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Becoming Math-Lingual: An Exploration of the MATLITLA Model for Improving Mathematics Vocabulary

Trini Lewis
California State University Long Beach
Marisol Ruiz
Cal Poly Humboldt
Jennifer Nunez
South Whitter School District, California

This exploratory action research study examined the efficacy of MALITLA (acronym for mathematics, literacy and language), a language-based intervention model for improving second-grade multilingual learners' mathematics vocabulary word knowledge. The MALITLA model contained a variety of language and literacy-based scaffolds. Data sources were collected by the classroom teacher and co-author who was experienced in conducting action research. The data sources included children's work samples, teacher observational fieldnotes, pre- and post-vocabulary assessment results, an online quiz, and a student survey. After MALITLA instruction, a comparison of the children's pre- and post-vocabulary assessment results indicated improvement in mathematics vocabulary word knowledge, and particularly for the English learners. Qualitative data also provided contextual details for supporting the assessment results. This study contributes to the literature on the importance of literacy and language scaffolds for addressing multilingual learners' academic and linguistic needs to improve their mathematical vocabulary knowledge.

Keywords: mathematics vocabulary word knowledge, literacy and language-based models, translanguaging, multilingual learners, dual language

An increasing number of children who speak a language other than English are attending United States public schools in historical proportions. One in five school-age children speak a home language other than English and in some states the percentages are greater. A number of these children are also English learners (ELs), and approximately 5.1 million ELs comprise the United States public school age population. (National Center for Education Statistics, 2022), Unlike past trends, there is an increasing population of ELs referred to as long term English learners (LTELs) who are United States citizens and not recent immigrants (Olson, 2010; U. S. Census Bureau American Community Survey, 2013). Shifts in ELs residency patterns are another prominent trend. English learners previously resided in urban centers; however, population clusters in nontraditional locales of the South and Midwest are emerging in rural areas, small cities and in suburbia. Another important feature of ELs is their diverse formal school experiences, and ranges of language and literacy proficiencies in their heritage and/or English language development.

Given the academic and linguistic variation in today's EL school-age population, most are at risk for experiencing challenges with expressing and demonstrating their content area knowledge due to language-based issues hindering their access to informational content. For example, revisions in the *Mathematics framework for California public schools* posed new linguistic and communicative demands for ELs requiring the application of English language competencies in listening, speaking, reading, and writing for demonstrating their mathematical proficiency (California Department of Education [CDE], 2013). The new standards required ELs to construct, describe and explain mathematical arguments and to critique the reasoning of others utilizing higher order cognitive skills involving analysis, evaluation, and comparison. The application of such skills is also particularly evident for problem solving. Additionally, the utilization of English language skills is further underscored in the Common Core State Standards for Mathematics (CCSM)'s Eight Standards for Mathematical Practice. Mathematical Practice No. 1 states that "Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. "Mathematical Practice No. 3 also notes that "students at all grades can listen to or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments" (Common Core State Standards for Mathematics (2010, p. 6).

The effects of English language proficiency on mathematical learning is further illustrated in ELs' standardized mathematics test scores. According to data from the National Assessment of Educational Progress, disparities exist consistently between the test scores of EL students in comparison to non-EL students. The 2019 mathematics assessment data indicated that 14% of EL students in fourth and eighth-grade performed at or above proficient in mathematics (National Center for Educational Statistics, 2020) Similarly, Smarter Balanced test results from the California Assessment of Student Performance and Progress (CAASPP) in n mathematics for grades 3-8 and grade 11 indicated low performance levels. Between 2016 to 2019, a small percentage of ELs, 12-12.6% met or exceeded expectations in demonstrating knowledge about concepts, procedures, problem solving, modeling, data analysis, and communicating reasoning (California Department of Education,2020). The historical trends in Els' low mathematical performance on national and state standardized tests directed our attention towards the improvement efforts for addressing the linguistic complexity and resulting academic challenges ELs encounter with demonstrating their mathematical knowledge. Studies indicate that with appropriate and relevant language support or instructional scaffolds, ELs can develop the linguistic communicative competency for demonstrating their knowledge to meet the CCSSM and other learning expectations (Abedi & Gandara, 2006; Avalos et al., 2013). Genesee et al. (2006) further claimed that ELs need quality language-based instruction provided by teachers with specialized knowledge, training, and expertise. To address the academic and linguistic challenges EL children encounter with demonstrating their mathematical knowledge, we embarked on an exploratory action research study to examine the efficacy of a language-based intervention model we refer to as MALITLA. The study investigated: How does application of the MALITLA (acronym for mathematics, literacy and language approaches) intervention model effect second grade Spanish-speaking bilingual children's ability to understand and apply mathematics vocabulary words?

Conceptual Background and Related Literature

The conceptual bases of the MALITLA model were drawn from three areas of research related to language learning. The design of the model was guided by: (a) the interdisciplinary literature on mathematics assessment, literacy, and language acquisition; (b) a variety of language and literacy-based scaffolds based on the theoretical work of Garcia and Lei (2014) on translanguaging; and (c) current pedagogical practices effective for improving language development. An overview of the related literature for each area follows.

Interdisciplinary Emphasis in the MALITLA Model Design

Interdisciplinary research from the fields of mathematics assessment, literacy, language and pedagogy informed the design of the MALITLA model examined in this study. For example, seminal work on mathematics assessment conducted by Abedi and Lord (2001) found that when linguistic modifications were made to 20 original NAEP standardized test items for improving comprehensible input, increased test scores resulted for all students. Their results suggested that when the burden of linguistic complexity was reduced for comprehending vocabulary mathematics terms, students were able to make better meaning of the terms for problem solving. Language ability was found to be a predictor of mathematics performance on standardized tests, both for ELs and struggling mathematics students.

Vokovic and Lesaux (2013) also examined how language ability affected mathematics learning. In a four-year longitudinal study of linguistically and ethnically diverse six- through nine-year-old children, including ELs living in high-poverty urban areas, the results indicated that language ability also predicted mathematics performance, but with distinctions unreported in earlier studies. Language ability factored into mathematics performance in data analysis/probability and geometry. However, language ability was not correlated with improved performance in arithmetic or algebraic reasoning using symbols. This finding suggests that mathematics skills that draw upon universal symbolic representations might not be affected by students' English language proficiency. Nonetheless, consensus exists in the research literature that language ability influences children's overall mathematical meaning-making abilities.

Although the evidence is clear that a close relationship exists between English language proficiency and ELs mathematical performance (Chval et al., 2015), much is still unknown about the specific types of language supports or scaffolds that are effective for improving ELs mathematical development (Olson et al., 2009). Questions remain about how to improve ELs conceptual knowledge of mathematics vocabulary words for improving effective problem solving. An ample body of literacy research on vocabulary instruction has yielded substantial evidence that vocabulary strategies are effective in helping language learners acquire academic language (Nation, 2005; McKeon & Beck; 2014; Sibanda & Baxen, 2018). Other literature in mathematics instruction suggests that content specific linguistic skills are more effective for improving mathematical knowledge than general ones (Purpura & Reid, 2016). Banse et al. (2017) noted that EL children's conceptual knowledge and understanding improved when specific practices including repetition, elaboration, vocabulary use, and teacher talk were employed.

Translanguaging Theory in the MALITLA Model Design

Given the close relationship with mathematics and language development as discussed in the interdisciplinary research, the design of MALITLA in this study also benefited greatly from the complimentary theoretical work on translanguaging by Garcia and Lei (2014). Garcia and Lei claim that multilinguals utilize their multilingual language abilities as a unified linguistic system by selecting specific language structures and features to facilitate meaning-making. Garcia and Lei's translanguaging theory marks a departure from previous bilingual theories that claim bilinguals communicate by drawing upon separate language skills from two or more distinct linguistic systems. According to Vogel and Garcia (2017), "Bilinguals have more linguistic features than monolinguals. The more extended linguistic repertoire of bilinguals, and the more complex decisions concerning selection of linguistic features they have to make in schools and society, demands recognition" (p.7). Translanguaging theory is garnering recognition and has been operationalized as a pedagogical approach with related practices for enhancing language development in more than one language. Thus, we were eager to develop and to apply translanguaging theory as a series of pedagogical practices in the MALITLA model to close the gap between language and mathematics learning for multilingual learners. The translanguaging features in the MALITLA model were designed to reduce the linguistic burden and to increase linguistic access for improving multilingual children's understanding of mathematics vocabulary words.

Pedagogical Practices in the MALITLA Model Design

Additionally, the MALITLA model components included current pedagogical practices effective for improving language development as noted in the research literature and other scholarly work., The four components include:

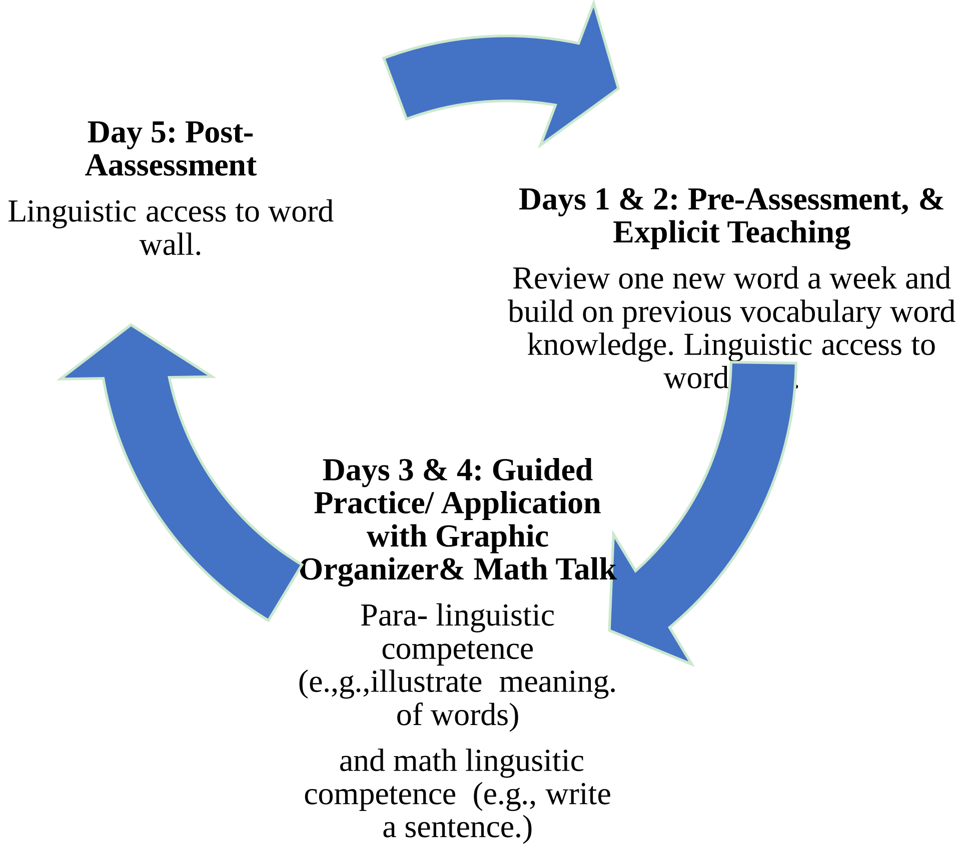
1. Provide explicit instruction allowing for the gradual release of responsibility (Pearson & Gallagher, 1983) for learning from the teacher to the student,
2. Utilize vocabulary building literacy strategies (LaBrocca & Morrow, 2016; McKeown & Beck, 2014),
3. Engage students in translanguaging mathematics talk with heritage language and tsecond language listening and speaking opportunitites for supporting cognition and meaning-making (Garcia & Wei, 2014; Robertson & Graven, 2019) involving repetition, elaboration, and mathematical vocabulary usage (Banse et al., 2017; Huffered-Ackles et al., 2004),
4. All instruction and student learning is grounded in authentic listening, speaking, reading, and writing mathematic activities (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

MALITLA Model Instructional Components and Procedures

In planning the intervention, we identified six mathematics vocabulary words that appeared on a number of different test items from the iReading Classroom Mathematics program including the diagnostic, mid-unit and end-of-the unit examinations. Although the six mathematics vocabulary words were only in English, we included the Spanish equivalents to facilitate translanguaging for improving meaning making since the bilingual participants spoke Spanish and English. The mathematics vocabulary words were: (a) matriz/array, (b) columna/column, (c) fila/row, (d) par/even, (e) impar/odd, and (f) repetida/repeated sum.

The MALITLA intervention model was implemented over a six-week period, five days a week and separated into two three-week cycles. Cycle 1 occurred during the first three weeks and focused on the first set of vocabulary words (i.e., matriz/array and columna/column; fila/row). Cycle 2 occurred for another three-week period and focused on the second set of vocabulary words (par/even, impar/odd and repetida/repeated sum). Although Cycles 1 and 2 targeted a different set of mathematics vocabulary words, the same MALITLA instructional components were utilized. Figure 1 illustrates the recursive nature of the MALITLA model for Cycles 1 and 2 and the daily breakdown of instructional and assessment activities.

Figure 1
MALITLA Weekly Instructional Process for Cycles 1 and 2



On Day One of each three-week MALITLA intervention cycle a pre-vocabulary assessment for measuring children's pre-existing knowledge of the first or second set of vocabulary words was administered. Similarly, at the end of each intervention cycle, a post-vocabulary assessment was completed. The post-vocabulary assessment included the same set of targeted mathematics vocabulary words from the pre-vocabulary assessment. Figure 2 notes the pre- and post-vocabulary assessments utilized to inform ongoing instruction and to measure and compare the children's developing mathematics vocabulary word knowledge.

Figure 2
Cycle 1 Pre-vocabulary Mathematics Assessment

Unidad 5 Ciclo 1 - Pre-evaluación

Nombre: ______________________________ fecha: ______________

Instrucciones: Escribe o dibuja el significado de cada palabra.

palabra	significado
matriz	
columna	
fila	

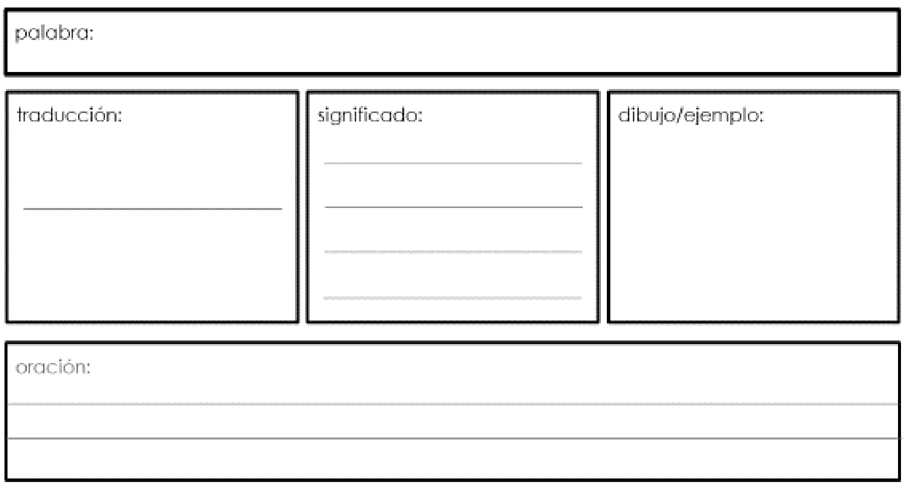
Note. The same vocabulary words were used for the post-vocabulary assessment

On Day 2, a whole-class lesson with explicit instruction occurred. The decision for explicit instruction was based on the belief that implicit mathematics vocabulary strategies, such as identifying mathematics terms in the context of a word problem were insufficient for improving EL children's mathematics development. Research suggests that students who receive explicit vocabulary instruction are more likely to acquire, understand, and retain the new target words (Blarney & Beauchat, 2011; Erkaya & Drower, 2012; Johnston et al., 2018; Juriah, 2015; LaBrocca & Morrow, 2016; McKeown & Beck, 2014; Schoen & Schoen, 2003; Seifer & Espin, 2015; Sibanda & Baxen, 2018; Winsor, 2017). Explicit instructional sequences included explanation, modeling, demonstration, illustration and reviewing the mathematics vocabulary words displayed on the classroom word wall.

On Day 3, the gradual release of responsibility for the learning transferred from the classroom teacher to the children with the application of specific mathematics content and language activities during guided and independent practice sessions. In guided practice, children participated in mathematics talk with translanguaging between their heritage language and their second language with a bilingual partner of their choosing. Mathematics talk provides discourse opportunities for supporting mathematical learning with the goal of understanding and extending one's own thinking as well as the thinking of others in the classroom (Hufferd-Ackles et al., 2004,). A graphic organizer anchored the translanguaging mathematics talk discussions (see Figure 3) for:

(a.) exchanging ideas about how mathematics vocabulary words could be individually defined in the children's own words,
(b.) identifying similarities and differences between the Spanish term and its English equivalent,
(c.) drawing an illustration, and
(d.) using the word in a sentence.

Figure 3
Graphic Organizer

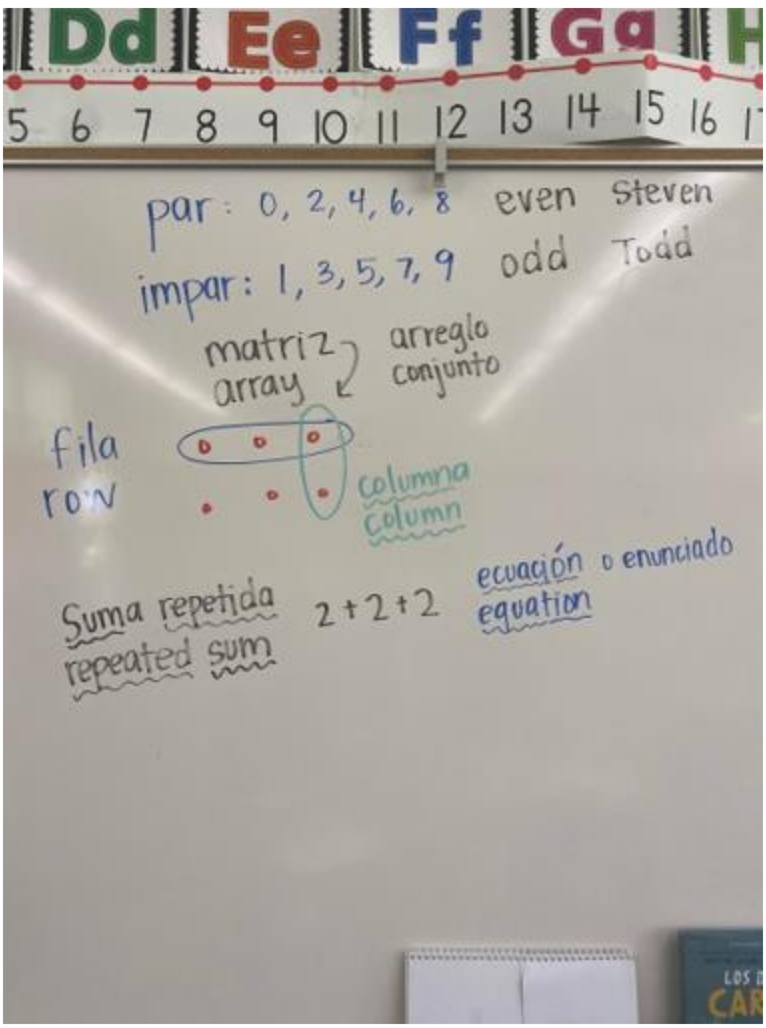


Note. Translations:
palabra = word;
traducción = translation
significado = significance
dibujo/ejemplo = illustration/example
oración = sentence

Embedding mathematics talk as a MALITLA component held promise for providing the children with ample discussion opportunities for improving their language development and mathematics vocabulary word knowledge in an authentic learning environment. Additionally, the total physical response (TPR) was employed during mathematics talk to further scaffold the children's language (Asher, 1969) and mathematics development. The total physical response method linked the children's translanguaging listening abilities with their body movements to enhance the conceptual understanding of the mathematics terms. Total physical response is also a current and effective practice for supporting their second language acquisition of vocabulary terms.

Following the guided practice activities, on Day 4, children were reconvened as a whole class to share and review the Spanish and English word equivalents for the mathematics vocabulary words. Portions of the Spanish and English words were underlined to help the children discuss the metalinguistic similarities for recognizing the cognates. As each Spanish word was introduced the children were encouraged by the teacher to draw upon their linguistic repertoire in their heritage language and/or their second language to support an accurate understanding of the mathematics vocabulary words and the underlying concepts associated with each word (see Figure 4).

Figure 4
Whole Class Explicit Instruction with Examples of Mathematics Vocabulary Words on White Board



Day 5 was reserved for administering the post-vocabulary assessment and for engaging the students with an additional assessment tool known as Kahoot! Kahoot served as an online multiple-choice quiz in a game format to motivate the children to learn the vocabulary words. During each day of the intervention, students had access to a classroom word wall for supporting learning and assessment activities.

Methods

Classroom Teacher and Action Research

This action research study included Jennifer, a co-author and a Spanish-speaking second grade dual language teacher. At the time of the study, Jennifer had taught for three years, earned two Master's degrees and was experienced in conducting action research. Jennifer noted during informal classroom observations that her EL students struggled learning mathematics vocabulary terms and performed poorly on word problems when assessed by the school district's examinations. Thus, action research appealed to Jennifer because it allowed her to identify a problem, investigate solutions, implement an intervention to address the problem, and to reflect on the results to improve her future instructional actions (Mertler, 2017; Mills, 2018). Action research was also compatible with her teaching style and responsibilities because it would not be a disruption to her students' routine learning process and classroom environment.

Upon embarking on the action research, it was important for Jennifer to address her biases to provide a credible and confirmable interpretation of the study. To this end, Jennifer engaged in a series of inquiries and comprehensive conversations known as peer debriefing with the other authors of this article to ensure the trustworthiness in the interpretation of the findings. According to Mertler (2019), peer debriefing is the act of using other professionals to help reflect on the research by reviewing and critiquing the processes of data collection, analysis, and interpretation. Jennifer also engaged in reflexivity, a practice to better understand her relationship to the research by routinely reflecting on her initial interpretations, assumptions, or biases about the study which were written in her research journal.

Participants

Jennifer's entire class of 20 second-grade Spanish-speaking dual language learners, aged 7-8 from Ross Elementary (pseudonym), California participated in this study. Ross Elementary is a Title 1 school serving grades TK-5 with a high Hispanic/Latinx student population and surrounding community. The school was comprised of 86% Hispanic/Latinx students, 6% Black students, 4% White students, and 3% Asian students. Additionally, 48% were considered ELs and 91% came from low-income families. The 20 Spanish-speaking dual second grade language learners in Jennifer's classroom represented 13 girls and 7 boys of Hispanic/Latinx heritage. They were all bilingual in Spanish and English in varying degrees of language proficiency. In accordance with California's EL classification status, one student was classified with emerging English language proficiency, four students were classified with expanding English language proficiency, and four other students were classified with bridging English language proficiency for a total of nine English learners. The remaining 11 students were classified with English only (EO) language status.

Data Sources and Analysis

The quantitative data sources analyzed for this action research study included pre- and post-vocabulary assessments. The assessments included the six vocabulary words identified from the mandated mathematics curricula as previously discussed. Three mathematics vocabulary terms in Spanish and English were assessed at the beginning and ending of each of the two cycles. Cycle 1 included the first set of three words (i.e., fila/row, matriz/array, and columna/column) and Cycle 2 assessed the second set of vocabulary words. (i.e., par/even, impar/odd, and repetida/repeated sum). The assessments were administered to the whole class and completed individually as paper and pencil activities. An end-of-the unit examination result from the school district's mandated mathematics curricula was also included to indicate a change in the children's overall mathematics scores, but the assessment results were not analyzed because they were beyond the scope of measuring the children's mathematics vocabulary development. However, the pre- and post-vocabulary assessment scores were analyzed using frequency analysis to identify the percentages of children who improved or did not improve their mathematics vocabulary knowledge. Kahoot, an online quiz platform, along with a Google generated student survey completed the data collection sources.

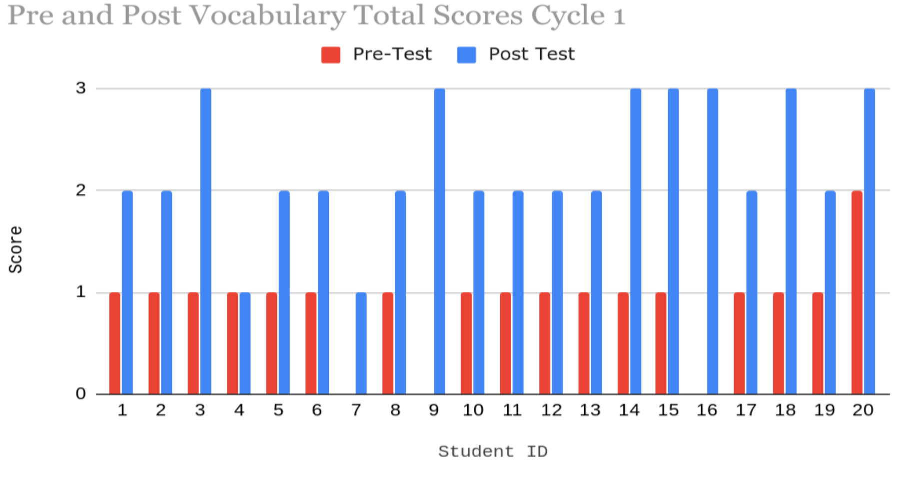
The qualitative data sources included Jennifer's field notes. In her field notes, Jennifer wrote her classroom observations about the students' translanguaging discourse interactions with their peers, the children's behaviors during assessment time, and her impressions about the application and effectiveness of the MALITLA model for improving the children's mathematics vocabulary development. A graphic organizer was another data source for examining the children's conceptual knowledge and application of the mathematics vocabulary words in their heritage language and their second language during oral and written discourse activities. The qualitative data sources were coded and three themes were identified related to: (a) the children's translanguaging interactions during mathematics talk; (b) the children's behaviors during assessment time; and (c) the children's conceptual understanding of the mathematics vocabulary words in Spanish and English as demonstrated in oral and written discourse activities. The variety of data sources facilitated the triangulation of the findings for ensuring the trustworthiness of the data analysis and the study's interpretation.

Findings

Cycle 1 Results

The Cycle 1 individual scores for the pre- and post-vocabulary assessment results are illustrated in Figure 5. The pre-vocabulary assessment scores averaged 0.9 out of 3 possible points (one point for each vocabulary term) with 16 students scoring 1 point and one student scoring 2 points. No student received a perfect score and three students scored 0 points (i.e., #7-English learner, #9-English only, and #16-English learner). The children's post-vocabulary assessment scores averaged 2.25 out of 3 possible points. Two students scored 1 point, 11 students scored 2 points, and seven students scored the maximum of 3 possible points. The pre-vocabulary assessment scores indicated that 18 out of 20 students, or 90%, improved their post-vocabulary assessment scores in comparison with their pre-vocabulary formative assessment scores. Additionally, nine English learners (#7, #10, #11, #12, #13, #15, #16, #18, and # 19) also improved their post-vocabulary assessment scores by 1.4 points in comparison to their pre-vocabulary assessment scores.

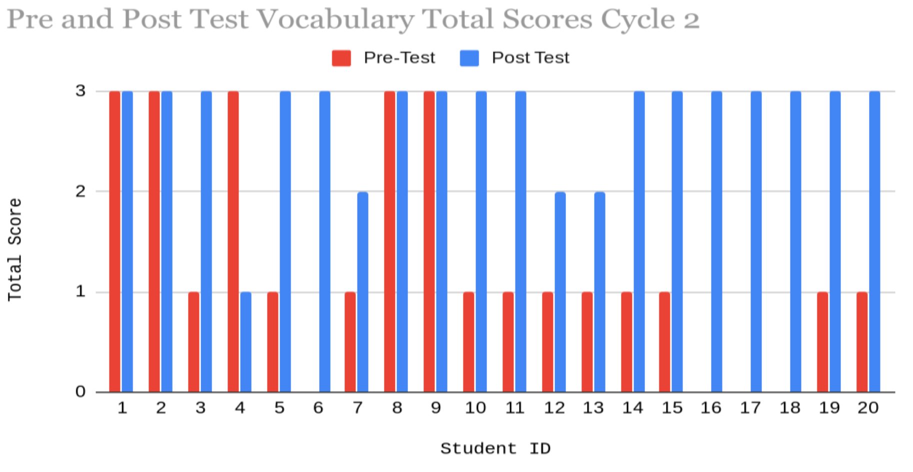
Figure 5
Cycle 1 Pre- and Post-Vocabulary Assessment Result



Cycle 2 Results

The Cycle 2 pre-vocabulary assessment scores as illustrated in Figure 6 indicated an average score of 1.3 out of 3 possible points. Eleven students scored one-point and five students scored 3 possible points. Three other students (English learners # 6, # 17, and #18) scored 0 points and student (English learner #16) was absent on the day of the pre-vocabulary assessment and did not complete the assessment. The post-vocabulary assessment average score was 2.75 and 16 students scored the maximum of 3 possible points. Three other students (#7, #12, and #13) scored 2 points and the remaining student (#4) scored 1 point.

Figure 6
Cycle 2 Pre- and Post-Vocabulary Assessment Resul



Pre- and Post-Vocabulary Assessment Results

Overall, 11 students, including nine ELs improved their Cycle 2 post-vocabulary assessment scores in comparison with their pre-vocabulary assessment scores. Since five students (#1, #2, #4, #8, and # 9) scored 3 maximum points on their Cycle 2 pre- vocabulary assessment they were not counted in the sub-set of students showing improvement. Students #6, #16 (English learner), #17, and #18 (English learner) also demonstrated significant progress and were able to define correctly all three mathematics vocabulary words, even though they did not demonstrate any knowledge of the mathematics vocabulary words on the Cycle 2 pre-vocabulary assessment and previously scored zero points. We speculate that the mathematics words, par/even and impar/odd were vocabulary terms that the students were exposed to previously in their Spanish language iReady Classroom Mathematics workbooks and in the digital text prior to the intervention, which might have contributed to the increase in their scores. It is also important to note that the pre-published iReady Classroom Mathematics mid- and end-of the-unit assessments were in Spanish and the diagnostic assessments were in English.

The Role of Translanguaging

Completing assessments in two different languages might have been very problematic for some of the students because of the ranges in their heritage language and English language proficiencies. However, the translanguaging discourse opportunities inherent in the MALITLA model might have also contributed to higher scores because the children were able to access their Spanish and English language skills as a unified linguistic scaffold for enhancing their mathematical word knowledge. Qualitative data sources suggest the translanguaging mathematics talk opportunities with listening, speaking, reading, and writing activities uniquely supported the children's accurate understanding of the mathematics vocabulary words and the underlying concepts associated with each word. For example, Jennifer's field notes (2-12-2) indicated the emergence of student-centered discussions during Cycle 2. One student, Miguel (pseudonym) stated that par is "2, 4, 6; it is like my two shoes". Es como decir –"mis dos ojos", "mis dos manos", "my two legs". Another field note (2-18-21) mentioned that during a whole class explicit instructional sequence a small group of children mentioned that counting by two means "like combining 2 eyes with someone else and now we have 4 eyes".

During the question/answer exchanges in the whole class explicit instructional sequences and the partner activities in guided practice, Jennifer observed that the students recorded notes about their own understanding of the mathematics words on the graphic organizer without her direction or guidance (Fieldnote, 2-12-21). Additionally, Google student survey results confirmed that the illustrations drawn on the graphic organizer used during the translanguaging mathematics talk activities was one of the most valuable scaffold learning activities. The word wall was also noted as valuable in preparing for and completing the assessments. Employing a translanguaging approach with related literacy and language scaffolds provided enhanced access to a unified linguistic scaffold for improving the children's mathematical vocabulary knowledge in both Spanish and English.

In sum, a comparison of the Cycle 1 pre- and post-vocabulary assessment scores indicated that 90% of the students improved their mathematics vocabulary knowledge. However, the Cycle 2 comparison of the pre- and post-vocabulary assessment scores indicated 25% of the English Only (EO) students (#1, #2, 4, #8, and #9) did not demonstrate any improvement in their performance. Jennifer's field notes observations about the children's interactions during the assessments indicated a variety of off-task behaviors (e.g., appearing bored and not attempting to complete the assessment) exhibited by some children which might have affected their performance on the Cycle 2 formative assessments (Fieldnote 2-19-21).

Discussion

Although the end-of-the-unit assessment results were not a focus of this discussion because of the difference between the test items with the pre- and post-vocabulary assessment items, the end-of-the unit assessment results demonstrated that the children's overall mathematics scores indicated a 20% overall improvement. This finding reflects research by Abedi and Lord (2001) that suggests when the linguistic burden is reduced for children, including ELs, their performance on mathematics assessments can improve. In light of such findings, several MALITLA components warrant special discussion.

Importance of Consistent Literacy and Language Scaffolds in Mathematical Instructional Routines

The systematic application of the MALITLA model provided 55-60 instructional minutes each week with activities embedded with literacy and language scaffolds. In a study conducted by Labrocca and Morrow (2016), routine instructional scaffolds such as an ongoing word wall were found to have a positive effect on children's vocabulary acquisition. As mentioned previous, the students had continuous access to the word wall during classroom activities and during the assessments. Continual access to the word wall might have been an important factor for improving the children's overall mathematics performance on the district mandated assessments.

Translanguaging during Mathematics Talk

Students who have a shared and developed linguistic system are better able to communicate their mathematical ideas, thoughts, and conceptual knowledge. The incorporation of translanguaging during mathematics talk discussions provided the children with opportunities to use their heritage language and their second language linguistic systems to support teacher-centered mathematics talk during explicit whole-class instruction and student-centered mathematics talk in guided practice during partner activities with the graphic organizer. The graphic organizer was another example of a literacy and language scaffold that was consistently used during translanguaging mathematical talk discussions.

The translanguaging mathematics talk also facilitated the transferring of the responsibility for learning to the students as discussed by Pearson and Gallagher (1983) and Garica and Wei (2014). During explicit instruction with the whole class, Jennifer asked higher order thinking questions in Spanish and English. For example, when discussing the graphic organizer, Jennifer asked, "How would you describe this term to a Kindergartener?" "What can you draw to represent the term?" Garcia and Wei (2014) noted that translanguaging requires learners to take control of their language practices to access texts and knowledge, and in the process, the teacher no longer needs to preserve their authority role. The translanguaging mathematics talk opportunities to associate the vocabulary words with student generated familiar concepts in a variety of activities appeared to be another effective component of the MALITLA model, given the improved Cycle 1 and Cycle 2 post-vocabulary assessment scores. According to Nation (2005), Blarney and Beauchat (2011), and Winsor (2007), when students develop and record their understanding of targeted vocabulary words through self-generated examples, increases in their vocabulary acquisition result.

Games and Improved Engagement in Mathematics Learning

Another MALITLA component that appeared to be effective for contributing to the increased post-vocabulary assessment scores was the online Kahoot assessment game activity. According to student survey results, Kahoot had a high level of student interest and engagement and appeared to promote intrinsic motivation for learning the vocabulary words.

Conclusion

The results suggest that the MALITLA model components were effective for improving the students' conceptual knowledge and application of the mathematics vocabulary words in instructional and assessment activities. The MALITLA components functioned to introduce, review, practice, apply and assess the words. The findings yielded from this examination challenge the belief that mathematics is a universal language (Adams, 2003; Morin, 2010; Rubenstein & Thompson, 2002) that does not require language supports or scaffolds for bilingual, including English learner's mathematical meaning making. The findings also reflect the research literature informing this study that if children encounter word problems with unfamiliar mathematics vocabulary terms due to limited English language proficiency, demonstrating their mathematical knowledge might be compromised, particularly on assessments. This study contributes to the literature on the relationship between language proficiency and mathematical learning and confirms the significance of a language-based approaches with scaffolds to support multilingual children's mathematical competencies.

We contend the MALITLA intervention model effectively addressed the students mathematical and linguistic challenges for improving their mathematics vocabulary word knowledge; however, the MALITLA model might benefit particular dual language learners instead of others. For example, the English learners demonstrated overall improvement on the pre- and post- vocabulary assessments, but 25% of the English only children showed no improvement in learning the mathematics vocabulary as indicated in the comparison of the Cycle 1 and Cycle 2 pre- and post-vocabulary assessment scores.

Although we were able to make comparisons between the pre- and post-vocabulary assessment scores we were unable to provide a cross-comparison between the vocabulary and the end-of-the unit assessment scores. The school districts mathematics curriculum did not provide vocabulary assessments and a cross-comparison of the scores between the assessments was not possible. Future research might consider utilizing compatible assessments for the cross-comparison of scores. Additionally, this study did not include a treatment and control group. Future research needs to consider including a greater number of participants with an experimental design for making comparisons with statistical testing to ascertain if the MALITLA model benefits some multilinguals more than others.

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Authors:

Trini Lewis
California State University Long Beach
Email: trini.lewis@csulb.edu

Marisol Ruiz
Cal Poly Humboldt
Email: marisol.ruiz@humboldt.edu

Jennifer Nunez
South Whitter School District, California
Email: Jennifernunez13@gmail.com