esquared. Teacher: Either way is correct... shhh!) You have to do the exponents first. This was hard because I
didn’t know if it was sixteen or negative sixteen. But there is not parentheses around the four so that means four time four. Keep the negative by itself. My new problem is eight times three minus sixteen. Order of operations says do multiplication first. So now I have twenty-four minus sixteen. The answer is positive eight because the bigger number is positive.

Sarah (level 3)

Ok, do I really have to do this? My problem is order of operations. Fifteen minus seven. The line means divide. Negative three multiplied by three plus five. Do what is on top first. You get eight. (teacher: Why?) I don’t know cause you do. If you have fifteen and you take out seven you have eight. Then you do the bottom. PEMDAS says do multiplication first then add. Negative three time positive three is nine, negative nine. Then add five. This is the hard part. Negative nine plus five. Follow the rules. Take the big integer and minus the small integer. You get 4. Keep sign of big number. Negative. Negative four. Top is eight and bottom is negative 4. So eight divide negative four is two negative. Oh I have to tell why it is negative. Negative divided by positive is negative. Solution is negative two.

Asma (level 3)

Oh this problem is too hard. I am just girl I cannot do it. I am doing the last one. I see negative three. What are those called? (Teacher: Brackets.) Eight plus four parenthesis two minus five. You do two minus five. It is negative three. (Teacher: Explain why.) Ok, draw two positive signs and five negative signs. Cross them out. You have three negative signs left. Ok inside you do multiply first. Four times negative three is twelve. (Teacher: What should the sign be? Positive or negative.) Oh I don’t know. (Student: Negative) Oh thank you. So eight minus twelve. Eight positive signs and twelve negative signs and you have more negatives. There are four. You have negative four. (Teacher: What about the brackets? Did you forget about the negative three?) Oh yes. Brackets mean multiply I think. So negative three times negative four is positive twelve. When the signs are the same answer is positive.
Appendix K

Written Language Component
Rubric Average Scores
<table>
<thead>
<tr>
<th>Participants</th>
<th>WIDA Writing Level</th>
<th>Correctly written math equation</th>
<th>Math Steps are shown</th>
<th>Correct Answer</th>
<th>Written Explanations</th>
<th>Vocabulary Usage</th>
<th>Explanation is comprehensible</th>
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</thead>
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Proficient: 70% or higher

Approaching Proficient: 60-70%

Not Proficient: below 60%
Appendix L

Comparison of Pre-Test and Post-Test Scores
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<th>Participants Name</th>
<th>Pre-test Score</th>
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<td>Sarah (LL3)</td>
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</tbody>
</table>

Proficient: 70% or higher
Approaching: 60-70%
Not Proficient: below 60%
REFERENCES


Rubenstein, R.N. & Thompson, D.R. (2002). Understanding and supporting children’s


The English Language Development Standards. (2012). Madison, WI. Board of Regents of the University of Wisconsin System on the behalf of the WIDA™ consortium.

