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Teaching Academic Vocabulary in Mathematics to English Language Learners

An Action Research Report

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Teaching Academic Vocabulary in Mathematics to English Language Learners

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Abstract

The purpose of this research was to explore the effects of explicit academic vocabulary instruction in mathematics on English language learners' understanding of mathematics concepts. The study took place in a third-grade classroom, where 50% of the students were English language learners. Data collection methods included pre- and post-assessments, student self-assessment ratings, teacher reflections, and student discussion questions. Results of the study indicated positive increases in assessment scores for students at all levels of English language proficiency. Going forward, the teacher researcher will continue to use vocabulary journals, discussions, activities, and games in her classroom to provide multiple opportunities for her students to practice the academic vocabulary in mathematics. Future research topics include strategies to further support level 1 English language learners in the classroom.

Keywords: academic vocabulary, mathematics, English language learners

In classrooms across the United States, the number of English language learners (ELLs) is increasing rapidly. In the last 20 years, this population has increased 169% in the United States, making ELLs the fastest growing group in our country's schools (Allison & Rehm, 2011). In fact, this group is growing so quickly that it is predicted that by 2030, 50% of all students will be English language learners (Capps et al., 2005). As these students are representing a larger section of the classroom population, it is important that teachers understand their unique needs and utilize strategies that are successful in helping them learn English.

ELLs may only take one to two years to speak conversational English fluently (Cummons, 2011). However, it takes five years or longer to become fluent in academic English (Cummons, 2011). According to Mohr and Mohr (2007), "Competence in academic English certainly cannot be accomplished without exposure to and practice with the vocabulary and the structures that characterize the language of school" (p. 442). Therefore, it is crucial that ELLs receive effective vocabulary instruction in the classroom.

This area of inquiry is strongly related to my teaching situation because I teach in a school with a high ELL population. 50% of my class are ELLs, including many students who are refugees and came to the country knowing very little or no English. According to the WIDA English Language Proficiency Standards, the majority of the ELLs in my class have an English language proficiency of between level 1 (entering) and level 3 (developing). The students' home languages include Amharic, Burmese, Nepali, S'Gaw Karen, Somali, Spanish, Urdu, and Vietnamese. There are 28 students, in total, in my third grade classroom, which is located in a suburban area of Minnesota.

In the past couple of years, many of the ELLs in my class have performed extremely well on mathematics tests that assess solely computation. However, on standardized mathematics tests, such as the Numbers and Operations Strand on the Minnesota Comprehensive Assessments (MCAs) mathematics test, they have scored considerably lower. This has led me to realize that they are likely struggling with these mathematics assessments due to language issues. I would like to learn a way to effectively teach these students academic vocabulary, so they can succeed in all subject areas, with a specific focus on mathematics.

Review of Literature

This literature review highlights research that examines strategies to teach academic vocabulary to ELLs. The importance of teaching academic vocabulary and an effective process for this vocabulary instruction was investigated. Exploration of these two aspects of teaching academic vocabulary helped me design action research.

The Importance of Academic Vocabulary Instruction for ELLs

Students who are ELLs may have a more limited English vocabulary than their peers. Research has shown that not only do ELLs know fewer words than their native English-speaking peers, they also know less about the meaning of these words (August, Carlo, Dressler, & Snow, 2005). According to Saville-Troike's (1984) research concentrated on school-age ELLs, vocabulary knowledge is the single best predictor of their academic achievement across subject matter domains. Therefore, if ELLs are going to be successful in school, they need help in developing their academic vocabulary (Sibold, 2011).

Many teachers believe that ELLs will learn English naturally; so instead of directly teaching the language, they have set up learning environments for the students to learn from each other (Dutro & Moran, 2003). However, Dutro and Moran (2003) concluded that when ELLs were simply exposed to English-language rich, interactive classrooms, they "did not develop sufficient language skills for academic success" (p. 2).

Based on a meta-analysis by Stahl and Fairbanks, direct vocabulary instruction is very effective in helping students improve their background knowledge and comprehend academic content (as cited in Marzano, 2004). The results of this meta-analysis showed that a student who receives direct vocabulary instruction on words related to the content will, on average, increase their comprehension by 33 percentile points, as opposed to a student who receives no vocabulary instruction (Marzano, 2004). While this research showed the importance of direct vocabulary instruction, it is crucial to understand the necessary components to include. Next, I examined how to effectively provide that vocabulary instruction in the classroom.

Effective Vocabulary Instruction

Marzano (2004) analyzed the results of multiple studies on vocabulary instruction, and he used these results to define eight research-based characteristics of effective vocabulary instruction. Then, he applied these characteristics to create an approach for direct vocabulary instruction. Marzano (2004) called this approach the "six steps to effective vocabulary instruction" (p. 91). Although Marzano's six-step process is not specifically targeted at ELLs, there has been other research done within each component of the process that focuses on ELLs. These other studies (which I will introduce in the following paragraphs) have found that all of the components, including

explicit vocabulary instruction, vocabulary notebooks, review and practice with the words, and vocabulary games, are all effective with ELL populations (August et al., 2005; Azar, 2012; Sibold, 2011; Sylvester et al., 2014; Townsend, 2009; Tran, 2006; Walters & Bozkurt, 2009).

The first step in Marzano's six-step process is for the teacher to explain the vocabulary word to the students (Marzano, 2004). Explicitly teaching the vocabulary word includes the teacher pronouncing the word and having students repeat it, explaining the word's meaning, and providing examples of the word (Feldman & Kinsella, 2005; Sibold, 2011; Sylvester, Kragler, & Lionas, 2014). These examples may include showing images of the word, using the word in different sentences, or provided concrete examples of the word's meaning. Helping the students to learn how to pronounce the word accurately is important, because it not only helps them decode the word with confidence, but it also helps them to remember the word (Feldman & Kinsella, 2005). When the teacher is explaining the word to students, lexical definitions should be avoided, because they often contain words that students do not understand (Feldman & Kinsella, 2005; Marzano, 2004; Sibold, 2011). Lexical definitions are the types of definitions that are often found in dictionaries.

Marzano's second step is to have the students explain the vocabulary word using their own words (Marzano, 2004). The third step is when students create a "nonlinguistic representation" (p. 96) of the word, such as a picture or graphic organizer (Marzano, 2004). These steps should be done together, immediately after the teacher explains the word. Results from a meta-analysis by Powell (1980) show that of these two steps, having students create the nonlinguistic representation (e.g. a picture) of the word is the

most helpful (as cited in Marzano, 2004). According to Powell's meta-analysis, nonlinguistically based techniques caused students to gain 34 percentile points in vocabulary learning. Therefore, this step should be highlighted in instruction.

An effective way to organize the student descriptions and pictures of the words is in a vocabulary notebook. Studies have found vocabulary notebooks to be a successful tool for developing academic vocabulary with ELLs (Tran, 2006; Walters & Bozkurt, 2009). In a study done by Walters and Bozkurt (2009), in which a vocabulary notebook program was implemented in a lower intermediate ELL class, students scored significantly higher on vocabulary tests than students in the control groups. Also, students involved in the program used the target vocabulary words more frequently in their own writing (Walters & Bozkurt, 2009). When the students are actively involved with writing about the word meanings, they are able to integrate their prior knowledge; this is one reason that writing in vocabulary notebooks is beneficial to ELLs (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006). The vocabulary notebooks may use different formats and include components such as ratings, charts, pictures, and ideas that connect to previous learning (Sibold, 2011). However the vocabulary notebooks are set up, it is important to have some kind of clear organizational plan for students to use when recording information about their vocabulary words (Feldman & Kinsella, 2005).

The fourth step in Marzano's process is for the students to regularly engage in activities that help them interact with the vocabulary words (Marzano, 2004). Marzano's fifth step is for the students to discuss the words with their peers (Marzano, 2004). Both of these steps allow for further review and practice with the vocabulary. The fourth and fifth steps of Marzano's process are very general, as there are a variety of different ways

that the students can engage in activities and discuss the vocabulary words. The lack of specificity in these steps allows the teacher to incorporate student interests while planning a wide range of activities for the classroom. The important part of these activities and discussions is that they provide periodic review of the vocabulary. This periodic review is an essential part of the process that ELLs need in order to solidify their understanding of the targeted words (August et al., 2005; Sylvester et al., 2014). To emphasize how much continued practice ELLs need with each vocabulary word, Sylvester et al. (2014) stated "researchers estimate that ELLs need at least 12 opportunities to produce a particular word before they can retrieve and use it on their own" (p. 441). For students to have multiple opportunities to produce the vocabulary words, they need to engage in structured activities in which they discuss and interact with the words.

The final step in the process is for the students to play games that involve the vocabulary words (Marzano, 2004). Games are an effective way to provide extra practice and reinforce the students' understanding of the words (Azar, 2012; Sibold, 2011; Townsend, 2009). Often, these games bring enthusiasm to the classroom (Sibold, 2011). In one example called the Language Workshop, a voluntary after-school intervention for middle school ELLs designed to help them develop academic vocabulary words, the games were so engaging that they became the motivation for students to attend the program, when they otherwise would not have (Townsend, 2009). However, the literature is very clear that vocabulary games should be used to review the vocabulary that has been learned, after students have received direct instruction on these words (Azar, 2012; Sibold, 2011; Townsend, 2009). Using games exclusively, as the vocabulary instruction, would not be as effective.

Marzano originally published this six-step process in 2004. In 2009, five years later, he was able to review over 50 studies of classrooms that had implemented this process (Marzano, 2009). In each of the studies, a teacher used the six-step process with one class but not with another class. By analyzing the results of these studies, Marzano was able to make some conclusions about the process. Marzano (2009) concluded that the strategy does work at all grade levels, ranging from kindergarten through high school. He also determined that the process works the best if all six-steps are followed completely, without omitting any components (Marzano, 2009).

Insights for Action Research

As the ELL student population continues to grow, all teachers must work to understand these students and their unique needs (Allison & Rehm, 2011). A key element in their academic success, across subject areas, is quality vocabulary instruction (Feldman & Kinsella, 2005). The research shows that Marzano's six-step process is effective in teaching academic vocabulary in the classroom (Marzano, 2009). Review of the literature reinforces the success of these strategies with ELLs (August et al., 2005; Azar, 2012; Sibold, 2011; Sylvester et al., 2014; Townsend, 2009; Tran, 2006; Walters & Bozkurt, 2009). To ensure that ELLs are able to achieve high levels of success in school, teachers must provide them with direct vocabulary instruction that incorporates all of the components of Marzano's six-step process (Marzano, 2009).

The literature offers implication for my teaching. Vocabulary instruction should be a priority in each content area. The students will need to experience and practice the vocabulary in various ways, including listening, reading, speaking, writing, drawing, discussing, and playing games with the words. I need to intentionally plan all of these

experiences for my students to guarantee they can understand and apply these words in the academic content areas. Effectively teaching the ELLs each content area's academic vocabulary will set them up for success in mastering the content material.

While these vocabulary instructional strategies would be useful in any content area, my action research is focused on math. The goal of this action research project is to teach the third grade ELLs the mathematics academic vocabulary necessary for them to understand and interact with the mathematics concepts. Ideally, by using the research-based instructional strategies, the students will be able to increase their knowledge of academic vocabulary, which will lead to greater understanding of the mathematics concepts. With this in mind, I decided to pose this question: What effects will the implementation of Marzano's six-step process, in a third-grade classroom, have on English language learners' academic vocabulary knowledge, and their understanding of the units' mathematics concepts?

Methodology

Before beginning the research, I created a passive consent form of approval for student participation (Appendix A). To ensure that the majority of the students' families understood the research, I also had translators translate this form into S'Gaw Karen and Spanish, which were the languages that I predicted would be spoken by the majority of the ELLs in my classroom (Appendix B and C). There were no students who opted out of the study.

Throughout the action research project, I collected both quantitative and qualitative data using a variety of data collection instruments. The quantitative data was collected from student test scores and student self-assessments. Pre-tests and post-tests

were given to assess the students' mathematics vocabulary knowledge and understanding of mathematics concepts, for both units. The student self-assessment ratings were based on the students' own reports of how they understood the current vocabulary words, throughout the daily instruction. The qualitative data was collected to assess both the teacher and students' perspectives on the action research. The teacher's perspectives were recorded daily in a reflection journal, where I wrote about the successes and challenges of that day's vocabulary instruction. The students' perspectives were collected through discussion questions, after both math units had been completed.

At the beginning of the school year, prior to teaching any mathematics lessons, I administered two pre-tests to the third graders, the Place Value Unit Test and the Place Value Vocabulary Test (Appendix D and E). These pre-tests assessed the mathematics concepts and vocabulary that would be covered during the first mathematics unit. Similarly, I gave the Addition Unit Test and the Addition Vocabulary Test before teaching the second mathematics unit (Appendix F and G). If the words were difficult for the students to read, that student could request help reading the pre-test from the teacher. In that way, I attempted to accurately test the students' mathematics knowledge, not their reading ability.

Every day, throughout the action research, I taught the third graders the mathematics content, according to the curriculum that my school uses. However, I also incorporated into these lessons Marzano's six-step process for effective vocabulary instruction. I focused on the vocabulary words that the students needed to know to be able to understand the mathematics concepts.

At the beginning of the unit, I began each lesson by explicitly teaching the students the one, two, or three vocabulary words that they would need to understand for that day's lesson. During this explicit teaching, the students participated in steps 1, 2, and 3, of the six-steps. I said the vocabulary word, students repeated it, and then I explained what the word meant. This explanation was in student-friendly terms and included examples and connections to their previous learning. On the Smartboard, I displayed the word, my written explanation, and some visuals that helped to understand the word. Next, the students would write the word, their own written explanation of the word, and two visual representations of the word. The students would write about each vocabulary term in a separate box in their mathematics vocabulary notebook (Appendix H). The last thing that the students did, before putting their vocabulary notebooks away for the day, was self-assess their understanding of the vocabulary words, at that point. To do this, they circled a 1, 2, 3, or 4 next to each word. To guide them in their self-assessment, students were taught to rate themselves according to these levels: 4 meant "I've got it and I can teach it to a friend." 3 meant "I get it. I can do it by myself." 2 meant "I get some of it. I might need help." 1 meant "I don't get it. I need help." I recorded the students' self-assessment ratings in a class grid to monitor the students' perceptions of how their vocabulary knowledge was progressing (Appendix I).

Later in the unit, after all of the significant mathematics vocabulary words had been explicitly taught and added to the students' vocabulary journals, the class practiced these words using steps 4, 5, and 6 of Marzano's six-steps. I provided an opportunity for the students to review and practice the words daily, through activities, discussions, and games. We did this in a variety of ways. My main goal in planning for these vocabulary

activities was to have all students actively involved and interacting with the vocabulary.

Step 4 of Marzano's process is to engage in activities that help students practice the words. Based on the specific vocabulary words being practiced, students completed some paper and pencil activities to further their understanding of these words. For example, to refine their understanding of the word "rounding", each student created a foldable brochure, which included an explanation of the steps for rounding, and a few examples of how to round numbers to the tens and hundreds place. Also, many students were not confident about the differences between "standard form", "expanded form", and "number form". To show the relationships between these terms, the students completed a sort of concrete examples of numbers in each form.

Step 5 of Marzano's process is to discuss the vocabulary words with each other. These discussions took many forms in the classroom. Often, students would turn and talk about the words with a partner, using guiding questions that were displayed on the Smartboard. One day, the students cut out premade vocabulary cards, and discussed the structured questions about each word with a partner. At the end of this activity, they reflected on which words were easier and which were harder for them to understand at this point.

Step 6 of Marzano's process is to play games to practice the words. The students played these games with partners and as a whole class. On the iPads, students worked with partners to use an app called "Quizlet"; in this game, they practiced matching the vocabulary words with their definitions. As a whole class, the students played a game using "Kahoot!" In this web-based game, a question about a vocabulary word was displayed on the Smartboard, and students chose between four multiple-choice answers

on their iPads. The class' results were displayed immediately, in a fast-paced and trivia game atmosphere. After the questions in which many students chose the incorrect choice, the class took the time to clarify the vocabulary word and review which answer should have been selected. Students also spent a day at the end of the unit playing a vocabulary review game, where each student wrote their own answers on individual whiteboards. Then, students could earn points for their teams if they had the correct answer recorded.

As students continued to have multiple exposures to the terms, throughout steps 4, 5, and 6 of the process, I often had them stop to self-assess their understanding of the vocabulary terms we were focused on at that point. Similar to the rating in the vocabulary journals, the students rated themselves on a scale of 1-4. I recorded their self-assessment ratings at least three times each week in the class grid (Appendix I). I attempted to spread out the self-assessment days throughout the week, to see how the students' assessment of their understanding was progressing.

Each day, after the students left, I reflected and wrote in a personal journal about the opportunity that I have given to the students to practice the vocabulary that day. In my journal, I included notes about how the opportunity had worked with all student groups and what successes and challenges the students had. I used focused journal prompts to guide me in this reflection (Appendix J).

At the end of each math unit, I gave a final unit assessment and vocabulary assessment to the students. I used the same assessments for the post-assessments as I had used for the pre-assessments (Appendix D, Appendix E, Appendix F, and Appendix G).

This allowed me to directly compare what they had known at the beginning and end of the unit.

After both math units had been completed, I asked a few students about their perspectives toward the mathematics vocabulary instruction. I randomly chose five students, and I met with each student individually. I asked them discussion questions to find out what they thought were the most fun and the most effective vocabulary activities (Appendix K).

Analysis of Data

Throughout the research process, results were analyzed from multiple data sources. These data sources included: pre- and post-tests on mathematics unit concepts, pre- and post-tests on mathematics vocabulary knowledge, students' self-assessment ratings, teacher's personal reflection journal, and individual discussion questions with the students. The initial data sources analyzed were the mathematics assessments that were administered to the students. The two mathematics units that were taught during this action research were focused on place value and addition. For each of these units, the students took a mathematics vocabulary test and a unit test. These same tests were given as both pre-tests and post-tests.

Figures 1, 2, 3, and 4 represent the students' test scores on each of these different assessments. In addition to showing the data for the class as a whole, the data is separated according to the English language proficiency level of the students. Because the pre-tests and the post-tests given to the students were identical, the results have been placed side-by-side for ease of comparison.

According to these graphs, students in every level of English proficiency made growth in both vocabulary knowledge and understanding of the mathematics concepts in these two units. In the place value unit, the level 2 students scored slightly lower than the rest of their peers in both post-assessments, and the level 1 students scored considerably lower. Even though students in both of these groups made progress during this unit, the progress they made was not enough for them to score as high as the students at higher language proficiency levels. On the place value post-test, the scores of the level 3 students, exited ELLs, and native English speakers were similar to each other. The average scores for these groups were 16, 16, and 15, respectively.

The data from the addition tests was slightly different. On these post-tests, level 2 students scored very similarly to the native English speakers in the classroom. Level 1 students were the only group of students that scored considerably lower than the native English speakers.

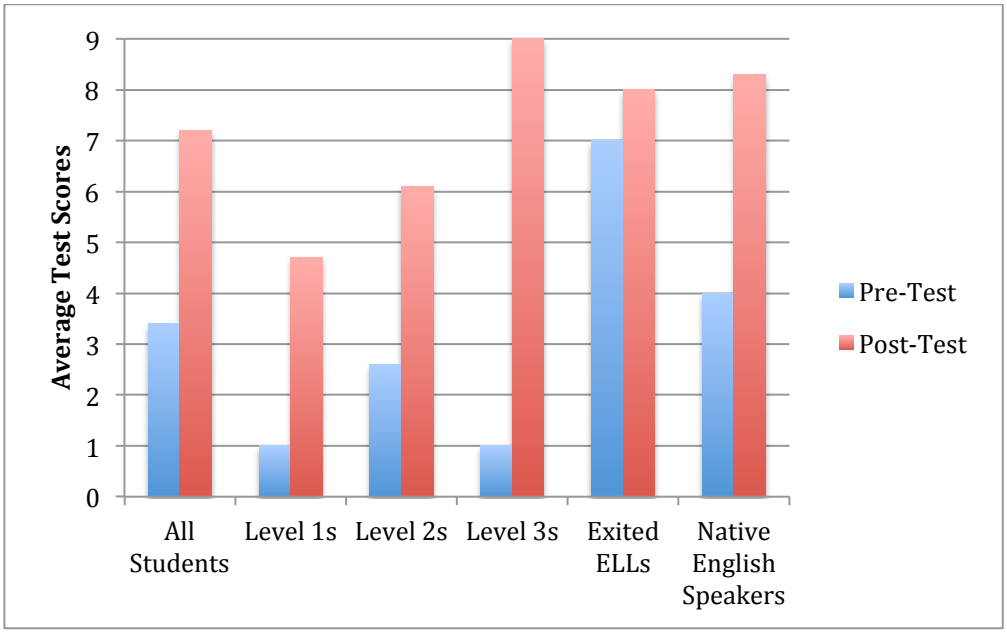

Figure 1. Place value vocabulary test scores.

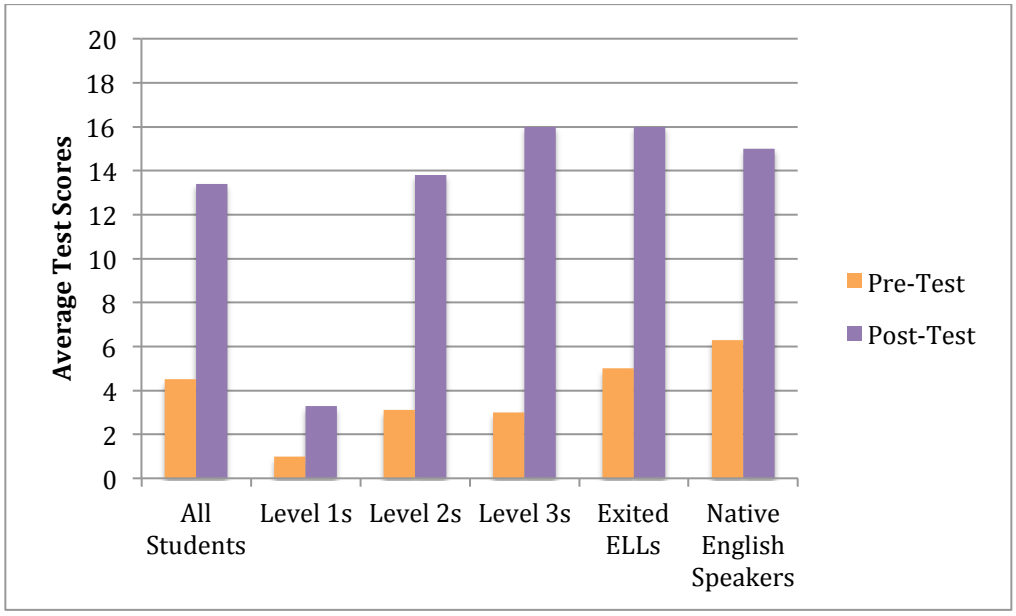

Figure 2. Place value unit test scores.

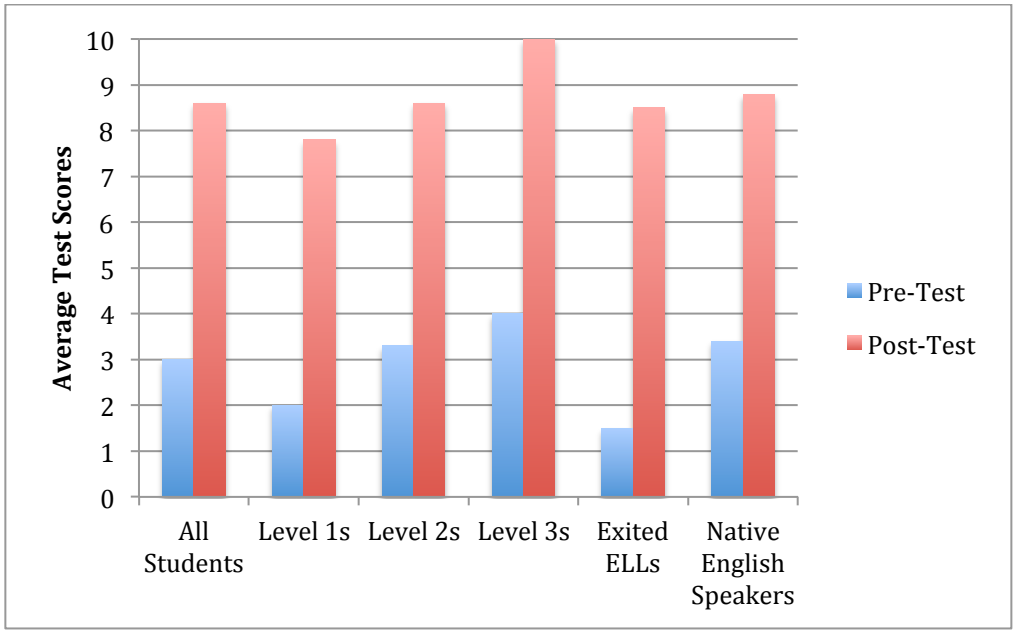

Figure 3. Addition vocabulary test scores.

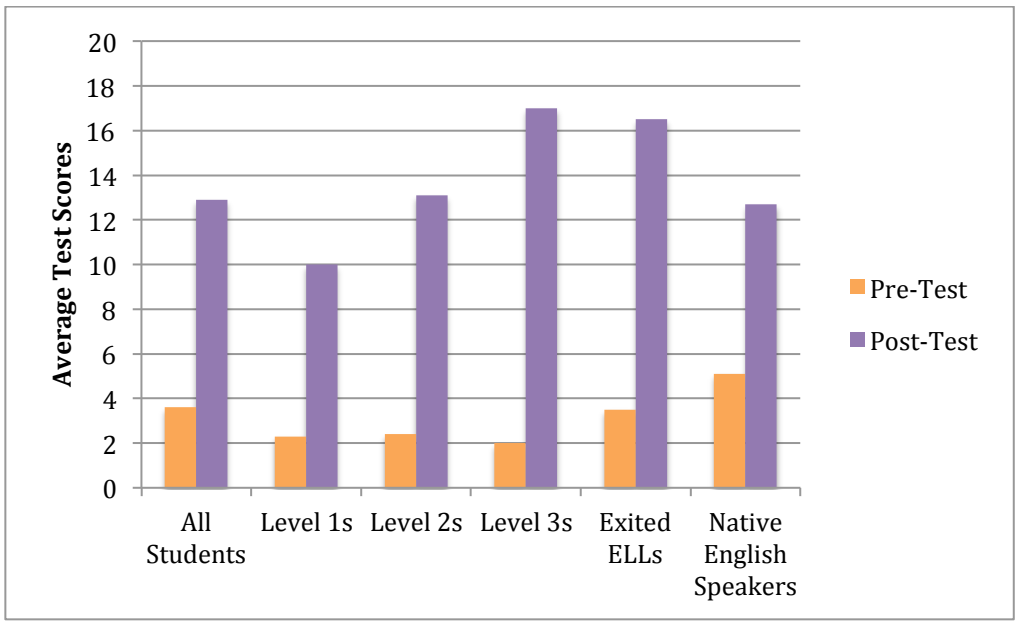

Figure 4. Addition unit test scores.

The next data sources analyzed were the students' self-assessment ratings. The students self-assessed their understandings of the mathematics vocabulary words about 3 times each week. For this self-assessment, they used a rating scale of 1-4. A rating of 4 meant "I've got it and I can teach it to a friend!" 3 meant "I get it. I can do it by myself." 2 meant "I get some of it. I might need some help." 1 meant "I don't get it. I need help." In order for the students to feel comfortable sharing their true self-assessment ratings, the ratings were done privately, so only the teacher would view them. The self-assessment ratings were shared in two different ways. Sometimes, the students circled the number (1, 2, 3, or 4) next to the vocabulary word in their vocabulary journal. Other times, the students would place a clothespin with their name on it on the selected number of their self-assessment bookmark. After these self-assessments were complete, they would be turned into the teacher.

These self-assessment ratings were recorded and analyzed throughout the math units to see how the students perceived their understanding. Students who reported

ratings of 1s or 2s were given extra help and support. However, after the unit tests had been completed, the data was analyzed further to answer the question: were the students accurately reporting their understanding of the vocabulary words? For this analysis, two of the vocabulary concepts that the students reported as being the most challenging were studied more closely.

First, there were three different days when the lesson focused on understanding the vocabulary word "rounding". On each of these days, the students self-assessed their understanding of this word at the end of the class period. On the unit test, there were three story problems that required the students to show their understanding of the word "rounding". Figure 5 shows the correlation between the students' self-assessment ratings on their understanding of "rounding" and the number of rounding problems that they actually got correct on the post-test.

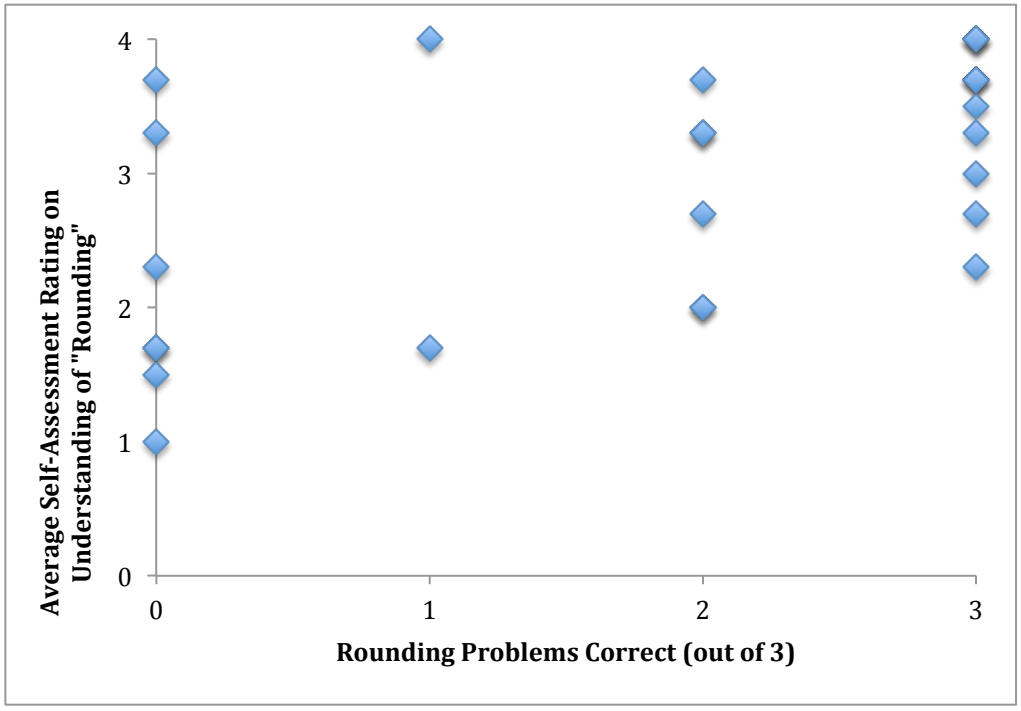

Figure 5. Self-Assessment vs. Performance on "Rounding"

In a similar way, during the addition unit, there were three different days when the lesson was focused on understanding the vocabulary word “estimate”. On each of these days, the students provided a self-assessment rating on how well they understood “estimate”. At the end of the unit, there were 4 problems on the post-test that tested their understanding of “estimate”. Figure 6 shows the correlation between the students’ self-assessment ratings on their understanding of “estimate” and the number of estimate problem they answered correctly on the post-test.

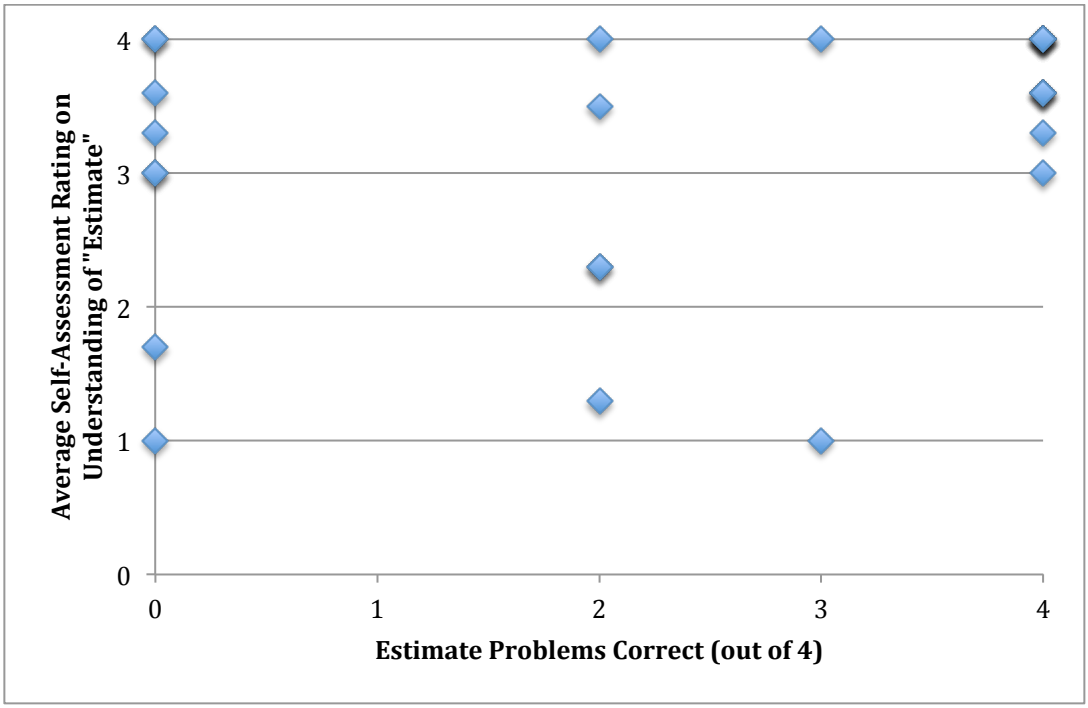

Figure 6. Self-Assessment vs. Performance on “Estimate”

The data on these graphs shows that some students are very aware and honest about their level of understanding. For example, six students reported self-assessment ratings of “4” on the word “estimate”, and did actually get all four estimate problems

correct on the test. Some other students accurately gave themselves a lower self-assessment rating and actually scored a lower score on that section of the test.

On both graphs, the widest range of students' self-assessment ratings occur within the group of students who got none of the problems correct on the post-test. While some of these students seem aware that they did not understand this mathematical concept, others report great understanding. Also, on both graphs, the narrowest range of students' self-assessment ratings occur within the group of students who got all of the problems correct on the post-test. In other words, when the students did understand the concept, they usually self-assessed with a high rating. However, when the students did not understand the concept, their self-assessment ratings varied greatly.

The next data sources that were analyzed gave qualitative data on the research. These sources included the teacher's personal reflection journal and discussion questions with the students. The teacher's personal reflection journal was written in daily, as the teacher reflected on the mathematics vocabulary instruction of the day. This writing was focused on how the vocabulary activities were working with all student groups, and what successes and challenges the ELLs had during the activities. This journal allowed the teacher to consistently reflect throughout the entire research study.

To hear the students' perspectives on the vocabulary instruction, five students were randomly chosen at the end of the study. These students were asking three discussion questions about the vocabulary activities that they had participated in. After being given a list of the activities, they were asked which activity was the most fun, which activity helped them learn the most, and which activity was the hardest for them.

All five students answered the questions, and then they explained why they had answered that way.

The qualitative data from the teacher's reflection journal and the students' discussion questions was analyzed, in an effort to identify which vocabulary strategies seemed to work with all student groups. To analyze the qualitative data, I read through my daily journal reflections and the student responses, and I recorded keywords about what the teacher or students found to be successful. Then, I was able to organize and categorize these keywords into larger themes. In this analysis, two common themes were noted: engagement through technology and support from immediate feedback.

The first theme, engagement through technology, was evident from both the teacher's and students' perspectives. In the discussion questions, four out of five of the students stated that the activity that was most fun for them involved technology. Two out of five of these students also identified an activity involving technology as being the most helpful in their learning. Similarly, throughout the teacher's reflections, it was frequently noted that the activities using the iPads were extremely engaging for the students because they allowed all students to participate simultaneously. Also, the students' excitement toward using the technology ensured that most students were focused on the learning task during this time.

To take advantage of this strong student interest in technology, the teacher had the students use iPads to practice mathematics vocabulary in many different ways. The classroom had a 2:1 set of iPads, so the activities on iPads were done while students were working with a partner. Because of this, the students were encouraged to work together and help their partners in each activity. A clear favorite of the students was Kahoot!, an

internet-based game where students chose their answers using iPads to questions that were displayed on the Smartboard. Another game on the iPad that many of them enjoyed was Quizlet, where students matched the vocabulary words with the definitions. Also, students shared their learning verbally using an iPad app called Seesaw, where they recorded sentences about their vocabulary words. While these iPad activities were enjoyable and made learning fun for the students, they were also effective tools to help the students practice their vocabulary words.

The second theme that emerged form analyzing the qualitative data was support from immediate feedback. The students and teacher both reflected that activities in which the students could get feedback quickly were most effective when learning new concepts. According to one student's response to the discussion questions, "I like doing the math questions on whiteboards because I do the problem and I find out right away if I did it right. If I made a mistake, I can just erase it and try again." This benefit was also seen in other activities. For example, one day, the students completed a QR code activity, as their independent work to practice rounding. Instead of having to wait for the teacher to correct the worksheets and give them back, the students were able to immediately scan the QR codes next to each rounding problem to see if they rounded correctly. As the teacher reflection journal notes, students were excited that they were getting better at this activity as they went along. The immediate feedback they received, from scanning the QR codes, helped them to understand the concept more fully. In the discussion questions, another student reflected that the activity that helped her to learn the most was working in a small group with a teacher to practice the words, because, as she said, "The teacher helped me when I didn't understand." The strategy of working with

small groups allowed for immediate feedback, where the teacher could recognize misunderstandings and immediately assist the students with fixing mistakes.

The analysis of the data in the teacher's reflection journal and the students' discussion questions shows a strong difference in one area: the importance of vocabulary notebooks. This shows a notable contrast between the teacher's perspective and the students' perspective on the vocabulary instruction. One of the main focuses of the teacher's reflection journal was on ensuring that the students had a solid basic understanding of the vocabulary words, using Marzano's first three steps in the Six-Step Process for Effective Vocabulary Instruction. These steps included the teacher providing an explanation of the vocabulary word, the students restating the explanation in their own words, and the students drawing a picture of the word. The written explanations and drawings were done in the students' vocabulary notebooks. The teacher acknowledged the importance of these first three steps in the teaching of the vocabulary words. This initial teaching gave the students the foundation of the word's meaning, which would continue to be developed throughout the later vocabulary activities. During the student discussion questions, however, no students mentioned anything related to vocabulary notebooks or the first three steps in the process of learning the vocabulary words.

During the last three steps of the vocabulary learning process, the students revise and review the words through activities, discussions and games. The data from the student discussion questions showed that the activities, discussions, and games in these last three steps were more memorable and important to the students than the vocabulary notebooks used in the first three steps. Even when "drawing in vocabulary notebooks" and "writing in vocabulary notebooks" were given to the students on the list as possible

answers to the questions, all five students reported that other activities helped them to learn the most.

Action Plan

The data analysis can provide insights into how the students are learning. From the data collected from the place value tests, it appears as if the level 1 and 2 students' limited English proficiency is correlated with lower scores on both the vocabulary post-test and the unit post-test. This may have been a result of the place value unit being heavily dependent on academic vocabulary, in which the students needed to understand numerous vocabulary words in order to access the mathematics concepts. Also, in this unit, it was observed that many of the lower-level ELLs struggled because they did not have the necessary background knowledge that most of the other students had. This included knowledge like how to write and read a three-digit number and understanding of the meaning of hundreds, tens, and ones places.

On the addition post-tests, the level 2 students scored more closely to the native English speakers. The level 1 students were the sole group of students that scored considerably lower. This could be due to the fact that the addition unit included fewer academic vocabulary words, so the majority of the ELLs were able to focus on mastering those few words they needed to know to access the mathematics concepts. For the level 1 students, even this small number of vocabulary words would have been challenging, because they are at such a beginning language level. Also, many of the concepts in the addition unit were built on the foundational concepts just taught in the place value unit. This could also have helped the level 2 students, because the first unit provided the background knowledge that they needed to succeed in the second unit.

It is interesting to note that level 3 students and exited ELLs scored higher, overall, than the native English speakers on the addition unit post-test. (See Figure 4.) Most of the students that have this higher-proficiency of English understood the vocabulary necessary to answer the questions. The difference in scores, in this case, was mainly due to the lack of addition computational skills shown by some native English speakers.

The pre-test and post-test data gives information that will change my practice. Seeing that all student groups made growth in both their vocabulary knowledge and their understanding of mathematics concepts tells me that the instructional strategies are working. All levels of ELLs and Native English speakers are benefitting from the focus on Marzano's Six-Step Process for Effective Vocabulary Instruction. I will continue to explicitly teach the mathematics vocabulary and have students practice these words throughout the unit, using activities, discussions, and games.

The pre-test and post-test results also show that, even with this focused instruction on vocabulary words, the level 1 ELLs continue to score lower than the other students on mathematics assessments. I have observed in the classroom that this is a combined effect of the students not understanding the language of the math problems and not possessing the necessary background knowledge to complete the problems. This leads me to a question for a possible future action research investigation: what strategies work best with level 1 students to help them access grade-level math concepts?

The analysis of the students' self-assessment ratings lead to some interesting observations. When the students understood the concept, they usually accurately self-assessed with a high rating. However, when they did not understand the concept, their

self-assessment ratings were unpredictable. It is unclear whether the students who did not understand didn't realize that they didn't understand, if they were showing an inability to reflect critically on their own learning, or if they were knowingly rating themselves higher than their true understanding.

These results will change the future practice in my classroom, because it is important to me that the students are able to accurately understand their level of understanding. I want them to have a realistic perspective on their progress. First, the data tells me that the students who are performing well on a skill know that they are performing well. This is not a surprise for me, because I give a considerable amount of praise to students when they are succeeding. However, the students that did not understand sometimes did not realize their lack of understanding. I need to focus on giving more specific feedback to the students who are struggling, so they are aware of what they still need to work on. This could improve the accuracy of their self-assessments.

The results of the qualitative data from the teacher's reflection notebook and student discussion questions also will change my practice. I will continue to incorporate activities using the iPads into my math instruction. The students enjoyed the iPad activities, which raised their engagement level. These activities were also beneficial, from the teacher's perspective, because they allowed all of the students to be actively involved in the learning at the same time.

The other characteristic of a quality vocabulary activity, as observed by both the students and the teacher, was the ability to receive immediate feedback. Students appreciated how they could find out right away if their ideas were correct, and the option

to fix their mistakes right away. I, as the teacher, liked these activities because I could immediately assess what the students understood and help them correct any misconceptions. In the future, I will continue to incorporate these types of activities into the instruction.

The qualitative data shows a difference between the importance the students and teachers place on vocabulary journals. No students mentioned the journals in the discussion questions as a part of their learning that was most helpful or most fun. However, in the teacher's perspective, these vocabulary journals were an important foundation while learning the words. Upon further reflection, the teacher still identifies using vocabulary notebooks as a crucial part of learning the new vocabulary, even though it may not be a highlight for any of the students. To make these journals even more effective in the future, the teacher could be more intentional of returning to the journals throughout the learning, to reflect and refine the vocabulary words. This would be instead of simply using the journals as a way to introduce and learn the vocabulary initially.

Overall, the results of the action research showed positive results for all levels of language learners, as well as native English speakers. These positive results validate that practicing academic vocabulary in mathematics, in multiple ways, is beneficial for all students. With this particular group of students, vocabulary activities that incorporated technology and immediate feedback were especially successful. More research could be done on how to support level 1 students in a mathematics classroom.

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Appendix A
Passive Consent Form

Teaching Academic Vocabulary in Mathematics
Assent Form

September 10, 2015

Dear Families,

I am a student at St. Catherine University. As a final project for my Master's degree, I am researching how to teach math words in our 3rd grade classroom.

Students will learn math words using writing, drawing, discussing, and playing games. I will see if these activities help the students learn the math words and improve their scores.

All students will participate in the activities. When I am done, I will share my results with others. No one will know if your child's scores (such as pre and post-math tests, self-assessments, and discussion responses) are in my study or not.

Please note:

- I am working with a faculty member at St. Kate's and an advisor to complete this project.
- Students will learn and practice new math vocabulary words. After learning these math words, they will be better able to understand the math lessons, which should help them. By practicing math words in many different ways, students will learn the words well.
- I will be writing about the results that I get from this research. However, none of the writing that I do will include the name of this school, the names of any students, or anything that would make it possible to identify a particular student. ***Other people will not know if your child is in my study.***
- To help other teachers, my report will be available at St. Kate's library.
- It is fine if you do not want me to include your child's scores and responses. I will still teach your child everything.

YES, I am okay with my child's scores and responses included in the study.	→	Thank you! You do NOT have to sign this form.
NO, I do NOT want my child's scores and responses included in the study.	→	That's okay! Sign the bottom of this page and send it back to class by **September 17**.

If you have any questions, please feel free to call me at (651) 481-9951, or call my advisor, Dr. Yasemin Gunpinar, at (651) 690-6313, or Dr. John Schmitt, who is in charge of research review at St. Catherine University, at (651) 690-7739.

You may keep a copy of this form for your records.

_________________________ _____________

Emily Sasse Date

- -

I do NOT want my child's scores and responses to be included in this study.

_________________________ _____________

Parent Signature Date

If you are not sure, please contact me to discuss.

Appendix B
S'Gaw Karen Translation of Passive Consent Form

စဲးပထဲဖၢဉ် ၁၀, ၂၀၁၅

ဆူ ဟံဉ်ဖိဃီဖိတဖဉ်အိဉ်

ယမ့ၢ်ဝဲစ့ဉ်ခဲဉ်သရံယူၤနံဉ်ဖၢဉ်စတံၤပှၤကွိဖန္ဉ်လီၤ.လၢယမဉ်စတၢၤဒံကရံးတ့ၢ်မၤလိအလိၢ်ခံက တ့ၢ်အဂီၢ်,ယဃုသ့ဉ်ညါဘဉ်ဃးတ့ၢ်သိဉ်လိပှၤကွိဖိသၢတီၤလၢလံာ်တ့ၢ်ဒွးလၢပကသိဉ်လိအဝဲသ့ဉ် လၢကျဲလၢအစ့ၤကတ့ၢ်ဒ်လဲဉ်နှဉ်လီၤ.

ကွိဖိကမၤလိဝဲဒဉ်လံာ်တ့ၢ်ဒွးအလံာ်မဲာ်ဖျၢဉ်တဖဉ်လၢကသူဝဲလၢတ့ၢ်ကွဲးလံာ်,တ့ၢ်ဆွဲတ့ၢ်ဂီၤ,တ့ၢ် တၢဉ်ပိဉ်သကိးလိာ်သးတ့ၢ်ဒီးတ့ၢ်ဂဲၤလိာ်ကွဲသ့ဉ်တဖဉ်နှဉ်လီၤ.ယကကွၢ်တ့ၢ်ဟူးတ့ၢ်ဂဲၤတဖဉ်အံၤမ့ၢ် အကမၤစၢၤပှၤကွိဖိတဖဉ်လၢတ့ၢ်မၤလိလံာ်တ့ၢ်ဒွးအဂီၢ်ဒီးအဝဲသ့ဉ်တ့ၢ်ဒီးစဲးလံာ်တ့ၢ်ဒွးအမးကအါ ထိဉ်စ့ၢ်ဓါ.

ကွိဖိကိးစၤဒဲးကမၤလိဝဲဒဉ်နှဉ်လီၤ.တုၤယသ့ဉ်ဘဉ်တ့ၢ်မၤလိအဆၢတဘျိယကဟ့ဉ်ဒုးသ့ဉ်ညါပှၤ ဂၤတဖဉ်စ့ၢ်လီၤ.ယတဒုးသ့ဉ်ညါပှၤဂၤလၢဘဉ်ဃးနဖိအဂ့ၢ်အကျိဒီးတ့ၢ်မၤလိတ့ၢ်မၤနီဉ်သ့ဉ်တဖဉ် လၢယတ့ၢ်မၤလိအပူၤဘဉ်.

ယဟ့ဉ်အခွဲးလၢတ့ၢ်မၤန္ဉ် ⟶ တ့ၢ်ဘျုး,တလိဉ်ဆဲးလီၤမံၤဘဉ်
ယဖိတ့ၢ်မၤလိတ့ၢ်မၤနီဉ်သ့ဉ်တဖဉ်လၢတ့ၢ်မၤလိပူၤ

ယတဟ့ဉ်အခွဲးလၢတ့ၢ်မၤန္ဉ် ⟶ သ့လီၤ. စဲလီၤနမံၤလၢလံာ်အ
ယဖိတ့ၢ်မၤလိတ့ၢ်မၤနီဉ်သ့ဉ် တ့ၢ်ဒီးဆ့ၢကဒၢက့ၤဖဲလါစဲးပ
တဖဉ်လၢတ့ၢ်မၤလိပူၤ တဲဖၢဉ်ၥ့လၢတီၤပူၤတက့ၢ်

တ့ၢ်သံကွၢ်မ့ၢ်အိဉ်တခီစဲးကျိးဘဉ်ဖ၅၁–၄စ၁–၉၉၅၁,မ့တမ့ၢ်စဲးကျိးပှၤဟ့ဉ်ကူဉ်တ့ၢ်ဒီကတၢဉ်ယၤစ မံကါဖံနၤလၢဖ၅၁–ဖ၉၀–ဖ၃၁၃,ဒီမ့တမ့ၢ်ဒီကတၢဉ်ကွီစမံဉ်အမ့ၢ်ပှၤဘဉ်မူဘဉ်ဒၢဘဉ်ဃးတ့ၢ်ဃု သ့ဉ်ညါအခိဉ်ဖဲစ့ဉ်ခဲသရံယူၤနံဉ်ဖၢဉ်စတံၤ လၢဖ၅၁–ဖ၉၀–၇၇၃၉.

အဲမလံၤစဲးစံၤ မုၢ်နံၤမုၢ်သီ

ယတဟ့ဉ်အခွဲးလၢတ့ၢ်မၤန္ဉ်ယဖိတ့ၢ်မၤလိတ့ၢ်မၤနီဉ်သ့ဉ်တဖဉ်လၢတ့ၢ်မၤလိဘဉ်

မိၢ်ပၢ်ဆဲးလီၤမံၤ မုၢ်နံၤမုၢ်သီ

Appendix C
Spanish Translation of Passive Consent Form

Para enseñar vocabulario en matemáticas

Forma de acuerdo

10 de septiembre, 2015

Yo soy una estudiante de St. Catherine University. Para un proyecto final de mi diploma de Masters, estoy investigando como enseñar palabras matemáticas en nuestras clases de tercer grado

Estudiantes van a aprender palabras matemáticas para escribir, dibujar, discutir, y jugar. Voy a aprender si las actividades ayudan a los estudiantes para aprender las palabras matemáticas y mejorar las notas.

Todos los estudiantes van a participar en las actividades. Cuando terminé, voy a compartir mis resultados con otros. Nadie va a saber si los resultados de su hijo (como resultados de pruebas antes y despues, autoevaluaciones, y respuestas de discuciones) están en mi estudio.

Por favor notar:

- Estoy trabajando con un miembro de la faculdad de St. Kate y un consejero para terminar el proyecto.
- Estudiantes van a aprender y practicar palabras de vocabulario de matemáticas. Después de apreder las palabras, van a entender las lecciones mejor, para ayudarlos. Practicando las palabras matemáticas de maneras diferentes, los estudiantes van a aprender las palabras mejor.
- Voy a escribir sobre los resultados que recibiré de la investigación. Aunque, ninguno de los escritos va a incluyar el nombre de la escuela, ni los nombres de los estudiantes, ni nada que va a hacer posible para identificar un estudiante en particular.
- Otras personas no van a saber si su hijo esta en mi estudio.
- Para ayudar otras maestras, mi reportaje va a estar disponible en la biblioteca de St. Kate.
- Esta bien si no quiere que incluya los resultados y respuestas de su hijo. Todavia voy a enseñar a su hijo de la misma manera.

SÍ, está bien si los resultados y respuestas de mi hijo esten incluyidas en el studio.	→	Gracias! Usted no tiene que firmar la forma.
NO, no queiro que los resultos ni las respuestas de mi hijo esten incluyidas en el studio.	→	Está bien! Firma la pagina y mandala para la clase para el **17 de Septiembre**.

Si tiene algunas preguntas, porfavor llamame al 651-481-9951, o llamar a mi consejero, Dr. Yasemin Gunpinar, al 651-690-6313, o Dr. John Schmitt, quien es el jefe de las investigaciones en St. Catherine University, al 651-690-7739.

Usted puede quedarse una copia de la forma si quiere.

_____ _____

Emily Sasse Fecha

No queiro que los resultos ni las respuestas de mi hijo esten incluyidas en el estudio

_____ _____

Firma de padre Fecha

Si usted no está seguro, porfavor llamame para discutir.

Appendix D
Place Value Unit Test

Name _____ Date _____

Place Value Unit Test

Read each question carefully. Write your answer on the line.

Write each number in standard form.

1. 6 thousands, 2 hundreds, 3 tens, 5 ones **1.** _____

2. *two thousand, eleven* **2.** _____

3. *five thousand, seventeen* **3.** _____

Write each number in expanded form.

4. 5,792 **4.** _____

_____

5. 8,341 **5.** _____

_____

What is the value of the 7 in each number?

6. 7,462 **6.** _____

7. 8,475 **7.** _____

8. 6,127 **8.** _____

9. Which digit is in the thousands place? 4,509 **9.** _____

10. Which digit is in the hundreds place? 8,012 **10.** _____

Order the numbers from *least* to *greatest*.

11. 2,312; 2,132; 2,321 **11.** _____

12. 6,456; 6,546; 6,465 **12.** _____

Place Value Unit Test *(continued)*

Order the numbers from *greatest* to *least*.

13. 9,012; 9,102; 9,120 **13.** _____

14. 6,688; 6,868; 6,886 **14.** _____

Solve.

15. Emily collected 191 seashells. **15.** _____
Dennis collected 119 seashells.
Sadie collected 189 seashells.
Who collected the most seashells?

16. Abe scored 82 points on his math test. **16.** _____
To the nearest ten, what was Abe's score?

17. Cassidy bought a new bracelet for $124. To the **17.** _____
nearest ten dollars, about how much did Cassidy
spend on the bracelet?

18. Asya has $277 in her savings account. To the **18.** _____
nearest hundred dollars, about how much does
Asya have in her savings account?

19. John has 408 stickers. Becky has 470 stickers. **19.** _____
John thinks that he has more, because 8 is
bigger than 7. Is he correct? Why or why not? _____
_____
_____

20. Write three different numbers that when rounded **20.** _____
to the nearest ten, the answer is 60.
_____
_____

Appendix E
Place Value Vocabulary Test

Name _____ Date _____

Place Value Vocabulary Test

Using the word bank below, complete each sentence by writing the correct word or words in the blank.

is greater than	expanded form	is less than
word form	is equal to	greatest
least	standard form	rounding

1. The symbol > means _____. 1. _____

2. The symbol < means _____. 2. _____

3. The symbol = means _____. 3. _____

4. The biggest number is the _____. 4. _____

5. The smallest number is the _____. 5. _____

6. The usual way of writing number that shows only its digits, not words, is called _____. 6. _____
(For example: 1,035)

7. Using written words to write a number is called _____. 7. _____
(For example: one thousand thirty-five)

8. A way of writing a number as a sum that shows the value of each digit is called _____. 8. _____
(For example: 1,000 + 0 + 30 + 5)

9. Changing the value of a number to the nearest ten or the nearest hundred makes it easier to work with. This is called _____. 9. _____

Appendix F
Addition Unit Test

Name _____ Date _____

Addition Unit Test

Read each question carefully. Write your answer on the line provided. Show your work!

Find each sum.

1. $278 + $321 = ▢ **1.** _____

2. $562 + $309 = ▢ **2.** _____

3. 3,097 + 4,519 = ▢ **3.** _____

Identify the addition property.

WORD BANK
Associative Property
Commutative Property
Identity Property

4. 7 + 0 = 7 **4.** _____

5. 69 + 17 = 17 + 69 **5.** _____

6. 5 + (9 + 1) = (5 + 9) + 1 **6.** _____

Estimate. Round each addend to the indicated place value. Show your work!

7. 49 + 32; tens **7.** _____

8. 66 + 78; tens **8.** _____

9. 347 + 479; hundreds **9.** _____

10. 538 + 192; hundreds **10.** _____

Addition Unit Test *(continued)*

Find each sum. Show your work!

11. 3.112 + 2.890 = **11.** _____

12. 8,038 + 976 = **12.** _____

13. 6,015 + 1,765 = **13.** _____

14. 8,620 + 617 = **14.** _____

Use any strategy to solve each problem.

15. Rex has $1,901 in his bank account on Monday. On Tuesday, $4,174 is added to his account. Is it reasonable to say that there is now about $5,000 in his account? Explain.

15. _____

_____

_____

_____

16. The ice cream shop sold 87 chocolate ice cream cones, 45 strawberry ice cream cones, and 92 vanilla ice cream cones. How many cones did they sell altogether?

16. _____

17. Ava's mother is buying school supplies. She needs 10 pencils, 5 erasers, and 3 notebooks. How many total supplies will her mother buy?

17. _____

18. The Franklin family drives 236 miles on Monday and 272 miles on Tuesday. How many miles will the family drive in all?

18. _____

19. Kennedy wants to buy a video game for $59. She also wants to buy a DVD for $23. She is standing in the store and has $100 in her pocket. She wants to know if she has enough money. Does it make sense for her to estimate or find the exact price? Why?

19. _____

_____

_____

_____

Appendix G
Addition Vocabulary Test

Name _____Date _____

Addition Vocabulary Test

Match each vocabulary word to its definition. Write the letter of the answer on the line provided.

1. Associative Property_____

2. Commutative Property _____

3. Identity Property_____

4. estimate _____

5. parentheses _____

6. reasonable _____

A. states that the numbers can be added in any order (For example, 6+8 = 8+6)

B. states that the way addends are grouped does not change the sum (For example, (3+4)+7 = 3+(4+7))

C. states that the sum of any number and zero is the number (For example, 5+0 = 5)

D. making sense

E. a number close to the exact number

F. ( ) symbols which show grouping

---

7. Circle the **3 key words** that give you a clue that you should add in a story problem.

in all	less
more	altogether
total	left

Explain why these words would tell you to add. _____

_____

Appendix H
Mathematics Vocabulary Notebook Page

Term:	My Understanding:	1	2	3	4
Describe:					
Draw:					

Term:	My Understanding:	1	2	3	4
Describe:					
Draw:					

Appendix I
Mathematic Vocabulary Self-Assessment Rating Grid

Mathematics Vocabulary Self-Assessment

Date: _____

Student Rating Scale	
4	**I've got it and I can teach it to a friend!**
3	**I get it. I can use the word by myself.**
2	**I get some of it. I might need help using the word.**
1	**I don't get it. I need help with this word.**

Vocabulary Word					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					
Name					

Appendix J
Teacher Reflection Journal Prompts

Personal Reflection Journal Prompts

What type of opportunities did I provide for the students to use the vocabulary today?

Did the opportunities seem to work with all student groups? Why or why not?

In particular, what successes and challenges did the ELL students have during the vocabulary activities today?

Appendix K
Student Discussion Questions

Student Discussion Questions

Circle the activity that was the most fun for you. Tell me why it was fun.

Underline the activity that helped you learn the most. Tell me why it helped you learn the most.

Cross out the activity that was the hardest for you. Tell me why it was hard for you.

Is there anything else that you want to tell me about these math vocabulary activities?

Please use these words in complete sentences, to show me that you know what they mean.

is greater than
word form
least
expanded form
is equal to
standard form
is less than
greatest
rounding

Associative Property
Commutative Property
Identity Property
estimate
parentheses
reasonable

Vocabulary Activities

Turn and Talks with a partner

Drawing in vocabulary notebooks

Writing in vocabulary notebooks

Making vocabulary flashcards

Practice problems with words on whiteboards

Quizlet matching game

Kahoot

Writing about words in small groups with a teacher

Answering questions about words in math journal

Buddy Games

Using the microphone to record sentences about words on Seesaw

QR Code activities

Kooshball review game

Creating foldables

Reading books with math words