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Vanessa Valley
University of Southern Maine, vanessa.valley@maine.edu

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The Impact of Math Vocabulary on Conceptual Understanding for ELLs

Vanessa Valley ~ *University of Southern Maine*

Abstract

The purpose of this study was to investigate the impact of teaching daily math word problems in a 3-6th grade ELL classroom on math vocabulary use and math word problem and place value comprehension. This study sought to answer the following research question: "How does direct instruction of mathematical operation keywords through teaching daily word problems on place value impact student math comprehension and oral use of math computation terms?" This quantitative study used a pre and post word problem test graded on a 16 point scale and a frequency tally to track math vocabulary use. The results showed a small increase in word problem comprehension and a large increase in math vocabulary frequency. I concluded that while math problems help some students' comprehension, the written format in English combined with the students' lower English reading ACCESS scores prevented many from benefiting in regards to comprehension. The study showed that daily implementation of math word problems in the classroom greatly increased use and understanding of English math vocabulary.

Keywords: ELL, ESL, Elementary Math Instruction, Math Instruction for ELLs, Teaching Math Vocabulary to ELLs

Introduction

The reason I chose to research math language interventions is because I teach math to elementary ELL students. This is my first year as an ELL Ed Tech and my degrees are in English and Education, so I have little experience teaching math. With that in mind, I chose to do this research in hopes of a) discovering multiple methods with which to teach mathematical keywords in a timely manner, b) to research the leading theories on how to teach math and English at the same time, and c) to discover ways to teach math keywords creatively.

I am required to teach my students first and foremost the English language, but I am also required to teach content (math, reading, writing etc.). In our ESL classroom, we don't technically have our own "class." Instead, they are seventeen students from four different grades

and eight different classrooms that we pull out into our ESL homeroom at various times of the day. Since the students are missing the content being taught in their mainstream classroom when they come to the ESL classroom, we need to teach them the content they are missing in addition to teaching them English. In my math group, I have five students from three different grades at very different math levels. But one of the things all of my students have in common is their extremely active engagement when I introduce math operations and keywords and use interactive games and group activities to teach them. I select math vocabulary words from the state-provided math curriculum, choosing key/commonly used words from each upcoming chapter to teach before and along with the math concept. Typically, I choose between 5-10 words, as any more can overwhelm the students, and focus on the most used/most relevant words for a math concept. I then connect these words to the corresponding math symbols, demonstrate the concept they represent, and provide written versions of the word with images of the symbol on the classroom wall for students to reference as they learn both the math vocabulary and the concept through word problems and other types of activities and direct instruction.

While researching for my literature review, I realized that there aren't many studies on this subject yet, but I believe with the increase of ELL students the studies in relation to ESL classrooms will increase as well. In the meantime, implementing my own study will certainly be relevant to ESL education in years to come. The goal of my study was to provide some research in the future for ESL teachers in Maine and the overall New England area.

Literature Review

At the beginning of my research on the subject of math vocabulary and the impact using and learning it has on ELLs, I first narrowed down my search to math sentences, text, and peer reviewed scholarly articles and found about half a dozen studies that fit what I was looking for.

All of my articles are fairly recent, with only two dating further back than four years ago, at 2000 and 2002. The results revealed three different themes: merging English-Language development with content area learning, the relationship between promising approaches and the knowledge base on effective teaching and confusion, and tension and assumptions about oral language use. These themes are discussed in great detail but the clearest takeaway from the results was that daily language needs to include both conversational and academic vocabulary, and that it is absolutely necessary to teach the English language to ELL learners, (proper grammar and syntax etc.) alongside content.

Overall, I found a variety of studies. There was a mix of quantitative and qualitative studies but all of the research questions explored similar issues. One repeating theme was that the researchers felt more studies on ELLs and related topics still need to be done. The majority of the research that I found was very recent, implying that the field of ELL instruction is growing and will continue to expand rapidly in the future, with the demand for relevant research going up along with it.

Research Question

Twenty-five percent of the students in my school are ELLs, and while the program is not exactly new, it is not as organized or consistent as I believe it should be for the sake of the students. There are three ELL classrooms and in mine alone there are ten students whose math abilities vary from first grade to fifth grade, and adding in English math vocabulary poses another challenge for my students. While some grasp the concept in their first language, they have to work much harder to do so in English. When considering ways I can teach my math small group both math concepts and math vocabulary at the same time, I was led to my research intervention and ultimately my research question: How does direct instruction of mathematical

operation keywords through teaching daily word problems on place value impact student math comprehension and oral use of math computation terms?

These were followed by two sub questions:

How does the daily instruction of mathematical operation keywords impact math language comprehension as measured on pre and post tests? How is the frequency of use of math vocabulary in students' oral communication affected by directly teaching math computation terms?

The constructs are math comprehension and verbal vocabulary frequency and the variable is the direct instruction of mathematical operation keywords.

Intervention

My intervention was to implement the group instruction and explanation of three math word problems a week with an elementary ELL Math class. These problems identified six key place value words: ones, tens, hundreds, thousands, ten thousands and hundred thousands, and asked students to place digits in the correct value on a sheet of paper. An example of a question used follows:

Sam was counting a large jar of pennies. Put the digits in the correct place value to determine how many pennies he had. There is a one in the tens place, a seven in the hundreds place, a six in the ten thousands place, and a zero in the ones and thousands place. How many pennies does Sam have?

These questions were read aloud to the ELL students while they could read along with their own printed copy, and they listened and placed the digits in the correct order on a sheet of paper, and then read the entire number back to the class aloud. I also reread phrases at students' request, and underlined the key math terms they should focus on. These word problems were to be taught for

a total of four weeks, with students receiving thirty minutes of math instruction three days a week. One word problem was introduced each day of instruction. The first two weeks consisted of teacher-created problems, followed by two weeks of student-created problems. This intervention was designed to gauge the impact of using word problems with new math vocabulary. The schedule was as follows:

Day one- Pre assessment and one teacher-crafted word problem and vocab tally

Day two- Teacher-craftedword problem and vocab tally

Day three- Teacher-crafted word problem and vocab tally

Day four- Teacher-crafted word problem and vocab tally

Day five- Teacher-crafted word problem and vocab tally

Day six- Student-crafted word problem and vocab tally

Day seven- Student-crafted word problem and vocab tally

Day eight- Student-crafted word problem and vocab tally

Day nine- Student-crafted word problem and vocab tally

Day ten- Student-crafted word problem and vocab tally

Day eleven- Student-crafted word problem, vocab tally and post assessment

More specifically, the intervention also included some of the following practices to help students. First, the instructor (myself) wrote the terms on the classroom whiteboard next to a place value chart and left them there as a reference during class time. Second, I asked students to underline the key math terms recognized from the whiteboard on their individual word problem worksheets as they completed their lesson. Finally, I had students practice identifying a term and the place value associated with it through weekly competitions which encompassed calling on students to write a specific number on the whiteboard in an unlabeled place value after hearing

the place value verbally given to them. These, along with my reminders to look for the key terms in their math problems, constituted the intervention.

Research Design

This is a quantitative study. I compared numerical results from pre- and posttests as well as frequency counts of students' use of the predetermined math vocabulary words. My theory was that the instruction of math word problems daily would allow students to learn math vocabulary and math concepts at the same time and perform better on the posttest than the pretest, as well as have an increase in tally numbers for the correct use of math vocabulary in the classroom.

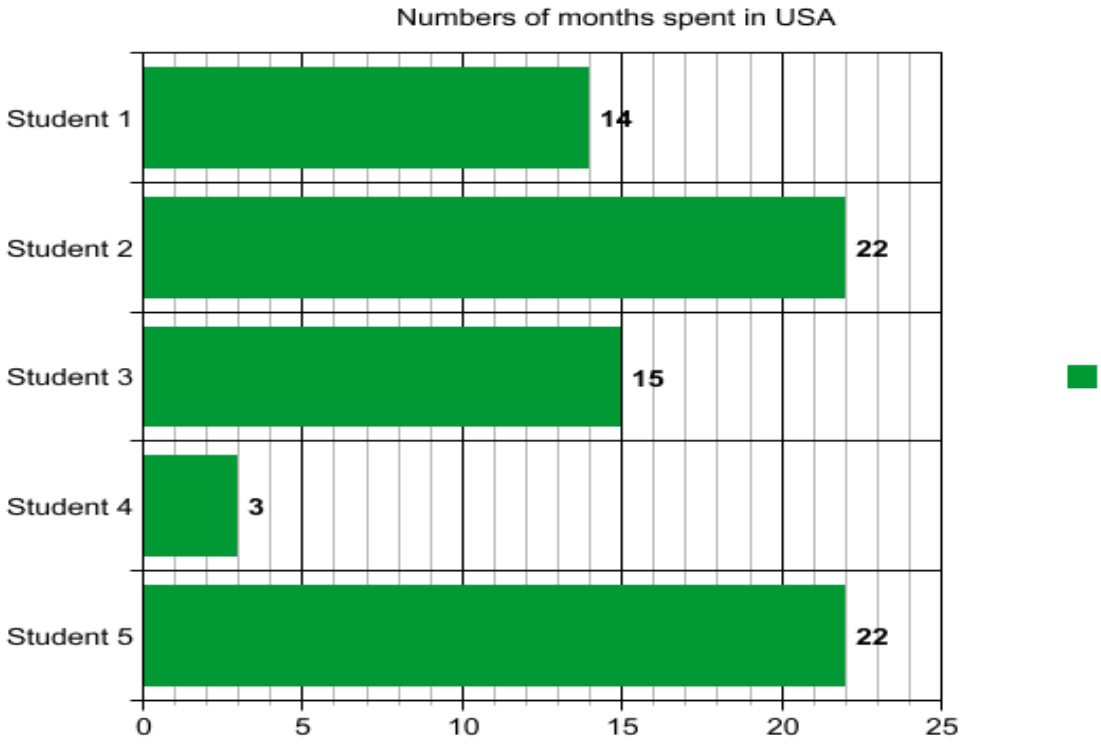
As an Ed Tech with limited class instruction time (thirty minutes three times a week), I chose not to pull students away from the instruction period for interviews, and as the only instructor, observations were not feasible.

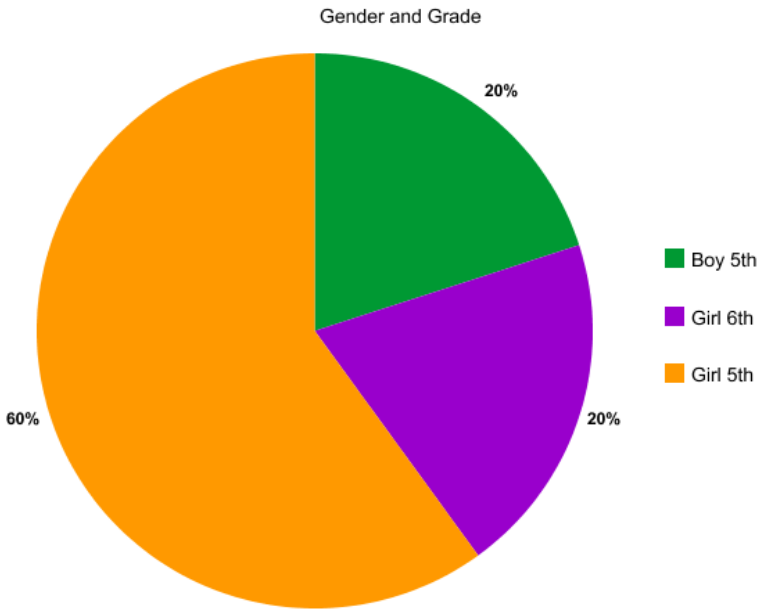
Setting and Sample

The setting is a lower level ELL classroom at an elementary school in northern New England. My school has just over 300 students and 25% of them are ELL students. The school has doubled their number of ELL students and ELL staff in the last year as more families join their friends and relatives already settled in the area. My classroom services the level ones and twos ELLs in grades 3-6. These levels are based on their ACCESS scores and WIDA standards, tests and standards designed specifically for ELLs.

The students I chose for this research were from my upper level math group. They are from the fourth, fifth, and sixth grades. One is male and four are female. They speak the following languages: Arabic, Spanish, Turkish and English. Some students speak more than one of these L1s. Their prior education experiences range from a full five grades to three years of

schooling. Three entered the USA with refugee status and one spent one year in Arizona at an American school before becoming my student. This data is reflected in the graphs below:

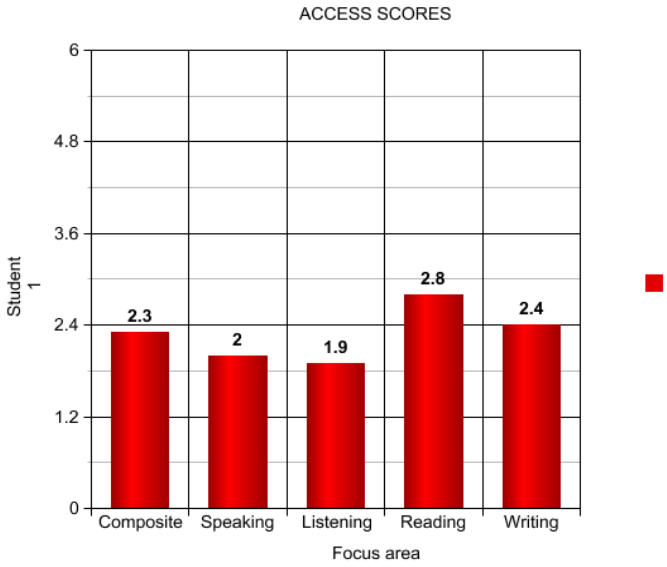


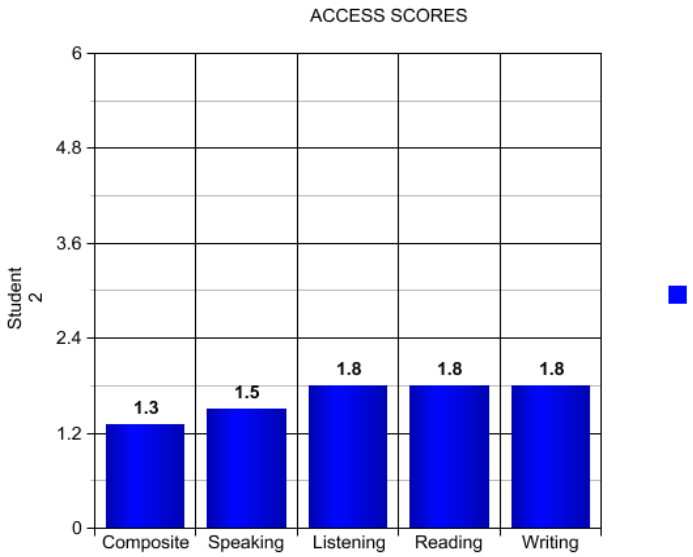


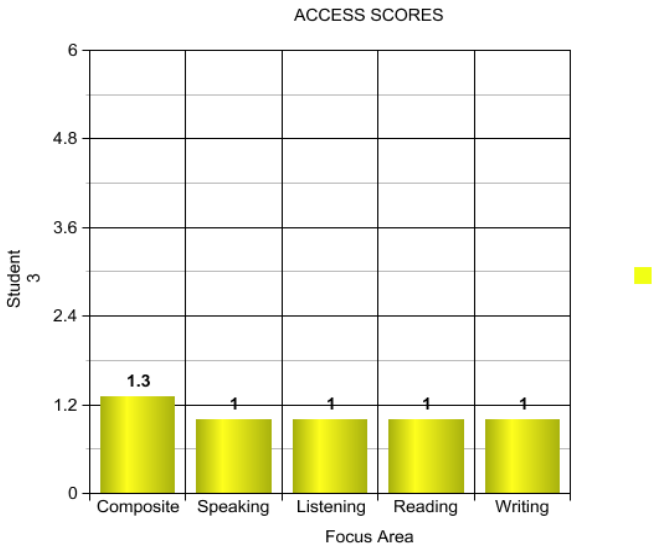
Data Collection

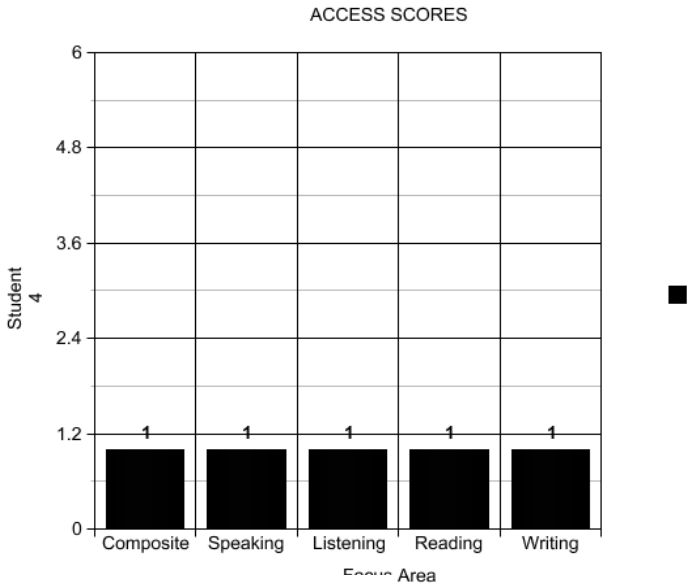
The data collection for this research was taken from three different sources: the pretest, posttest, and the frequency tally of oral use of math vocabulary by students. The pre- and posttests are pulled from chapter two of the McGraw-Hill My Math Volume I, grade four. I photocopied these tests directly from the chapter that taught place value. Each test was comprised of three word problems, similar in style and format to the example question I presented for my intervention.

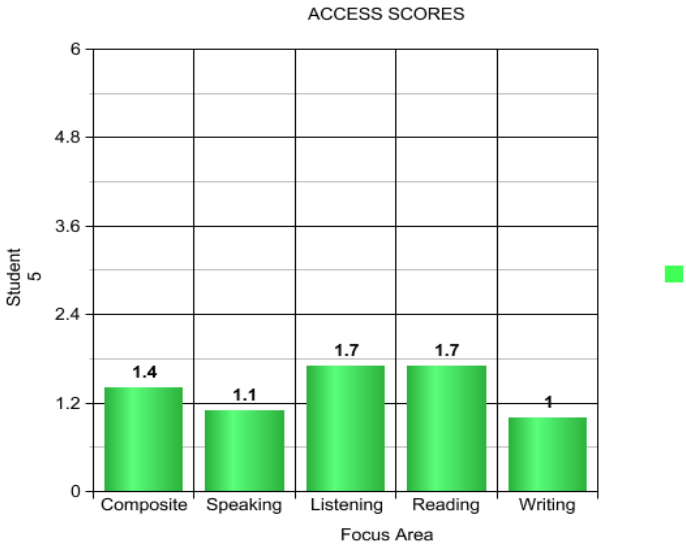
Early on, due to the lower English reading ACCESS scores of most of my students, I decided to read the questions aloud to the students with the intention that it would make the tests more accurately assess math comprehension and not just reading comprehension. ACCESS scores are listed by student below and include a breakdown of the four ACCESS categories:


ACCESS SCORES
Student 1
6
4.8
3.6
2.4
1.2
0
2.3
2
1.9
2.8
2.4
Composite
Speaking
Listening
Reading
Writing
Focus area


ACCESS SCORES
Student 2
6
4.8
3.6
2.4
1.2
0
1.3
1.5
1.8
1.8
1.8
Composite
Speaking
Listening
Reading
Writing


ACCESS SCORES
Student 3
6
4.8
3.6
2.4
1.2
0
1.3
1
1
1
1
Composite
Speaking
Listening
Reading
Writing
Focus Area


ACCESS SCORES
Student 4
6
4.8
3.6
2.4
1.2
0
1
1
1
1
1
Composite
Speaking
Listening
Reading
Writing


ACCESS SCORES
Student 5
6
4.8
3.6
2.4
1.2
0
1.4
1.1
1.7
1.7
1
Composite
Speaking
Listening
Reading
Writing
Focus Area

As shown in the graphs, only one student had a reading score above two, and I didn't want that to skew the assessment of the math vocabulary comprehension. With my research samples, I felt it made the most sense to focus on one aspect of comprehension at a time.

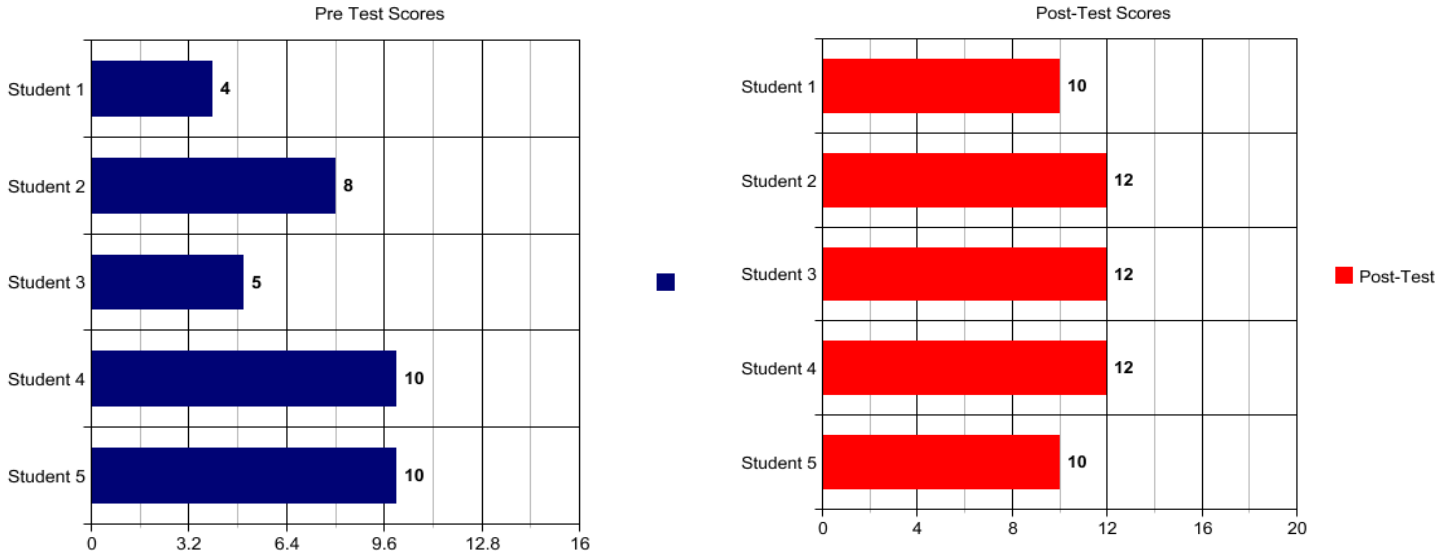
For the pretest I read each question aloud slowly and clearly three times. However, for the post test, I only read each question aloud once, encouraging the students to try to pick out the six vocabulary words we had practiced and deduce the answer themselves as much as possible.

For both tests I graded each student on four questions, on a four-point scale, 0-4, with zero indicating no effort and 4 indicating excellent or above and beyond effort. With four questions, this means the highest score that can be acquired is 16, and the lowest score is 0. The four questions I graded the tests on were:

- Did the student work to answer the question on their own?
- Did the student make an effort to use place value strategies such as labeled columns?
- Did the student show understanding of what the numerical answer represented the value of? (dollars, cars, population etc.)
- Did the student underline/circle key numbers, words or phrases that would help them solve the problem?

This final question was designed to assess the math vocabulary comprehension of the lower reading students especially. Several students in my math group read at a kindergarten level, so rather than gauge them on their ability to read or pronounce the words, I aimed to gauge their ability to recognize them, which would still indicate overall growth. I graded the pretests immediately after they were taken based on these questions and logged the students' scores. The frequency tally tallied the amount of times each day the students used the six place value math vocabulary words. An example of the frequency tally sheet used can be seen in appendix C.

Results



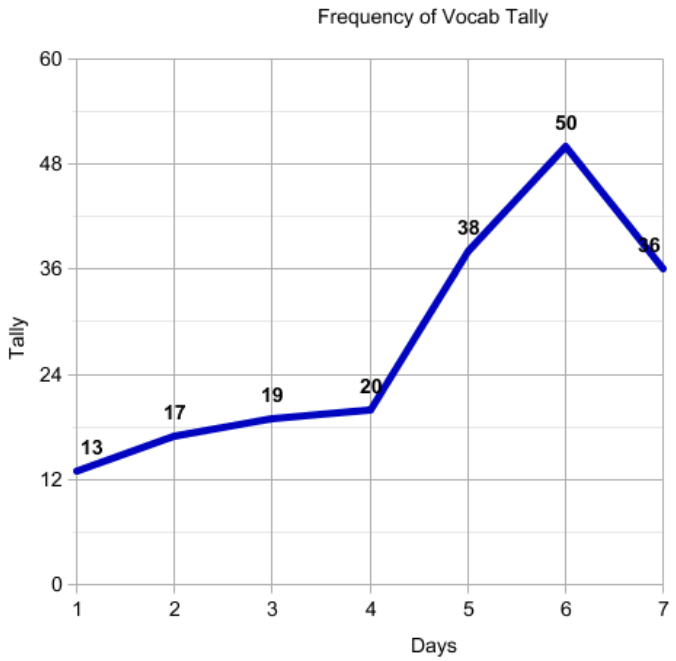
To discuss the results, let us first take a look at the graphs comparing pre- and posttest data.

As we can see, the posttest scores (in red) showed an average increase of 3.8 points. Overall, the students did show an increase in comprehension, but it wasn't as much as I had anticipated. This may be due to the shortness of the study, or factors such as previous years of schooling. For example, while some students made lots of progress, student five actually showed no improvement at all on their pre- and posttest score. Did they need more time to learn? Did they need to go further back and rebuild some lower level math concepts before undertaking place value? These are questions I hope to consider in a future study.

I also want to consider each student's ACCESS scores when analyzing their posttest scores. None of the five students scored higher than a two on the speaking and listening sections of the test, with the average score at 1.2 for all five students' speaking and listening combined. The pre- and posttests were read aloud, and the students' speaking or listening ability may have affected their test scores.

However, while the overall increase in scores was not as high as anticipated, there was a growth in math vocabulary comprehension, and with more instructional time, the students may have achieved more growth. Student One demonstrated the use of place value strategies on her posttest, an improvement over the pretest, on which not all student place value charts were written or accurate.

The third and final source of data was the vocabulary tally. There were six terms, tallied over the course of seven days of math instruction. The chart below shows the frequency count by day for the total number of math terms used (including all six in each daily tally).



This graph shows a significant increase in frequency of vocabulary usage. It is clear that the students' use of the six vocabulary words increased over the study period, as the words were introduced and then repeated through the group solving of the daily word problem. Students practiced both reading the vocabulary words from the classroom whiteboard where the word problems were written, and speaking them from memory in answer to questions later on during daily instruction time.

It is also important to mention the spike in the frequency tally between days four and five comes after the cessation of storm, holiday and student assembly interruptions to the instruction.

Themes and Conclusion

I will refer back to my original research question before exploring the themes and conclusions: How does direct instruction of mathematical operation keywords through teaching daily word problems on place value impact student math comprehension and oral use of math computation terms?

There are several themes shown in the research results. The first is that overall math vocabulary comprehension increased based on the pre- and posttest scores. The pre/post assessment showed that nearly all students made some progress with an average score increase of 3.8. Second, the results also showed that student awareness and oral use of the vocabulary words increased considerably, evidenced by the frequency tally of their correct math vocabulary use which showed an average increase of 3.3 spoken key terms a day, with numbers beginning in the teens and jumping into the 30s and even 50s at the end of the study. In this manner students were more capable of discussing place value when asking for assistance with a comprehension or reading comprehension related question. Third, even though students made progress in their verbal and comprehension skills, the study shows that they still had room for significant improvement. These themes show that the direct instruction of mathematical operation keywords through teaching daily word problems on place value improved students' oral math vocabulary greatly and their math comprehension partially. It is clear that the frequency of use of math vocabulary in students' oral communication was increased exponentially by directly teaching math computation terms, while the comprehension growth could be more significant, based on the pre- and posttest scores.

Recommendations/Implications

There are several recommendations I can make after concluding this action research study. While I did my best to ensure the validity of data, there were some holes that I would seek to fix when conducting my next research study. I recommend adding at least one more data source, such as a mid-assessment, and a longer pre- and post-assessment. With more time, I would also conduct student interviews or another form of student feedback. In addition, I found that keeping a tally of verbal use of vocabulary words while teaching to be extremely difficult and not always accurate. In the future, I would record the class session and go back to document the frequency tally data. I would also recommend a larger sample size to add more data for analysis. There may be similar samples sizes in other places, but the specific grades of the students and the subject of instruction are unique to the study; therefore, the results may not apply to broader fields of educational research. With a larger sample size, the results would be more applicable to the greater ELL Education field. Within the time constraints of this action research I don't believe that these two concepts were utilized to their fullest potential, and as such students didn't make large leaps in their progress. Most of the studies in the literature review include much larger sample sizes, which help make up for any inaccuracy or bias in their data, especially the studies that focus on a specific group of ELLs, such as "Classroom Instruction and the Mathematics Achievement of Non-English Learners and English Learners" (Valle, Waxman, Diaz, & Padron, 2013). That study examined the effects of mathematical instructional practices on 5th grade mathematics achievement for White non-ELLs, Hispanic non-ELLs and Hispanic ELLs based on the data from the ECLS-K and had a sample of 300 total students. With a longer study period and a slightly larger sample size, such as 15-20, the data results would be more applicable to other educators.

Summary

I learned several important things about myself as a researcher during this study. The first was that a researcher always has more to learn about how to conduct better research. I learned different methods for gathering data such as frequency tallies, to have consistent pre- and posttests, and different methods for turning raw data into charts and graphs. I learned that I am organized, I am creative and I am efficient when planning. I also learned that I need to document more of my students' progress both in research and in class in general. Students who receive feedback seem to learn more, but more importantly, when I assess my students more frequently, it allows me to tailor my lessons to my students and be a better a teacher overall.

Action research is not easy, and I was often overwhelmed by the data and by the options for research topics. But I learned the steps of how to conduct a research study, which tools to use, how to choose a research topic, and how to analyze and present results.

There are some keys things that I learned about what kind of teacher I want to be when I'm in charge of my own classroom, and these are elements that I will try to bring into the classroom I work in now, as much as I can. First, structure and consistency is key for effective teaching. My current classroom has a very chaotic and often rushed feel to it. Conducting this research taught me the value of slowing down and making sure the students understand key concepts, especially in math--in which concepts build upon one another--before moving onto the next concept. Second, I found that word problems were an excellent way to repeat vocabulary words in a fun and creative way. Clearly, the results of the frequency tally show that the word problems were effective for vocabulary, and I will use them again in future as a way to teach new vocabulary. But third and finally, I was reminded that there are many different ways to help

teach vocabulary in addition to word problems, such as song or rhymes, which I will use in the future to help students solidly remember vocabulary words.

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Appendix A

Research Notification

Dear Students and Families,

I am sending this letter to inform you of a study I am conducting in class. The purpose of my study is to evaluate the impact of direct instruction of mathematical operation keywords on student success with word problems in an elementary ELL classroom. You have received this letter because I plan to collect data in your child's class.

My study will be conducted through the middle of November, and will NOT include any activities outside of normal, day-to-day classroom activities. As part of my study, I plan to include the use of flashcards, writing on the board, and the standard math curriculum packets and assessments to conduct the study and gather data for my study.

Please understand the following regarding your child's participation in my study:

- Your child will not be video or audio recorded at any time.
- The records of this study will be kept private.
- Any sort of report I write will not include your child's name, or anyone else's.
- Pseudonyms for our school and district will also be used.
- Research records will be kept in password protected files.
- Records will be destroyed within a year.

Appendix B

Teacher Created Place Value Word Problems

1. John went to the zoo in Puerto Rico and saw a large number of animals. There is an eight in the thousands place, a zero in the hundreds place, a seven in the ones place and a nine in the tens place. How many animals did he see at the zoo?

2. Reza went to a farm to go apple picking. She saw too many apples to count but there was a sign at the farm that told her how many apples the farm had all together. There was a one in the ten thousands place, a seven in the tens place, a zero in the thousands place, a five in the hundreds place and a nine in the ones place. How many apples did the farm have?

3. George visited an art museum in New York City. The museum used to have 10,000 pieces of art but they recently purchased more. There is a nine in the thousands places, a one in the ten thousands place, a five in the ones place, and zeros in the tens and ones place. How many art pieces does the museum have now?

4. Ellie likes to count her pennies once a month. This month she had a five in the thousands place, a zero in the hundreds place, a two in the ones place and a seven in the tens place. How many pennies did she have?

5. Emily has an entire bedroom full of rocks. She like to collect them. There is a nine in the hundred thousands place, a one in the tens places, a seven in the ten thousands place, a two in the thousands place, a zero in the hundreds place, a four in the ones place and a five in the tens places. How many rocks does Om have?

Appendix C

Oral Tally Sheet

Fourth grade math place value vocabulary

Vocab	Student 1	Student 2	Student 3	Student 4	Student 5
Ones place					
Tens place					
Hundreds places					
Thousands place					
Ten thousands place					
Hundred thousands place					