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### Learning the Language of Math

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University of Northern Colorado  
Greeley, Colorado

Learning the Language of Math

A Thesis Submitted in  
Fulfillment for Graduation with Honors Distinction and  
the Degree of Bachelor of Science

Christen Ayers

College of Natural and Health Sciences

May 2018

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## Abstract

### Significance and Purpose:

The purpose of this research study is to determine the level of positive impact that automated storybook interventions have on the mathematical vocabulary acquisition of Kindergarten through second grade children who are English Language Learners with language impairments, as well as to determine the most effective delivery style of the language of the intervention.

### Design and Methods:

This study is based on a quantitative research design with a multi-case study approach. Participants will include a small population of English Language Learners with language impairments. Interventions will be provided through three automated storybooks. Results will be analyzed by pretest and posttest data scoring.

### Results:

Baseline results from the control group suggest that mathematical vocabulary knowledge will increase to a similar level after completion of this intervention.

### Conclusions:

Data indicates positive learning outcomes for participants in kindergarten through second grade who are native English speakers with no language impairments. Future study includes implementing the intervention to the target population of English Language Learners in an English only instruction format as well as Spanish only instruction and determine the most effective language of instruction based on vocabulary acquisition results.

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## **Introduction**

The purpose of this research study is to determine the level of positive impact that automated storybook interventions have on the mathematical vocabulary acquisition of English Language Learners with language impairments. This study is based on a quantitative research design with a multi-case study approach.

The primary research question for this study is, to what extent do automated storybook interventions increase mathematical vocabulary knowledge for kindergarten to 2<sup>nd</sup> grade English Language Learners?

The secondary research question for this study is, to what extent does the use of the native language of an English Language Learner in the intervention process increase mathematical vocabulary acquisition when compared to the intervention when instructed in English only?

The following literature provides background information demonstrating the need for intervention approaches targeting mathematical vocabulary acquisition for children who are English Language Learners with language impairments. This literature will also prove the efficacy of automated storybook interventions as a productive tool for increasing vocabulary knowledge.

## **ELL Background**

An English Language Learner, or ELL, is defined as someone whose native language is one other than English but who is in the process of learning English. According to research conducted by the U.S. Census Bureau, the population of citizens who speak a language other than English is expected to increase from 33.5 million in

2010 to 39.6 million by 2020, with 66% of this population being over the age of five. (*English Language*) Due to this steady influx of English Language Learners, it is increasingly important to provide these students with the resources needed to succeed academically.

The foundational aspect of academic success is understanding and being proficient in the language of instruction. However, by definition, this is not a luxury that English Language Learners are accustomed to. Since these students are not familiar with the language of instruction in English only schools, they struggle to understand the academic lexicon that they are presented with. This can be detrimental due to the fact that vocabulary knowledge has a direct correlation to literacy acquisition. (Chlapana, 2014) Therefore, students who are not native speakers of the language that they encounter in school perform at a lower level than students whose native language is the one of dominant academia (Alt, Arizmendi, & Beal, 2014). Because of this, an achievement gap has occurred between ELL's and their English-speaking peers.

The achievement gap was recognized in the 1960's, beginning with the passing of the Bilingual Education Act in 1968, providing federal funding to schools to implement programs for students who are limited in English. This has more recently been followed by the No Child Left Behind Act in 2002, which placed more responsibility on schools for student learning outcomes, especially those students who are English Language Learners and those in special education. Based on the increasing number of ELL students being referred to special education. This heightened referring to special education is reaffirmed by the fact that according to the US Department of Education, Spanish speaking ELL's are five times more likely to begin their schooling with academic deficits

compared to their English-speaking peers. This sets them on a long road for this achievement gap to increase, or at least remain steady, because they are not receiving the right instructional foundation in their early formative years. (Alsace, 2008).

Because of these alarming statistics, the language of instruction is extremely important to consider when providing vocabulary interventions. In a previous study, (Lugo-Neris, Wood, & Goldstein, 2010) looked at whether English only vocabulary instruction or English bridged with Spanish vocabulary instruction facilitated increases in word learning during storybook interventions. Twenty-two Spanish speaking kindergarten aged participants were selected. They all received two weeks of word expansions in English only as well as two weeks of word expansions in Spanish. Their results showed that children had a greater increase in receptive knowledge and expressive definitions when provided with the Spanish bridged intervention compared to the English only explanations. These studies show that English bridged with Spanish is an effective language of intervention for increased vocabulary knowledge in English Language Learners with and without language impairments.

Whether embedded with the child's native language or taught alone, the process of second language acquisition is closely related to the comprehensible input model developed by Stephen D. Krashen. This model states that the best way to learn a new language is by understanding what words mean and how to apply those meanings in situational context. (Gxilishe, 2013) This means that if learners are shown visual representations of meaning at the same time they are hearing a new word, lasting comprehension is expected to occur. Ways to implement this model are by providing the new content in natural settings such as conversation, providing multiple opportunities for



use, and providing vocabulary and situations that are relevant to the learners' life.  
(Roseberry-McKibbin, 2007)

In order to provide intervention examples that are relevant to the learners' life, the person teaching second language vocabulary must understand the circumstances and happenings of the learners' everyday experiences. There are many facets of an individuals' life that must be taken into consideration, but some shared experiences between English Language Learners' have been noted that can affect meaningful intervention choices. The most common of these include overwhelming absences and low socioeconomic status. (Alsace, 2008) Other factors that negatively influence an ELL's language acquisition include acculturation levels, or how well a student has adapted to and is accepting the culture of the second language. If the student is not feeling comfortable in their environment, their psychological state might hinder them from performing well, such as anxiety or low self-esteem. Also, if a student's family intends to leave the country in a short amount of time, the ELL student will be less likely to put effort into second language acquisition. (Roseberry-McKibbin, 2007)

### **Language Impairment Background**

A language disorder is defined as,

"...the abnormal acquisition, comprehension, or expression of spoken or written language. Individuals with language disorders frequently have problems in sentence processing or in abstracting information meaningfully for storage and retrieval from short or long-term memory." (Roseberry-McKibbin, 2007)

Children with language impairments tend to have shared general qualities. These include slow initial language acquisition of which they do not outgrow, and genetic components seen as abnormalities in brain structure and function. This genetic component is a neurodevelopmental disorder that is inherited. The disruption in the neurocognitive development leads to difficulties in language learning. (Paradis, 2010)

However, their nonverbal intelligence is normal or above that of their typically developing peers. Children with language impairments also often exhibit certain characteristics of language. These include difficulties with morphology, syntax, and pragmatics. However, the language domain most effected by impairments is morphosyntax. This is the combination of morphology and syntax, or how words and parts of words are put together to create grammatically correct sentences. (Paradis, 2010). Processing issues are also considered a characteristic, which is why two main groups of language impairments have been discussed; processing limitations and deficits in grammatical knowledge. These groups are otherwise termed by The American Speech, Language, and Hearing Association (ASHA) as deficits in linguistic skills and/or processing skills.

As previously stated, children with language impairments struggle with abstract language; along with fast mapping, and word finding. (Roseberry-McKibbin, 2007) These issues can also manifest themselves as difficulties understanding, remembering, and accessing new words. (Zens & Gillon, 2006) However, studies have shown that children with language impairments are capable of learning new words, but that they require multiple exposures and time to be at the acquisition and word memory level of their peers. Although they can learn new words, children with language impairments have

reduced syntactic bootstrapping abilities. This means that they struggle to use context within a sentence or story to determine what a new word means. (Zens & Gillon, 2006) Because of this, a common form of intervention that is used for language and vocabulary acquisition is direct and explicit instruction.

Another major difficulty of language impairments is being non-proficient in phonological awareness, an issue that makes reading and writing extremely difficult for 50-75% of children with language impairments, setting them up for increased risk of poor academic performance in the future. (Roseberry-McKibbin, 2007). Stemming off of phonological awareness, other phonological issues arise, specifically phonological working memory. This impacts their ability to remember what specific phonemes sound like and how to organize those phonemes to create words. This difficulty produces impairments in organizing words into categories of meaning, leading to subsequent difficulties in recognition and retrieval of words. These phonological processing difficulties also have a negative effect on children's ability to repeat non-words, since they have no semantic background knowledge as well as no recognition of the sounds or sound patterns. Because of this, children with language impairments exhibit limited proficiency in processing rapidly presented sentences and rapid naming of objects or actions. (Zens & Gillon, 2006)

Other qualities of language difficulties in children with language impairments include shorter and less complex sentences, the omitting of bound morphemes, and trouble with the pragmatic aspects of assertiveness, passiveness, or both. Along with trouble using pragmatics comes difficulty maintaining the topic of discussion, leading children with language impairments to often interrupt. Obviously, all of the difficulties

that come along with language impairments do not make it easy for a child to socially succeed as well as typically developing, or TD peers. This leads to low self-esteem issues that can carry on well into adulthood and have lasting mental and emotional effects.

(Roseberry-McKibbin, 2007)

### **Vocabulary and Mathematics**

The vocabulary of mathematics contains concept words and spatial arrangements, such as below and above, as well as Tier 1-3 vocabulary words. Tier one terms are those that have a high frequency in the English language and are therefore more likely to be learned through natural exposure. Tier two words are those that students are unlikely to learn on their own due to a lack of frequency of the target words in the student's everyday lives. Consequently, these words are best taught using direct instruction.

(Mazaro, 2012) Tier three words are those subject-specific terms that are not frequently found outside of a specific field. Conceptual terminology is considerably the hardest for ELL students to understand because of the fact that different cultures have different meanings for certain words, and these concept words are extremely abstract in meaning. For the purposes of this study, Tier two words were chosen for intervention based on their frequency and importance in a foundational understanding of mathematical concepts in grades K-2, as well as for the level of concept words contained in Tier two terms.

Furthermore, for the purposes of this study, it is important to clarify that math is a language of its own, and it takes a great amount of effort to learn its symbols and meanings; effort that most ELL students are already exerting into the learning of their second language. The use of direct instruction in teaching mathematical vocabulary

words will likely reduce the amount of effort required for ELL students to understand the meaning of the language of math.

### **Automated Storybooks and Vocabulary**

Vocabulary acquisition is a primary part of increasing language skills. For this reason, story reading, or interactive read aloud, is a common strategy used for teaching ELL's. Interactive read aloud is defined as a form of instruction that uses spoken books to enhance vocabulary knowledge by active participation between reader and child, prediction by child, and expression of different voices for different characters by the reader. This strategy is often implemented by the use of automated story books. (Cruz, 2008)

Automated storybook reading does not only increase vocabulary acquisition, but concept development, narrative ability, and comprehension as well. (Cruz, 2008) This is important because vocabulary and comprehension rely heavily on each other. The more vocabulary and semantic knowledge a child has, the better their comprehension will be, and the more they will be encouraged to read. Consequently, the more that they read, the more vocabulary they will learn. This engages them in a constant cycle that supports expansion of their lexicon. (Cruz, 2008)

Since comprehension is improved by vocabulary instruction, and vice versa, it is vital that children fully understand the meaning of the words they are being presented with. A popular way of facilitating this is by robust vocabulary instruction. This means that vocabulary definitions must be connected with the students' prior knowledge, while being friendly, comprehensible, and filled with visual representations. The importance of

words being connected to prior knowledge was first proposed in the Knowledge Hypothesis, which states that knowledge causes an increase in vocabulary, and consequently, an increase in listening and reading comprehension. (Cruz, 2008)

Story reading is also a highly used method of vocabulary instruction because it does not leave the reading to the child alone, rather the reading is done at the same time between reader and child and the child is engaged by being asked to answer questions about the plot and make predictions. (Cruz, 2008) This is important because the ability to read is not always a good predictor of vocabulary knowledge or comprehension skills. Although a child may be able to quickly decode a written word, they do not always know what that word means. Their phonological awareness skills may be present, but these do not always predict semantic skills. For this reason, vocabulary teaching needs to be focused on multiple exposures to and meanings of words as well as morphology, syntax, and pragmatic aspects. All of these aspects of vocabulary instruction allow a child to expand their understanding of new words not only in different meanings but in different social situations as well. (Cruz, 2008)

## Summary

Providing interventions that will produce lasting results requires more than just evidence-based practices and the right individualized instruction, but an understanding and respect for a client's background and varied needs. The information provided has given insight into the cultural and personal aspects of English Language Learners as well as children with language delays. Understanding how ELL's with and without language impairments acquire vocabulary best is essential in forming intervention strategies that are effective. By the use of automated storybooks, participants mathematical vocabulary knowledge will be enriched, and their learning skills will flourish.

The findings of this project will enable Speech Language Pathologists, General and Special Education teachers, and primary caregivers to better understand the most effective ways to provide strategies for vocabulary acquisition. It is important that English Language Learners with language impairments are provided with proven, relevant vocabulary instruction so that they are given the most effective tools for a successful academic career. According to Claudia M. Pagliaro, "...young children's mathematics performance in all concept areas can be used to predict levels of academic achievement well into high school and in content areas beyond mathematics." (Alt et al. 2014) Knowing the language of math will give students a firm foundation on which to build their achievement outcomes.

## **Methodology**

### **Participants**

Kindergarten through 2nd grade children who are identified as English Language Learners with language impairments. Children were recruited to participate in the study from the University of Northern Colorado Speech Language Clinic and/or an after-school program. Selection to participate in the study is based on results from the Peabody Picture Vocabulary Test (PPVT-IV), where children who score 1.0 below standard deviation will represent language impairments. Parental permission and child assent was received before any tests were administered. This was through the use of IRB approved documents.

### **Format of Intervention**

Three scripts have been created for use in the automated storybooks. The first one will be a training book that will provide the introduction of characters and an initial look at the outline of the interactive books. After this, two additional books embedded with the math intervention will be introduced. These books will be designed to provide one concept lesson and three mathematical vocabulary words. Each book is approximately 8-10 minutes in length and 15 pages long with interactive pictures and bolded vocabulary words with definitions and examples. Each story contains an average of 15 vocabulary words. These vocabulary words will be given in English with definitions and examples through pictures and interactive learning. This provides the children with multiple exposures to the target word in different contexts. Vocabulary for the stories has been chosen from a selection from the Saxon Mathematics Curriculum and are grade appropriate.



### **Intervention Procedures**

Intervention is a repeated acquisition design to determine the efficacy of the intervention in being able to concretely attribute vocabulary growth directly to this study. One storybook will be presented to the children each week over three sessions per week. Before the first session of a new storybook, a pretest mastery monitoring probe will be administered to the participant in order for researchers to gather data on baseline vocabulary knowledge before learning begins. Upon completion of three sessions of a storybook, a posttest mastery monitoring probe will be administered to the participant in order for the researcher to determine the level of vocabulary retention. Pre and posttests will consist of the researcher asking five vocabulary specific questions to the participant in a variety of contexts and demonstrations, including decontextualized, expressive, and receptive questions.

### **Location**

These interventions were conducted at the Audiology & Speech-Language Clinic at the University of Northern Colorado, or in the child's after school program in Greeley, CO. At either site, testing and interventions will be done in small, quiet rooms where listening centers can be established.

### **Tools**

A Surface Pro Tablet and noise cancelling headphones were used to administer the intervention. The books will be presented in PowerPoint template and will have audio overlay.

## **Data collection and Analysis**

A repeated acquisition design was used to determine the efficacy of the intervention. Oral responses to mastery monitoring probes were recorded on scoring rubrics developed with specific criteria for this intervention. Each participant's consent forms and baseline PPVT test, along with their pre and posttests for each story, is stored in a separate folder in a secure location.

Upon the completion of the three stories, the participant's responses on pre and posttests for each story will be examined for an increase in vocabulary knowledge across time. Participant vocabulary acquisition will be proven if individual responses on the mastery monitoring probes show a better understanding of vocabulary words in context and their definitions on the posttest when compared to responses for the same questions on the pretests for each story.

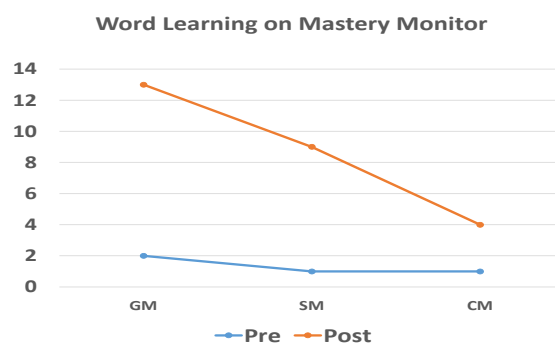
## **Results**

At this time, the intervention has not been completed with the participants of this particular study. Therefore, data and results are not available for children who are English Language Learners with language impairments. However, data has been successfully collected from a control group. This group consists of three kindergarten aged children who speak English as their first language and present no language delays.

The following table demonstrates the increase in mathematical vocabulary knowledge of three control participants for a set of fifteen words upon the completion of one storybook.

## Outcomes on Mastery Monitor (Out of 15 items)

	Pre	Post
<b>GM</b>	2	13
<b>SM</b>	1	9
<b>CM</b>	1	4



These results show a significant increase in the amount of correct responses on posttest mastery monitoring probes when compared to pretest mastery monitoring probes. This level of vocabulary acquisition is extremely promising and provides a concrete foundation for which to compare the data from the target population to in the future. These results indicate the effectiveness of this intervention in increasing mathematical vocabulary knowledge in children who are the same age as the intended participants, but who present no language impairments.

Since the participants who provided these results are already fluent in English and do not present language impairments, it is expected that the results from the participants of this study will be slightly lower due to their preliminary language challenges. Despite these present challenges, the anticipated results from the ELL population represent a steady increase of vocabulary acquisition. Even without being fully fluent in English and experiencing language delays, it is believed that learning will occur based on the intervention presenting the target words through explicit instruction and multiple exposures in a variety of contexts.

## **Conclusions and Implications**

This intervention was designed to engage at risk children in an interactive storybook that would increase their knowledge of mathematical vocabulary words by providing a range of measures in which target word learning could occur. These measures included the use of pictures, multiple examples within and outside the context of the story, and the implementation of mastery monitoring probes that tested the participants understanding of target words in decontextualized, expressive, and receptive tasks.

As detailed above, significant success in mathematical vocabulary acquisition through the use of this intervention has been shown in the control group, and the participants in this study are likely to achieve a similar level of mathematical vocabulary acquisition relevant to their baseline language scores. Once this intervention is proven effective for increasing mathematical vocabulary knowledge in English Language Learners with language impairments, it can be used as an intervention for a wide range of children presenting a variety of concerns. This intervention can be used by general educators as well as special educators in the classroom with students who are falling behind in mathematics or who need a boost of vocabulary knowledge. This intervention can be used with Speech-Language Pathologists as well to increase their clients' skills in areas such as receptive language and memory. Lastly, because this intervention does not require manipulation by an outside party, it can be used by primary caregivers to enhance their child's vocabulary knowledge or acquisition skills from the comfort of their home. No matter the setting, the use of this intervention has the potential to reduce the achievement gap by giving at-risk children the tools they need to succeed in mathematics, language acquisition, and the long road of educational successes that lie ahead.

### **Future Study**

An area of future study that would be profitable and applicable to this intervention is to examine the difference in results of this intervention being implemented with English Language Learners twice; the first time would be implemented with English only instruction, and the second time the same intervention would be implemented with Spanish only instruction. This would give an important insight into the relevance of a participants' native language in the acquisition of new vocabulary. This knowledge would enable teachers and SLP's to produce more effective interventions for specific populations.

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