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Examining the Effect of the Think-Aloud Instructional Strategy on ELL Student Performance in Middle School Mathematics Classrooms

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ACCEPTANCE

This dissertation, "EXAMINING THE EFFECT OF THE THINK-ALOUD INSTRUCTIONAL STRATEGY ON ELL STUDENT PERFORMANCE IN MIDDLE SCHOOL MATHEMATICS CLASSROOMS," by PHANI DUGGIRALA, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Education, in the College of Education & Human Development, Georgia State University.

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EXAMINING THE EFFECT OF THE THINK-ALOUD INSTRUCTIONAL STRATEGY ON ELL STUDENT PERFORMANCE IN MIDDLE SCHOOL MATHEMATICS CLASSROOMS

By

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Under the Direction of Dr. Pier A. Junor Clarke

ABSTRACT

This research study was based on Vygotsky's learning theory, the Zone of Proximal Development (ZPD). The Think Aloud strategy provides an effective scaffolding technique that is advocated in Vygotsky's conceptualization of ZPD. This study examined the effect of the think-aloud instructional strategy using academic language and problem-solving thought process on English Language Learners' student performance with solving word problems when teachers implement the protocol in middle school mathematics classrooms. This empirical study utilized a quantitative single-case research design for data collection and data analysis. The data collection occurred during the concurrent learning model due to the COVID-19 pandemic. In the single-case research study, the data were analyzed using the multiple baseline design composed of a baseline without think-aloud and treatment with the think-aloud strategy. The multiple baselines revealed seven trends, including task performance, academic language usage, a proportional relationship between task performance and academic language usage, gender differences, speaking vs. writing, the complexity of the content, and learning model in the pandemic. The findings from data analysis of various statistical measures revealed that the think-aloud approach positively impacted ELLs' problem-solving performance and academic language usage in multiple ways. The results were analyzed along with the study's potential limitations to make recommendations for future research studies.

KEYWORDS

Academic language, Problem-solving thought process, Think-aloud instructional strategy

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DEDICATION

I dedicate this dissertation to my dear husband, Surya and my two precious daughters, Soujanya and Aishwarya.

I Love you always

This dissertation is also dedicated to my late father, Kameswara Rao Gonella, and my mother, Kameswari Gonella, who always believed in education and provided my brothers and me with post graduate education.

You are in my heart forever

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ABBREVIATIONS

ACCESS	Assessing Comprehension and Communication in English State-to-State
DDA	District Developed Assessment
DL	Digital Learner
ELL	English Language Learner
ESOL	English to Speakers of Other Languages
F2F	Face-to-Face
IRB	Institutional Review Board
NCTM	National Council of Teachers of Mathematics
WIDA	World-class Instructional Design and Assessment
ZPD	Zone of Proximal Development

CHAPTER 1 INTRODUCTION

"Mathematics instruction that disregards students' diverse out-of-school mathematical knowledge and experiences is undemocratic and is simply another form of inequitable, subtractive schooling."

--- Crystal A. Kalinec-Craig

American public schools serve diverse learners with a variety of native languages and cultural backgrounds. The rapid increase of English language learners (ELLs) in schools poses a challenge for all teachers (Barrera et al., 2006; Cardimona, 2018; Hur & Suh, 2012; Willner et al., 2008). One of the primary foci of the U.S education system is to ensure the valid measurement of mathematics skills for students who are not proficient in the English language (Martiniello, 2008). Students who learn mathematics in a language other than their home language face many challenges in learning mathematics (Kalinec-Craig, 2017). To account for these challenges while measuring data, specific questions must be considered. How valid are these assessments to measure ELLs' academic skills? How can we reform the curriculum and assessment to help ELLs to succeed? How can educators develop ELLs' academic language proficiency?

Assessment inequality for ELLs in mathematics education is a significant issue in the U.S education system (Brown, 2005; Newkirk-Turner & Johnson, 2018). Therefore, establishing assessment equity is very important for ELLs' academic success who are also culturally and linguistically diverse students. There are chronic achievement disparities and achievement gap trends even before the No Child Left Behind Act of 2001 (Polat et al., 2016; Willner et al., 2008). There are over five million ELLs in U.S. schools, and these are the students whose first language is not English, but they are in the process of learning English (Pettit, 2011). With the growing number of ELLs in American public schools, not only are the student demographics changing but also ELL teachers are challenged to teach these children effectively for both language development and content understanding (Castellano et al., 2016; Pettit, 2011). National Research Council (2000) stated that an assessment could not provide valid information about students' knowledge and skills unless the language barrier could be shown to prevent students from showing what they know and can do (Martiniello, 2008).

Equity in Mathematics Education

Equity in education is crucial for the academic success of diverse learners in the American education system. Equity in education can be defined as providing equal educational opportunities and educational adequacy for all races to meet the cultural and linguistic needs of all students (Muhammad, 2020; Unterhalter, 2009). Promoting equity in teaching and learning plays a significant role in improving student achievement in U.S. schools. Several instructional practices can help teachers orient students toward a pedagogy that promotes equity for all learners who bring diverse needs and mathematical experiences (Kalinec-Craig, 2017; Martinez et al., 2010; Unterhalter, 2009). Bilingual education is one of the solutions to promote equity in the linguistically diverse populated American schools. There are several bilingual programs available in American schools: bilingual developmental programs, two-way (bilingual) immersion programs, foreign language immersion, and heritage language programs. Bilingual education teaches academic content in two languages, both in a native language and the second language, which helps ELLs understand the content. Learning and applying mathematics is an essential experience for bilingual students in their everyday lives. However, students' out-of-school languages are often not recognized or valued (Dominguez, 2011). A mathematics teacher's focus is primarily on ELL students' mathematics skills, often overlooking the extracurricular experiences these children might bring into their mathematics classrooms.

While many ELLs perform well in academic activities and assessments, the vast majority of ELLs struggle with academic achievement on state standardized testing (Newkirk-Turner & Johnson, 2018; Polat et al., 2016). One factor that might impact academic achievement is their lack of academic language mastery in English (Hur & Suh, 2012; Willner et al., 2008). According to Nagy and Townsend (2012), "Academic language is the specialized language, both oral and written, of academic settings that facilitates communication and thinking about disciplinary content" (p. 92). The ELLs who are new to this country struggle with communicating in the English language and understanding the academic language. Mathematics can be more challenging than other subjects for ELLs as mathematics content contains both languages of words and mathematics symbols (Kurz et al., 2017). When ELLs attempt to solve a mathematical word problem, they need first to understand the problem using their language skills. Then they need to find a solution using their conceptual knowledge, which is a dual-task.

Assessment items often confuse ELLs with lengthy sentences and complex words. ELL students struggle to decode those words. They may feel defeated despite their proficiency in conceptual knowledge; this may be because these assessments are created for native English speakers. As Matiniello (2008) posits, "Difficulty understanding words is related to their frequency of use" (p. 335); thus, low-frequency words on the test items slow down students' reading process, increase their memory load, and interfere with text comprehension. This can negatively impact students' self-efficacy and motivation to learn because when students face obstacles and failures, they slack in their efforts and give up quickly (Bandura, 2010). Another critical factor that impacts ELLs low mathematics performance, both in the classroom and on assessments, is teacher preparation. Novice teachers and teachers without experience and training with ELLs may not make the necessary accommodations for lessons to assist them. The lesson plan design often requires modifications to meet better the needs of ELLs in mathematics. It's beneficial to keep the language simple for ELLs. Because the complexity of the text, including word frequency, word length, and sentence length, force the reader to slow down, the misinterpretation of the problem becomes more likely, thus reducing readers' comprehension ability and impacting task performance (Kurz et al., 2017).

Instructional scaffolding (Vygotsky, 1978) plays a significant role in children's learning. According to Vygotsky's teaching theory of zone of proximal development (ZPD), teachers are required to provide scaffolding in content learning and conceptual understanding to help students achieve their learning goals (Bozkurt, 2017; Cardimona, 2018; Shabani et al., 2010; Sharkins et al., 2017). Teachers who add scaffolding components such as modeling, questioning with the wait time, breaking down the problem into pieces or steps, communicative and interactive elements help ELLs work within their zone of proximal development to solve problems successfully (Cardimona, 2018). Teachers may need to give the ELLs more opportunities for collaboration where ELLs interact with each other and with their non-ELL peers in problem-solving to enhance their language development and content learning. The National Council of Teachers of Mathematics (NCTM) standards emphasize the importance of social interaction and communication to develop a mathematical understanding (Steele, 1999). The more the students interact with their teachers and peers, the more they learn the content, building self-confidence.

Moreover, the NCTM standards identify two essential areas for students to be successful in mathematics: demonstration of mathematics problem solving and mathematics vocabulary (Cardimona, 2018). Both can be accomplished through collaborative student work. In addition, mathematics teachers are required to provide ELLs with opportunities to hear, speak, and write the academic language both in English and their home languages (Bunch et al., 2015; Dominguez, 2011; Mendez et al., 2017). Teachers may need to explicitly teach academic language in their instruction and encourage ELLs to utilize academic language by interacting with their peers.

The research indicates that ELLs need to be exposed to academic language to achieve educational equity (Martinez et al., 2010). Also, these students need to have access to high-quality education with high academic expectations regardless of their levels of language proficiency, which automatically provides them an increase in educational opportunities (Kalinec-Craig, 2017; Martinez et al., 2010). Also, teachers are required to give bilinguals the chance to use both languages to solve mathematics problems to develop students' content knowledge and mathematics competence (Dominguez, 2011; Mendez et al., 2017). ELLs feel more comfortable in the problem-solving process if they communicate in their native language with their bilingual peers and bilingual teachers. As NCTM positions, educators need to identify and remove language-based barriers and provide ELLs with appropriate assistance in learning mathematics (Celedon-Pattichis, 2004).

Teacher-education programs could be augmented to improve teachers' skills and expertise to understand ELLs' mathematical and linguistic needs better and to develop plans for more powerful instruction (Kurz et al., 2017; Nagy & Townsend, 2012). Research shows that teachers from other countries and teachers who are experienced in teaching ELLs are more optimistic about teaching ELLs. They are more likely to implement instructional strategies that meet ELLs' needs (Jao, 2012; Pettit, 2011; Slavit & Ernst-Slavit, 2007). NCTM suggests that the mathematics pedagogy and assessment strategies should include connections to students' cultural heritage and learning styles to improve ELLs' academic achievement (Celedon-Pattichis, 2004).

My Journey with English Language Learners

I was born and brought up in a small town in India. I completed my primary and secondary, undergraduate, and post-graduate education in my country. I moved to the United States 23 years ago. I am a bilingual woman who can speak one native language, Telugu, one Indian national language, Hindi, and English fluently. Although I completed my education in English, we used our mother tongue in peer interactions both in schools and colleges. Although I've spoken English very well since childhood, my speech was not very fluent when I moved to the U.S., and I struggled to understand the American accent and vice versa. After I had two children, I started my teaching career as a substitute teacher in American public schools to examine this country's school system and students. I continued this job for four years, and eventually, I picked up a slight American accent, and students started to understand my accent.

During the substituting journey, I came across several ELLs who paid me more attention and interacted with me very well; perhaps I am also a culturally and linguistically diverse woman. I worked as a long-term substitute and instructed several mathematics and science lessons to my students. Since I worked in the same school district that I am currently working in, I have experienced interactions with several students with diverse backgrounds. I started loving this job and decided to get certified to serve these culturally diverse students as a full-time mathematics teacher. I completed my Master of Arts in Teaching at a university to get accredited.

I began my teaching career in 2012 at a Title I school, Hope Middle School, as a mathematics/science teacher. I also completed my ESOL endorsement program in my first year of teaching, which provided me with opportunities for working closely with ELLs. This program taught me more about how cultural and linguistical differences make a difference in ELLs' performance and attitudes in the classrooms. These 15 years of teaching experience with ELLs inspired me to pursue adequate research on ELLs' strengths and challenges and how teachers can help them develop their essential mathematical skills and language succeed in mathematics classrooms. As an Indian-born American citizen and a bilingual teacher, I have always been compassionated to my students' struggles with the English language and their performance with word problems in my mathematics classroom.

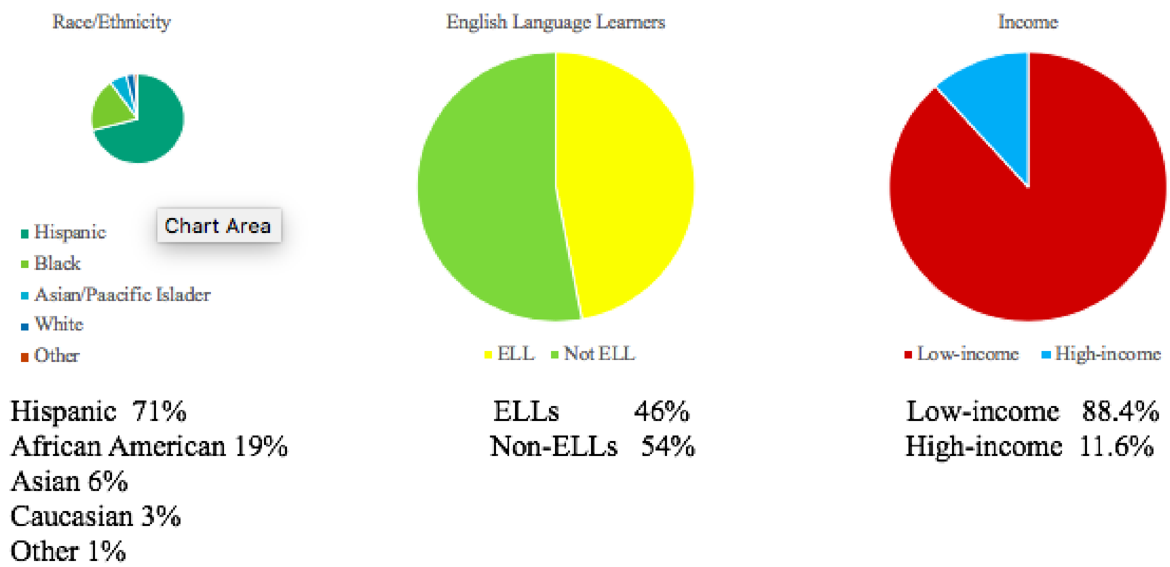
The Title I school in which I work at consists of a highly diverse population, among both the students and staff. A Title I school is a school with high percentages of children from low-income families. Part A of the Elementary and Secondary Education Act (ESEA) assists these schools in ensuring that all children can meet challenging state academic standards (Hooker, 2013). My school serves 88.4% of students from low-income families, 46% ELLs, and 54% non-ELL population. This school is also populated with 71% of Hispanic students, 19% of African American students, 6% Asian/Pacific Islander students, and 3% of Whites, and 1% of other races. Figure 1 presents the demographics of this school.

The school leaders in charge of ELLs' scheduling place the students in the classrooms based on their Assessing Comprehension and Communication in English State-to-State (ACCESS) test scores from previous years or with teacher recommendations. The ACCESS test assesses students' progress in learning English from kindergarten to grade 12. According to World-Class Instructional Design and Assessment (WIDA), seven domains assess ELLs' language proficiency, including listening, speaking, reading, writing, literacy, oral language, and comprehension. The composite scores are the combined scores of all of the above domains. The ACCESS test scores range from level 1 (entering) to level 6 (reaching).

My school serves various levels of students by utilizing multiple classroom models. An integrated classroom serves heterogeneous students of general education students and ELLs with ACCESS scores higher than 3.0 with an ESOL endorsed teacher. The ELLs get minor modifications in this classroom, such as scaffolding, small group instructions, visuals, word banks. The ELL push-in class serves both general education students and ELLs with ACCESS scores ranging between 2.0 to 3.0 with a general education teacher and a co-taught English to Speakers of Other Languages (ESOL). These students get test accommodations and instructional modifications based on their needs. Finally, a direct ELL classroom serves only ELLs who are either new to this country or students with ACCESS test scores below 2.0 with an ESOL teacher. In this classroom, the ESOL teacher teaches in both languages, and students can speak both languages. The ELLs in push-in classes and direct classes can use the word-to-word dictionary when they need them on the classroom assignments and assessments. The accommodations, modifications, and student placements based on their ACCESS scores might vary depending on student needs and vacancies in the classes.

Figure 1

Demographics of Hope Middle School



In my eight years of teaching experience, I confronted ELLs' academic struggles in classroom activities and assessments. In my view, the main obstacle to ELLs' academic success is low self-esteem due to low-English language proficiency. The insufficient English interpretation skills of ELLs perhaps holds them back from participating in the classroom and performing well on standardized testing. Based on my experience, students in integrated classrooms are inclined to struggle with academic language and vocabulary even though they hold high ACCESS test scores. The lack of English language and content vocabulary may be a cause that prevents them from attaining the essential conceptual understanding that is required to be successful in their mathematics classrooms. These immigrant students often feel disconnected from their learning and face limited opportunities to learn mathematics (Kalinec-Craig, 2017; Martinez et al., 2010). Often, engaging these children in classroom activities might be challenging for teachers in an integrated classroom where only one teacher can support diverse learners.

As a researcher, I view the issue of ELLs' low performance on the assessments through the lens of Vygotsky's theory of social constructivism. Egbert and Sanden (2014) defined social constructivism as "the construction of knowledge [as] viewed specifically as a result of our experiences with human practices that prompt understanding, which inherently varies from individual to individual" (p. 22). Student learning in a mathematical classroom may be improved when students acquire precise academic language by listening to the teacher's language usage in their delivery of the lesson and construct their own knowledge by interacting with peers in their collaborative learning process. Also, Vygotsky's theory of social constructivism says that teacher needs to provide students with guidance in problem-solving by modeling and scaffolding to assist them in content understanding. An ELL's performance on assessments depends on what test items ask and how they can successfully represent what they know (Kopriva, 2014). Although these children are strong in mathematics content and skills, they may have some challenges to perform well on the assessments if they have difficulty understanding the problem due to a lack of academic language mastery. However, these children may perform well either with test modifications or if the assessments were given in their first language.

Based on my experience with teaching ELLs in an integrated classroom, several factors impact ELLs' weak performance. These include lesson design that doesn't account for their cultural and linguistic needs, academic language not being taught explicitly, and the absence of modeling the problem-solving process to students. As a novice teacher, I always planned the same instruction for all of my students because I was unaware of how differentiated instruction can benefit diverse learners. As Cardimona (2018) states, teachers often individualize instruction for one subgroup of students rather than differentiating instruction, which causes boredom and frustration for struggling learners. Also, teachers set the same academic expectations for all students without thinking about these ELLs' needs and judging their academic abilities.

As a bilingual mathematics teacher with English as my second language, I empathized with my ELLs' struggle with English. It impacted their understanding of instruction, academic vocabulary, completing the classroom assignments with proficiency, and performing well on the word problems. Also, I understood why my ELLs showed the least participation in whole group or small group discussions; they lacked confidence in speaking the English language. However, they were strong in mathematics content, and they could perform well if the content material were in their first language. Eventually, I added differentiated instruction to meet the needs of my ELLs in my later years. This differentiated instruction included making simple modifications to questions, incorporating wait time, and cooperative small-group activities, letting them use English to Spanish dictionaries (Cardimona, 2018). Eventually, this improved the ELLs' participation, mathematics vocabulary acquisition, and independent problem-solving abilities.

Another factor that negatively affected my ELL student performance was the loss of content instruction due to pulling ELLs out of their content classes for English language instruction and ACCESS testing. Also, some teachers who teach direct ELL classes think that ELLs cannot learn content at the same pacing as native-English speakers, so they slowed the pacing for these children who put them at a disadvantage academically. Moreover, several students who are new to this country are often placed by the school administrators in the lower-level mathematics courses based on their language proficiency levels but not their mathematics abilities. This issue prevents ELLs from learning at the level at which they are capable of learning. Researchers suggest that student placement decisions be made based on their content knowledge and abilities in their first language to provide ELLs with the right opportunities that they deserve (Kalinec-Craig, 2017; Martinez et al., 2010).

In many schools, the ELLs are exposed to lower academic expectations and tracking practices regardless of their content abilities. Besides, many of them are not taught at the same depth of knowledge because most teachers may think it is difficult for them to learn content material at a higher level due to their low language proficiency. I agree with Martinez et al. (2010) that ELLs' student performance on standardized assessments reflects their educational experiences in the school and classroom as well as lack of academic opportunities. If teachers provided more opportunities for ELLs based on their mathematical skills and abilities, rather than on their language proficiency in English, ELL performance on the assessments would improve dramatically (Martinez et al., 2010).

In my teaching experience, several ELLs performed very well in classroom activities with scaffolding. Moreover, some of these students are highly motivated with high skills, but they needed scaffolding to overcome their language comprehension deficiencies. Immigrant students who are new to this country bring mathematical algorithms and symbolic notation from their home countries. However, teachers may consider assessing what students already know and what they can perform in their first language before making a judgment about their content abilities. Kalinec-Craig (2017) argues, "Mathematics instruction that disregards ELLs diverse out-of-school mathematical knowledge and experiences is undemocratic and is simply another form of inequitable, subtractive schooling" (p. 3). It is beneficial for ELLs if teachers encourage them to share their past experiences with mathematics to improve their classroom participation and confidence in speaking. Such student participation could be done by promoting bilingual education in the classroom using the Google translator for complex and academic vocabulary, providing a Spanish dictionary, and using Khan Academy Spanish version videos. As a bilingual person, even after living in the U. S. for more than 20 years, I am more comfortable using my native language in most of my daily activities. I use my first language to count, think about steps in solving any problem, and explain things to myself. The ELLs who get to use both languages in learning the content may improve student participation in mathematical discussions (Dominguez, 2011; Mendez et al., 2017).

Moreover, pairing up a monolingual with a bilingual student in problem-solving could benefit both students' mathematics performance in a diverse classroom. The bilingual student can help with reading and comprehending the problem given. The monolingual student can help with planning and solving the problem using their mathematical skills or vice versa. This approach could be the effective strategy for mutual participation in the problem-solving process. Bilingual students strategically use both languages to maximize their performance in solving challenging mathematics problems (Dominguez, 2011; Martinez et al., 2010; Mendez et al., 2017). Also, via in-class discussions or group discussions, encouraging ELLs to speak in either language is essential in developing their communication skills in mathematics (Dominguez, 2011).

Teachers may need to help ELLs develop academic vocabulary in their first language for mathematics and notice students' perceptions of language, culture, and mathematical competence during mathematics discussions (del Rosario Zavala, 2017; Dominguez, 2011; Roberts & Bryant, 2011). Therefore, as a bilingual teacher, I could understand my ELLs' comfort in solving problems and explaining the reasoning in their native language. I always believed in implementing a heterogeneous grouping strategy during students' problem-solving activities. This technique helped my monolingual students to perform well on the classroom tasks.

Although teachers provide several scaffolding strategies such as visuals, hands-on activities, and word banks, ELLs try to avoid classroom participation because academic language is taught only in English or because vocabulary isn't taught explicitly. Difficulty understanding the language, low self-esteem, and poor performance may result from the lack of classroom opportunities to ask questions or answer the questions in their first language, unfamiliar mathematical representations, or cultural differences (Truxaw & Rojas, 2014). Word-to-word dictionaries help ELLs understand academic language and watching content videos in their first language improves their mathematical competence. I have used Khan Academy Spanish version videos to enhance their academic language and mathematics vocabulary for my ELLs. However, these students are still required to take standardized testing in their second language anyway.

Although teachers who teach ELLs use modifications, these children will not get any such changes on the district or state assessments other than ELL accommodations. Therefore, teachers may be responsible for preparing these children for standardized assessments by teaching them both essential academic vocabulary and problem-solving techniques in English. However, as a linguistically diverse teacher, in my perspective, an individual doesn't need to be proficient in the English language to be successful in education; instead, they need to be skilled in the content. In order to maintain the assessment equity, the state and district assessments may need to be reformed in such a way that ELLs have the option of taking the tests in their native language in addition to English. As a researcher, I recommend the educational system to recognize the significance of creating assessments in multiple languages to help ELLs succeed academically in mathematics.

Understanding basic academic instructions in a second language is challenging and exhausting (Truxaw & Rojas, 2014). Research shows that teachers in ELL mathematics classrooms may be required to use specific instructional strategies. They include teaching the vocabulary explicitly in English and modeling the problem-solving process aloud. Also, teachers may need to encourage students to communicate in the academic language with their peers, both in their first and second language, in peer interactions, and in providing scaffolding when it is needed (Bernadowski, 2016; Bozkurt, 2017; Mendez et al., 2017). Peer interaction is perhaps vital for the development of ELLs' academic language. When learners interact with more capable peers or teachers who can teach them, they typically can achieve more than what they can learn independently (Culligan & Wagner, 2015; Shabani et al., 2010; Siyepu, 2013). Such instructional strategies may improve ELL student engagement, performance, and mathematical competence.

Statement of the Problem

Problem-solving has been a big struggle for ELLs in middle school mathematics classrooms. The issue results from a lack of academic language proficiency and conceptual understanding. Academic language is more challenging than the conversational language for ELLs because it's more abstract, contextualized, and culturally determined (Truxaw & Rojas, 2014). ELLs' performance may be impacted when they lack exposure to the academic uses of English and to teachers who explicitly teach academic vocabulary and problem-solving techniques (Martinez et al., 2010). Achievement of ELLs in mathematics has been a persistent concern in schools across the nation (Herges et al., 2017). Placing a strong emphasis on mathematics achievement was a reaction to the No Child Left Behind Act (NCLB) and Common Core State Standards (CCSS). Although ELLs have strong mathematics skills and perform at higher levels if the content is in their first language, it's challenging for them to take the standardized assessments in the English language. Therefore, teachers may need to teach ELLs academic language and vocabulary explicitly in the English language in their daily instruction to improve students' problem-solving skills and academic language acquisition.

When teachers consistently implement explicit teaching practices and collaborative learning opportunities, ELLs pick up that language and use it in problem-solving with more ease (Culligan & Wagner, 2015). Thus, teachers may need to consider implementing instructional strategies for ELLs where they get the opportunities to use diverse language functions such as descriptions, explanations, or summarizations both orally or in written responses to improve their academic language acquisition (Martinez et al., 2010). Also, teachers may be required to make simple modifications to questions, incorporate wait time, and plan collaborative small group activities so that ELLs can actively participate (Cardimona, 2018). The active classroom engagement can help them attain mathematics vocabulary and improve problem- solving skills.

Several problem-solving strategies are effective in enhancing students' problem-solving skills and academic language proficiency. Research indicates that one of the instructional strategies, think-aloud, can be an explicit teaching practice where individuals express their thoughts (Özcan et al., 2017). In this strategy, teachers model their problem-solving thought process precisely using academic language; this can allow ELLs to notice how teachers break down a word problem and organize their problem-solving through a step-by-step procedure in solving it. This thinking aloud approach may help the students improve their cognitive ability and may enhance their mathematical thinking and comprehension monitoring skills (Ghaith & Obeid, 2004; Ness, 2016; Tinker Sachs, 1989).

Purpose of the Study

The administrators of Hope Middle School have been enforcing the usage of the think-aloud instructional strategy in mathematics instruction for the past two years. Every mathematics teacher in the school is expected to teach their daily lessons incorporating a think-aloud instructional component that uses essential academic language and problem-solving skills. The district mathematics department believes, and research hypothesizes, that think-aloud can be an effective instructional strategy to develop students' problem-solving skills and student achievement (Montague & Applegate, 1993; Özcan et al., 2017). The main purpose of this study was to investigate the impact of the think-aloud protocol on ELLs' academic language proficiency and their performance in solving word problems in middle school mathematics classrooms. As the researcher, I aspired to examine the relationship between the think-aloud protocol and student performance when teachers implement this strategy in their mathematics classrooms.

Research Question

What is the effect of the think-aloud instructional strategy *using academic language and problem-solving thought process* on ELL student performance with solving word problems when teachers implement the protocol in middle school mathematics classrooms?

Significance of the Study

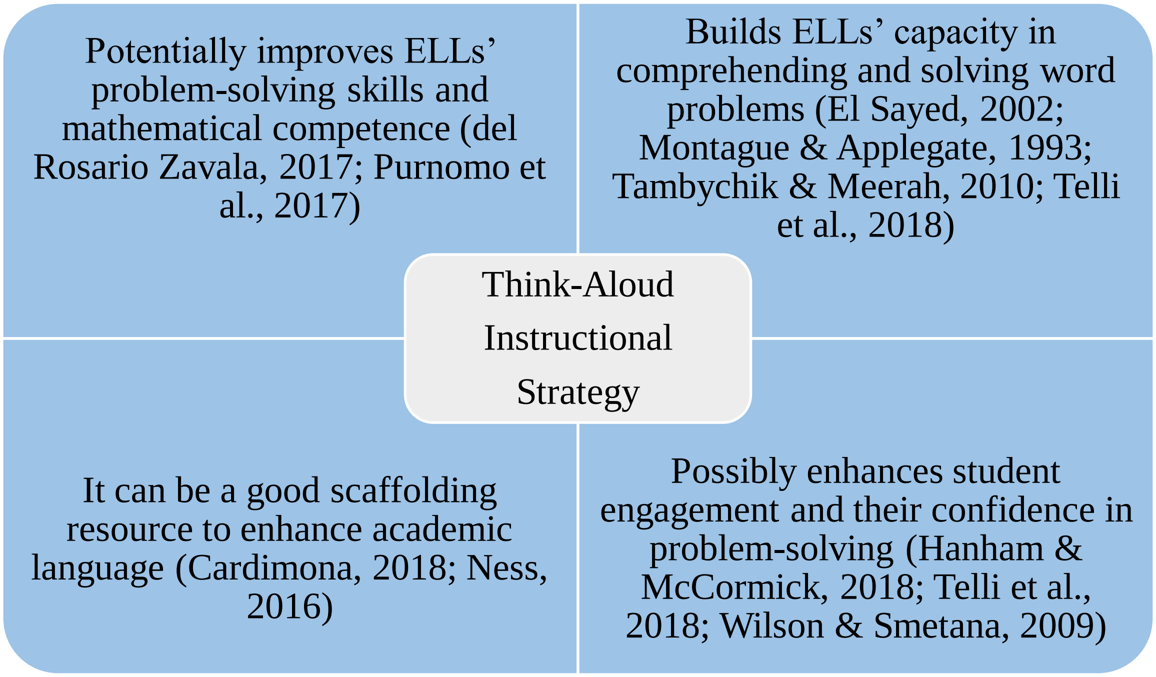
The significance of my study focused on the benefits of the think-aloud strategy for both ELLs and teachers who teach ELLs in their mathematics classrooms. The study's findings provided evidence to educators that teaching with the think-aloud instructional strategy could improve ELLs' problem-solving skills and academic language. This research study may help educators understand how the think-aloud instructional strategy can be an excellent scaffolding resource for ELLs. This study demonstrates to mathematics educators that implementing the think-aloud protocol has positive effects on ELL student performance.

Moreover, the think-aloud strategy could potentially build ELLs' capacity for solving word problems by modeling the cognitive steps of understanding the problem, planning and implementing the solution, and evaluating the process (El Sayed, 2002; Montague & Applegate, 1993; Tambychik & Meerah, 2010). Also, ELLs may improve their learning when teachers engage them in mathematics problem-solving tasks, give them opportunities to participate in class discussions, and mold them into good mathematics thinkers (del Rosario Zavala, 2017). To maintain equity in education, educators and school leaders may need to provide equal learning opportunities for ELLs' in mathematics classrooms by enhancing their mathematics skills and the vocabulary required for solving mathematical problems with confidence and mathematical competence.

Furthermore, this research study provides insight for teachers to examine how ELLs can learn mathematical problem-solving skills when teachers teach the concepts and language explicitly. This study also demonstrates that think-aloud protocol can be used as a differentiation tool for ELLs' instruction in an integrated classroom, consisting of both ELLs and non-ELLs. The study results provide evidence that teacher preparation and expertise have a significant role in delivering an effective think-aloud lesson. Finally, this study recommends school leaders to provide professional development on the think-aloud protocol to educators for an awareness of what they can do better for ELLs in improving their academic performance in mathematics. Figure 2 represents a summary of the significance of the research study.

Figure 2

Summary of the Significance of the Study



Definitions

Academic Language

Academic language is a specialized language, both oral and written, that facilitates communication and thinking about disciplinary content in academic settings (Nagy & Townsend, 2012). In other words, academic language is defined as the relationship between language and any subject area (Castellano et al., 2016).

Problem-Solving Thought Process

Problem-solving thought process is the process in which an individual expresses their thoughts while problem-solving (Özcan et al., 2017). Also, in this thought process, mathematics students verbalize their thinking through the steps as they solve a problem (Barrera et al., 2006).

Think-Aloud Instructional Strategy

A think-aloud instructional strategy is an explicit demonstration of cognition, where a teacher or a student shares their thought process while solving a mathematics problem (Wilson & Smetana, 2009). A think-aloud protocol can be a useful tool for teachers in a mathematics classroom that "allows students to stop periodically, think about their thought process, and verbalize what is happening in their minds as they read and solve word problems" (Bernadowski, 2016).

Chapter 1 Summary

Chapter 1examines the importance of equity in education for the academic success of ELLs. The rapid increase of ELLs in American schools became a challenge for teachers in providing equal educational opportunities due to their low language proficiency (Pettit, 2011). The ELLs face many challenges in a mathematics classroom in both learning the content and learning the language, which is a dual-task for these children (Kalinec-Craig, 2017). However, if teachers implement bilingual education, ELLs get opportunities to show their content abilities and apply their problem-solving skills. As a bilingual researcher, my first-hand experiences working with ELLs allowed me to understand how these young children struggle with content and the language due to low language proficiency in English. ELLs may enhance their mathematics skills if educators provide opportunities for them to use their first and second languages in the classrooms.

Promoting bilingual education may help these children and their academic achievement (Dominguez, 2011). However, all students, regardless of their English language proficiency levels, take the standardized mathematics testing in American public schools. Therefore, it is beneficial if teachers prepare ELLs with important mathematics content, academic language, and problem-solving skills in the English language.

The purpose of this research study was to examine the effect of the think-aloud instructional strategy using academic language and problem-solving thought process on ELL student performance with solving word problems when teachers implement the protocol in middle school mathematics classrooms. When teachers model solving a mathematical problem using the required language and problem-solving steps, ELLs grasp those skills and vocabulary to apply in their problem-solving (Ness, 2016). The findings of the research study may have provided insights for mathematics educators in implementing the think-aloud approach in their classrooms. The benefits may have included developing ELLs' content language proficiency, problem-solving skills, and mathematical thinking. Chapter 2 will encompass a literature review delineating the gaps in the literature concerning the benefits and challenges of the think-aloud instructional strategy.

CHAPTER 2 LITERATURE REVIEW

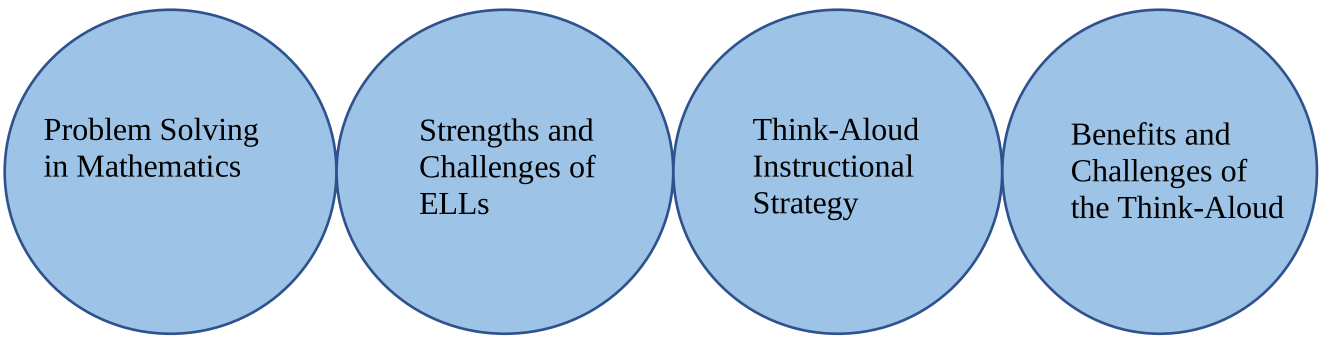
This research study's main focus was to closely examine the effects of the think-aloud instructional strategy on ELL student performance with solving word problems when this protocol is implemented in the mathematics classrooms. This chapter is a literature review of problem-solving in mathematics, the strengths and challenges that ELLs bring to the mathematics classrooms, and how the think-aloud instructional strategy is implemented in a mathematics classroom. Moreover, this chapter discusses the benefits and challenges of the think-aloud approach and the gaps in the literature. The study mainly focused on the student performance of a particular subgroup, ELLs.

Problem-solving is a fundamental process in mathematics. Several mathematics skills are involved in the process of problem-solving such as knowledge, application, and reasoning. There are four main stages in the problem-solving process: understanding the problem, developing a solution plan, implementing the plan, and evaluating the solution (El Sayed, 2002; Montague & Applegate, 1993; Tambychik & Meerah, 2010; Telli et al., 2018). However, if students do not understand the problem, they will be unable to move through the next stages. As Telli et al. (2018) state, students' performance on mathematical word problems is correlated with students' language proficiency and interrelated with their reading comprehension skills. When teachers have a better understanding of students' mathematical problem-solving skills, they can build strategies to help students progress through all of the problem-solving stages (Tambychik & Meerah, 2010).

According to Schoenfeld (2004), the National Council of Teachers of Mathematics (NCTM) proposed that the mathematics curriculum's fundamental goal is to develop problem-solving skills. Successful student learning depends on the ability to solve word problems in context. Mathematical competence depends on many factors, such as strong content knowledge, productive problem-solving strategies, and effective thinking process (Schoenfeld, 2004). Using a variety of instructional practices may potentially develop students' problem-solving skills. This aspect also has a direct effect on students' academic achievement in middle school mathematics classrooms. Figure 3 presents the outline of the literature review.

Figure 3

Outline of Literature Review



Problem-Solving in Middle School Mathematics Classrooms

In middle school, students may struggle to solve word problems, understand basic mathematics concepts, and express their thought processes during problem-solving. Özcan et al. (2017) suggest that developing students' problem-solving skills improve student understanding of mathematics and student performance. Problem solvers need to understand the problem first and develop the necessary strategies and steps to find an acceptable solution. The solution to a word problem requires the need to transform the problem into mathematical sentences and then execute the numerical computations. Research shows that middle school students have more difficulty completing the first procedural step than the other (Tambychik & Meerah, 2010). The first step involves understanding the problem by figuring out what information is given, what needs to be solved, and what mathematical concept is included. Once students can figure this out, they can proceed with the next step, the precise computation process.

Problem-solving depends on students' academic language proficiency, linguistic representations of number words, and word structures to understand the problem. In other words, if students can identify the mathematical language and vocabulary in a word problem, they will be able to comprehend the problem before planning the solution. As Telli et al. (2018) posit, students can better understand the problem if they can organize the problem with mental pictures, and this strategy is beneficial for ELLs. Moreover, conceptual understanding and procedural knowledge are essential skills in problem-solving. Students may need to apply and integrate several mathematical skills and concepts in the process of problem-solving. However, middle school students may struggle to plan and perform problem-solving strategies due to the lack of necessary mathematical skills and academic language (El Sayed, 2002; Tambychik & Meerah, 2010). Mathematics teachers may need to provide extra support and scaffolding to students, especially ELLs, to build their problem-solving capacity.

Furthermore, mathematics teachers may emphasize on computation and overlook the importance of the language skills necessary for effective problem-solving. The literacy skills essential for problem-solving are reading and interpreting the problem, planning, solving, and expressing the solution in English (Evans et al., 2017). Sometimes, students might lack these skills because they might not have been taught them explicitly by mathematics teachers, which hinders their success in their problem-solving process. As Kurz et al. (2017) postulate, successful problem-solving techniques using real-world contexts can develop ELLs' mathematics skills and content language proficiency.

Moreover, Montague and Applegate (1993) argue that the difficulty level of a mathematical problem may affect students' persistence and cognitive activity, causing student frustration and, ultimately, their abandonment of the task. Also, problems that appear difficult may cause students to shut down their cognitive resources without solving problems. Cognitive and metacognitive difficulties cause students to develop negative feelings about mathematics (Tzohar-Rozen & Kramarski, 2014). A problem solver must know how to plan, monitor, and evaluate performance, and individuals are often unaware of their own thought process. As Pate and Miller (2011) position, students' lack of attention to their reasoning and monitoring skills leads them to unsound attempts in problem-solving. The level of metacognitive thought process depends on their age and maturity; thus, sometimes, students may have difficulty focusing their verbalization in task completion (Pate & Miller, 2011).

Furthermore, low self-confidence in problem-solving may directly contribute to the development of a fear of mathematics. Middle school teachers may promote a positive attitude towards mathematics by helping students recognize how their own efforts impact their learning and achievement (Shellard, 2004). In the next few paragraphs, I discuss the factors that influence students' problem-solving performance. These factors include metacognition, comprehension, conceptual understanding, students' prior knowledge, student engagement, and motivation in mathematics classrooms.

Metacognition, also known as thinking about thinking, plays a vital role in mathematics problem-solving. Wilson and Smetana (2009) defined metacognition as the thought process of monitoring and regulating one's thinking. Expert problem-solvers organize their thought process to recover from memory, create meaningful patterns, implement the procedures effectively, and utilize self-monitoring skills to ensure successful problem-solving. Moreover, effective problem solving requires a coordinated application of various cognitive and metacognitive processes and strategies (Kurz et al., 2017; Montague & Applegate, 1993). These strategies include thinking aloud, talking aloud while writing the steps, reading comprehension, and explicit teacher modeling. Teachers may develop students' cognitive abilities by preparing rigorous instruction based on these strategies.

Secondly, comprehending the problem is a crucial step in the successful problem-solving process. Various levels of representations are involved in understanding the word problem (Voyer, 2011). Middle school students, including ELLs and non-ELLs, may have difficulty understanding the word problem due to the lack of math literacy, which is one of the main problem-solving features (Özcan et al., 2017; Tinker Sachs, 1989). Students may need fluent reading skills and mathematical vocabulary word recognition to understand what is being asked (Ulu, 2017). Although students have adequate mathematical computation skills, it's difficult for them to come up with a solution if they struggle to comprehend the text. Hence, as Tinker Sachs (1989) states, the problem-solving approach depends not only on using flexible knowledge and efficient strategies but also on reading with understanding. Once students understand what they are being asked in the word problem and decide what procedure to use that is both efficient and accurate, they will successfully solve the problems using their mathematical content knowledge.

In addition, students need conceptual understanding in problem-solving, including usage of mathematics they know, fluency with the symbolic language, and how to use the fundamental laws of mathematics (Schoenfeld, 2004). Conceptual understanding involves selecting mathematical concepts and operations that are appropriate for solving that particular mathematics problem. Fatqurhohman (2016) states that selecting of the right mathematical concepts consists of identifying and using the relevant ideas that can solve the problem.

Therefore, if students understand what is being asked in a word problem and determine the appropriate strategy and procedures to find the solution, they will strengthen their problem-solving skills. In other words, students may be successful in problem-solving when applying their procedural and conceptual knowledge (Fatqurhohman, 2016). Teachers are instrumental in this process by providing essential scaffolding techniques that enhance students' comprehension and conceptual understanding. Also, prior knowledge is vital for success in reading comprehension and problem-solving. As Tinker Sachs (1989) declared, students understand word problems better when they have previous experience and are interested in the topic of the problem. Also, students' prior knowledge helps them make associations with mathematical concepts and help them solve the problem better using that knowledge.

Moreover, student engagement and motivation are other aspects of successful problem solving and academic achievement. Students' attitudes and beliefs play a significant part in motivating students in mathematics classrooms. Students who lack motivation and confidence tend to avoid mathematical tasks or give minimal effort to solve them. Students who are enthusiastic about participating in learning tend to engage more and develop their problem-solving strategies (Herges et al., 2017; Özcan et al., 2017). Teachers may improve students' motivation with problem-solving by implementing collaborative group work where they actively engage with their peers (Hanham & McCormick, 2018; Sachs et al., 2003). Students can accomplish when they work with their peers. As Pate and Miller (2011) argue, when students get opportunities for expressing their thoughts aloud to externalize the thinking process, they are likely more engaged in the problem-solving task.

Furthermore, peer interactions can develop students' academic language usage and problem-solving performance. Students can learn problem-solving methods from higher achieving students in heterogeneous groups, which can eventually develop their mathematical thinking. Again, teachers tend to create a successful mathematics classroom if they understand students' behaviors and attitudes toward problem-solving (Telli et al., 2018). Teachers' expertise in pedagogical practices influences students' motivation. Herges et al. (2017) suggested that teachers who plan collaborative learning, such as group activities and class discussions, can help struggling students build confidence with problem-solving. Just as important is that individuals performing group work may share their motivational beliefs about their peers' capabilities (Hanham & McCormick, 2018).

Finally, critical thinking is another important factor that can influence problem-solving in mathematics. Critical thinking is crucial for problem-solving because it enables students to communicate effectively in difficult mathematical problems. Critical thinking is needed to evaluate the most effective problem-solving strategy, utilizing students' mathematical reasoning. Furthermore, critical thinking encourages students to think deeper to develop interpretation skills. As Basri et al. (2019) argued, effective mathematics instruction focuses not only on computation skills but also on critical thinking components in the analysis that promote problem-solving, such as evaluation, inference, explanation, and self-regulation.

On the other hand, teachers face several challenges in teaching problem-solving skills to students. These challenges include modeling problem-solving for students, asking questions, making suggestions, helping students understand the problem, and giving them enough time to complete the task. Teachers may need to provide these scaffolding techniques to prepare their pupils to become better problem-solvers. According to the literature I have reviewed, several instructional strategies may address students' needs for mathematical skills in problem-solving and build their conceptual knowledge. These strategies include the think-aloud approach, journal writing in mathematics, cooperative learning, and project-based learning with real-world applications. All of these instructional practices involve students' metacognition, communication in mathematical language, and problem-solving skills. However, my study focuses on the think-aloud strategy, which depends on an individual's metacognitive thought process.

The think-aloud strategy is one of the instructional approaches, where the teachers model their problem-solving skills through their metacognition using academic language (Nagy & Townsend, 2012). As Bernadowski (2016) states, "[t]eacher modeling is a vital component of how students learn" (p. 4) in mathematics classrooms. Teacher modeling their metacognition using academic language is a process of scaffolding. The teacher, as the expert, provides students with the exact steps for problem-solving. Based on Vygotsky's theory of the zone of proximal development, modeling helps move the students to self-sufficiency (Bozkurt, 2017; Cardimona, 2018; Shabani et al., 2010). The study predominantly focuses on improving ELLs' academic language proficiency and problem-solving skills by implementing the think-aloud instructional strategy in teaching and learning components of daily instruction. However, to serve ELLs better, it is critical for teachers to know and understand students' strengths and challenges.

Strengths and Challenges of English Language Learners

It is crucial to identify and address ELLs' strengths and challenges from their cultural and linguistic backgrounds. Mathematics teachers may need to consider these strengths and challenges to provide appropriate instruction and scaffolding for ELLs to succeed. Teachers attaining the awareness of ELLs' strengths encourage students to use their abilities and skills.

Strengths

There are specific properties of ELLs' native language that may boost their mathematics abilities to demonstrate their cognitive skills in mathematics classrooms. According to Jao

(2012), “ELLs may not always be at a disadvantage in the mathematics classroom” (p. 3). Their cultural background may indeed help them to succeed in mathematics. ELLs’ excellent performance may be possible only when teachers, administrators, and parents provide necessary support and become strong advocates for their students (Celedon-Pattichis, 2004). Since students might have learned mathematics concepts in their native language, students who are new to this country may benefit from being placed in classrooms based on their content knowledge and skills in English and their native language. In other words, students may require taking content knowledge placement tests in their native language instead of in English for teachers to understand their true capabilities in mathematics.

Occasionally, ELLs learn difficult mathematics concepts and skills in the earlier grades, and these students may bring strong mathematics computational skills to the classrooms. Although these ELLs struggle to decipher the English language related to mathematics, their cultural background may help them with their cognitive ability to succeed in mathematics classrooms (Cummins, 2001; Jao, 2012). Hence, mathematics educators may need to encourage these students to participate more in classes by providing opportunities to show their mathematics abilities through mathematical symbols and representations, not their English language skills.

Another strength that ELLs may bring from various cultural and linguistic backgrounds is their diverse beliefs and experiences. As Takeuchi and Esmonde (2011) suggest, educators need to find ways to utilize ELLs’ competencies to support further learning. Thus, teachers of multicultural classrooms who use strategies to apply their previous knowledge and experiences may strengthen their students’ understanding (del Rosario Zavala, 2017; Jao, 2012; Muhammad, 2020). Many ELLs bring varied lived experiences and knowledge, leading to a creative way of solving problems in mathematics classrooms. Teachers can enhance these students' motivation and confidence through sharing their problem-solving techniques and student samples with other students (Slavit & Ernst-Slavit, 2007). Such strategies enrich ELLs' mathematical learning experiences and enhance their risk-taking and participation in the classrooms.

A final strength that ELLs bring from their native country is their strong literacy skills and content knowledge in their first language (Slavit & Ernst-Slavit, 2007). For these children, the transition into an academic setting in English can be more comfortable and faster. Additionally, the ELLs who participate in multiple language communities tend to bring unique competence and resources to mathematics classrooms (Takeuchi & Esmonde, 2011). However, ELLs who had less access to educational opportunities will likely struggle to learn the second language and learn the mathematics content.

Challenges

There are some challenges to ELLs' learning, and as Jao (2012) states, one of the main restrictions maybe their low second-language proficiency. These children who are new to this country face the challenge of learning the vast English language, social language, and academic language. In classrooms that focus on teaching content like mathematics, ELLs have limited opportunities to interact in English to develop their academic language. Sometimes, mathematics teachers focus on implementing more computation-based activities and less communication-based activities, and this move may limit ELLs' content language usage in the classrooms. Takeuchi and Esmonde (2011) state in their research that ELLs can take anywhere from five to ten years to reach academic language proficiency levels compared to native English speakers in content areas like mathematics. Therefore, ELLs who are new to this country may need explicit, extensive scaffolding from mathematics teachers.

Another challenge that ELLs face is the usage of various mathematics words and symbols for the same concept. Some mathematics teachers may use multiple symbols for multiplication, such as ‘x,’ ‘*,’ ( ), or . (a dot). This method of using various symbols to represent the same idea may confuse ELLs. However, Jao (2012) argues that it is difficult for ELLs to remember these many symbols on top of the second language learning. When mathematics teachers teach ELLs, they may be required to stick to a single representation/symbol to explain a concept until they learn it. Then they can expose them to other symbols slowly to prepare them for testing. Teachers using various mathematics representations one after the other can enhance student participation and performance on mathematical tasks.

Furthermore, communication in mathematics is very stressful for ELLs because talking in mathematics uses a specific academic language. In their research, Slavit and Ernst-Slavit (2007) claimed that mathematics language uses a variety of words that mean one thing in mathematics and another in everyday contexts, such as the words rational and circular. Therefore, the redundant algebra representations, symbols, and vocabulary words can be particular barriers for ELLs because they are still striving to master their new language.

The next challenge for ELLs is classroom participation. When teachers emphasize on communicating mathematics using academic language only in English, then ELLs’ involvement may be limited due to their low comfort levels of English language usage. Research shows that the participation of Spanish-English bilingual learners improved when teachers provide opportunities for presenting their mathematical knowledge and experiences in Spanish through peer interactions (del Rosario Zavala, 2017; Takeuchi & Esmonde, 2011). ELLs also struggle with reading and writing in mathematics. Although mathematics is a universal language and most mathematics expressions are read from left to right, as Jao (2012) affirmed, some languages read and write from right to left and others from top to bottom. Teachers who are aware of these cultural and linguistic differences may provide the appropriate scaffolding.

Lastly, parental involvement is one of the challenges for ELLs' success in mathematics classrooms. Roberts and Bryant (2011) situate that culture and parental participation are interrelated, and they have a significant influence on ELLs' mathematics achievement. Parental involvement can be either a strength or a challenge for ELLs' success in mathematics classrooms based on their cultural backgrounds. In some families, parents are either highly educated or less educated, but they hold strong mathematical abilities. In Jao's (2012) study, parents who excelled in mathematics tend to be involved in their children's education. Although these parents learned the content in another language, they actively ensure that students learn and master the concepts. The students of these parents are the most likely to succeed in their mathematics classrooms.

Moreover, research indicates that many ELLs' come from low-income families, and their parents might be highly educated, but they might not be able to speak English fluently (Slavit & Ernst-Slavit, 2007). Parents' low language proficiency can be a barrier for parents to get involved in school-related activities. Roberts and Bryant (2011) claim that some ELLs who come from developing countries have minimal or no literacy and mathematics-related preschool experiences than ELLs from more advanced countries. Also, the parents of these children who come from poverty might not have higher education themselves and may not speak English (Slavit & Ernst-Slavit, 2007). Many ELL parents are categorized into a marginalized group due to their class, immigrant status, language proficiency, and education level. This marginalized group often has limited exposure to school or negative experiences with the school system, which does not mean that these parents are not concerned about their children's education (Arias

& Morillo-Campbell, 2008). Therefore, many barriers hinder ELLs' parents and may inhibit parents from active involvement in school-based activities and the support of their children's school and home educational experiences. These parents may need assistance from school leaders and teachers to support community-based education programs informing parents about school values and expectations and helping them become advocates for their children.

In conclusion, effectively supporting ELLs' participation requires a shift of focus from vocabulary to student involvement in classroom practices (Takeuchi & Esmonde, 2011). Teachers may improve student participation by paying less attention to ELLs' mathematical speech in English and giving them more autonomy to use their native language in task completion. Moreover, mathematics teachers who teach ELLs may need to focus on what students know and can do rather than what they cannot do and then design the instruction accordingly. Providing instructional modifications and accommodations may improve student involvement as well as mathematical competence. Most importantly, cultural background and participation level may be a barrier to ELLs' success in mathematics classrooms (Slavit & Ernst-Slavit, 2007).

Furthermore, mathematics teachers may be required to examine ELLs' engagement in the school, identify the challenges and find alternative pathways (Takeuchi & Esmonde, 2011) to enhance their participation to succeed in mathematics classrooms. Since ELLs need to do two jobs, learn a new language while learning mathematics (Slavit & Ernst-Slavit, 2007), they need additional support than other students in a mathematics classroom. Providing Vygotsky's scaffolding in the form of teacher modeling of the problem-solving process, which can also be known as the think-aloud strategy, may enhance ELLs' academic language usage and conceptual understanding.

Think-Aloud Instructional Strategy

According to El Sayed (2002), the main goal of mathematics teaching is to prepare students to be good problem solvers. To achieve this goal, teachers may have to consistently implement problem-solving strategies in their classrooms and challenge their students by engaging them in solving rich real-world problems. However, as Shellard's (2004) research indicates, middle school students may develop negative attitudes toward mathematics. These negative attitudes may result from their struggle with solving word problems by translating them into the mathematical operations they know. To overcome this issue, mathematics teachers may use the think-aloud approach, one of the metacognitive instructional strategies. In this approach, the teacher delivers the lesson by thinking aloud their metacognition using academic language and problem-solving techniques. Moreover, this strategy may help students think-aloud during the problem-solving process, either in an individual task or a group task.

Bernadowski (2016) believes that successful students may need to think critically, use higher-order reasoning, and articulate their problem-solving thought process in a mathematics classroom. However, to improve students' reasoning, critical thinking, and problem-solving skills, teachers may need to model these techniques through their thought process using the think-aloud approach. According to Vygotsky (1978), learners can accomplish the task with teachers' guidance or from a more capable peer. When teachers model the essential mathematical skills in their teaching, learners may pick up and use them in their learning (Cardimona, 2018; Shabani et al., 2010). Furthermore, Nagy and Townsend (2012) suggested that the academic thinking process involves metacognition, which is impossible without using the content language. Teachers who teach mathematical concepts through the think-aloud approach using metacognition may develop students' problem-solving and cognitive abilities.

As discussed above, the think-aloud refers to one's knowledge and a more in-depth understanding of the cognitive process (Basaraba et al., 2013; Wilson & Smetana, 2009). Hence, metacognition and problem-solving are interrelated. Metacognition executed by a problem solver depends on their own thinking and cognitive awareness (Hastuti et al., 2016; Purnomo et al., 2017; Wilson & Smetana, 2009). As Pate and Miller (2011) listed in their study, metacognition involved in problem-solving includes identifying the problem, mentally representing the problem, planning how to solve the problem, and evaluating one's performance in solving the problem. Furthermore, the think-aloud displays students' conceptual understanding and the ability to understand and make connections across mathematical concepts (Rosenzweig et al., 2011). This approach may lead to the improvement of student engagement in meaningful communication about mathematics. However, teachers may have to expose middle school students to an effective think-aloud process by modeling and implementing collaborative group work to help them learn and use it during their problem-solving tasks.

Moreover, the think-aloud instructional strategy demonstrates the steps needed to solve mathematical problems and to help students construct the understanding they need (Wilson & Smetana, 2009). Think-aloud is defined as the conscious disclosure of one's thought process while reading; it helps the reader acquire various metacognitive comprehension skills such as understanding, predicting, verifying, self-questioning, and evaluating (Baumann et al., 1993; Ghaith & Obeid, 2004). According to Park (2005), the think-aloud approach is an active and reflective process that requires students to perform self-instruction, self-question, and self-monitoring; it helps students recall what strategies they know and how to apply them to the given situation. This approach can help students monitor their own thinking and problem-solving abilities.

In summary, thinking aloud during problem-solving is where students speak out loud whatever thoughts come to their mind while performing the task. As Tinker Sachs (1989) stated, individuals may overlook their cognitive process, but through the think-aloud strategy, also known as verbal reporting, people can monitor their own cognitive abilities. Furthermore, think-aloud is an oral mediation process where students say aloud when they think about a particular task and solve it. This strategy is believed to be useful to enhance the learner's self-direction and autonomy, both academically and socially (Park, 2005). Additionally, as has been discussed before, reading comprehension skills are vital for effective problem-solving. They are necessary for the identification of the problem before a solution can be found. The think-aloud tool can effectively comprehend a text because the reader needs to explain what they understood about the situation by thinking aloud while they read the word problem. In other words, as Bulut and Ertem (2018) explained, this strategy facilitates the identification of the question and determination of what approach to use to solve it. However, there are many benefits and a few challenges involved in this think-aloud approach in mathematics classrooms.

Benefits and Challenges of Think-Aloud

Cardimona (2018) suggests that think-aloud as an instructional strategy can be an excellent scaffolding tool for ELLs in a mathematics classroom. However, this metacognitive strategy has some benefits and challenges, both with incorporating and implementing it in mathematics instruction; it may be effective for mathematics educators to know and understand the strengths and limitations of the think-aloud strategy before adopting it.

Benefits

The think-aloud instructional strategy is one of the comprehension monitoring strategies teachers have used recently in mathematics classrooms. Researchers believe that this strategy can help develop students' metacognitive skills and mathematical thinking (Purnomo et al., 2017). Since teachers model their problem-solving thought process using academic language and vocabulary in this instructional approach, students tend to catch those essential mathematical components and use them in their task execution. The think-aloud tends to improve both teachers' and students' cognitive abilities and content knowledge. Also, this method, if implemented effectively, may develop additional mathematical skills such as conceptual understanding, problem-solving, communication in precise language, and confidence in mathematics. According to Wilson and Smetana (2009), when middle school teachers consistently implement the think-aloud strategy in their mathematics classrooms, they get opportunities to demonstrate an active thinking process.

Most importantly, the think-aloud protocol provides rich information about how students solve problems, what strategies they use, and what difficulties they encounter during the problem-solving process (Nalliveettil, 2014). This approach can also develop students' in-depth understanding of the text and the metacognitive nature of questioning. Moreover, the think-aloud strategy may enhance students' comprehension skills and confidence in problem-solving. Students listen to themselves when they read the text out loud. During this process, as Bulut and Ertem (2018) believe, students can guess the meaning, infer, answer questions, understand the problem, and monitor their cognitive function, leading to their cognitive development and self-learning skills.

When teachers help students learn how to use their metacognitive skills through the think-aloud, it empowers students to take ownership of their learning (Wilson & Smetana, 2009). As Vygotsky (1978) situated in his theory, individuals learn with and from others in social interactions. The theory of ZPD is characterized by a social relationship of cooperation between learner and teacher (Shreyar et al., 2010). Encouraging students to think aloud during problem-solving, sharing their approach with the class, and allowing their peers to ask questions is useful in deepening their understanding and developing confidence in them, postulates Shellard (2004). The think-aloud approach helps monitor and regulate one's thinking process (Wilson & Smetana, 2009). Teachers who happen to follow students' metacognitive strategies while using it and provide scaffolding when needed tend to help these children become independent learners. Thus, as Özcan et al. (2017) suggested, teachers may need to create a classroom environment where students solve problems using the think-aloud strategy. Teachers monitor them to ensure that students use this approach correctly. Moreover, Wilson and Smetana's (2009) research indicated that the think-aloud using academic language might provide teachers and students with a common language when discussing metacognition.

The research's main focus was to examine the impacts of the think-aloud approach on the student performance of the subgroup, ELLs. According to Celedon-Pattichis (1999), ELLs face the dual-task of learning a new language while discovering new content. As discussed before, the problem-solving process involves several steps, such as translating, planning, and monitoring. ELLs' have difficulty with the first step due to their low language proficiency (Celedon-Pattichis, 1999). However, the think-aloud strategy may help by requiring that the problem is read aloud, thinking aloud in their own words, and understanding the problem before proceeding with the next problem-solving steps, explains Caledon-Pattichis (1999). Although ELLs face many challenges, the think-aloud strategy may help them overcome those challenges, especially mathematical problem-solving.

First of all, communicating in mathematics poses a challenge for ELLs due to their low English language proficiency. Since communication is crucial to solving mathematical problems, teachers are required to allow ELLs to communicate in their first language or in both languages during the think-aloud process to demonstrate their skill level in mathematics. As Park (2005) discussed, the think-aloud tends to increase students' mathematics performance with math difficulty regardless of their linguistic backgrounds. Their challenge of language proficiency is less likely to interrupt their mathematics learning during this method. The think-aloud approach may enable ELLs to develop their mathematical thinking and language by interacting with their peers and teachers. Moreover, the think-aloud strategy enhances students' cognitive skills such as awareness, evaluation, and regulation and choosing the right problem-solving approach in completing a mathematical task (Basri et al., 2019; Hastuti et al., 2016; Purnomo et al., 2017). Since metacognition is important in problem-solving, the think-aloud approach may help individuals monitor their cognitive processes, consisting of remembering, understanding, applying, analyzing, and evaluating (Purnomo et al., 2017; Telli et al., 2018).

A second challenge is that many mathematics teachers who teach ELLs may have a misconception that ELLs can learn mathematics with ease because they think mathematics has no linguistic concepts (Celedon-Pattichis, 1999). Some educators believe that mathematics is based on the language of symbols, and students don't need English language proficiency to succeed in this content, as argued by Lee et al. (2011). However, the majority of problem-solving in mathematics assignments and assessments contain word problems and open-ended questions. Thus, ELLs are not successful due to their second language struggle. Hence, Celedon-Pattichis (1999) believed that the think-aloud strategy might be one of the solutions to improve students' academic language acquisition. Also, think-aloud teaches them how to break down the problem to understand English sentences and translate words to numbers and symbols by talking aloud in peer interactions. Furthermore, teachers may improve students' active participation in think-aloud by creating word problems in their first language and promoting self-talk in their native language during problem-solving (Lee et al., 2011). This strategy may help ELLs check their understanding of the problem and reduce their anxiety about learning new content.

Moreover, comprehending the problem in English might be a significant challenge for most middle school ELLs before they even begin planning for the solution. Many bilingual students may succeed in the problem-solving process, using their first language to understand the problem (Celedon-Pattichis, 1999). These students may benefit from the think-aloud in comprehending while talking aloud and exploring the new vocabulary embedded in the text. Since think-aloud is predominantly about describing one's cognitive process, research indicates that it can facilitate the comprehension process for student understanding (Bulut & Ertem, 2018; Tinker Sachs, 1989). When ELLs work in small collaborative groups, the think-aloud strategy helps them actively engage in task completion, and it refines their content knowledge. In the think-aloud approach, students share and exchange their ideas through conversations with their peers and develop their knowledge under the teacher's guidance (Zolkower & Shreyar, 2007). Successful mathematics teachers have the proper training to engage middle-grades students, including ELLs and non-ELLs, on using the think-aloud process to comprehend the problem (Bernadowski, 2016; Ghaith & Obeid, 2004; Ness, 2016).

Finally, as Erath et al. (2018) argued, the ELLs with low language proficiency could not perform well on mathematics assessments due to their struggle with active participation in classroom activities. Thus, if implemented consistently by teachers, the think-aloud instructional approach most likely accelerates students' adaptation of the strategy and shifts their focus towards active learning. Learning is conceptualized as participation in interactive mathematics classrooms. Students who participate adequately in mathematics classrooms tend to learn better and perform well on the assessments (Erath et al., 2018). When students use this strategy daily in their task completion, it may improve students' engagement in problem-solving and academic language usage, ultimately helping them become independent learners.

Challenges

There are some challenges in implementing the think-aloud instructional strategy in middle school mathematics classrooms. First, students may have difficulty participating actively in the think-aloud process due to a lack of motivation and comfort in expressing their thoughts with their peers. They may have trouble focusing their verbalization on the task due to their developmental stage (Pate & Miller, 2011). Next, students who have mathematics difficulty tend to lack confidence in their mathematics skills and may show the least interest in the think-aloud strategy. As Nalliveettil (2014) argues, the think-aloud approach might be a challenge for ELLs due to the verbal facility and low language skills, which leads to low confidence and motivation. In contrast, teachers who implement problem-solving activities where students can think aloud in their native language with their peers may enhance their motivation to participate and develop their conceptual understanding through problem-solving.

Lastly, teacher preparation may be a challenge that needs teacher expertise in preparing an excellent think-aloud script and planning think-aloud activities. School leaders are required to provide professional development for mathematics teachers to prepare them for effective think-aloud instruction. According to the research by Ness and Kenny (2016), teachers who "received meaningful instruction on why, how, and when to think-aloud" (p. 454) improved their expertise in creating well-prepared think-aloud. Students can learn higher-order thinking skills such as compare and contrast, evaluate, analyze, explain their thinking through a teacher's skillful think-aloud modeling. Teachers may have to consider incorporating the think-aloud approach in their daily mathematics instruction to examine the enhancement of ELLs' performance in the classroom and on the assessments. Overall, my research may provide evidence of the benefits of using the think-aloud protocol in problem-solving for ELLs.

Specific Gaps in the Literature

There are many gaps in the literature related to my research study on ELLs' strengths in mathematics and the positive impact of the think-aloud approach on mathematics problem-solving. First, there is limited research on the skills and abilities of ELLs in mathematics classrooms. ELLs bring their expertise in mathematics problem-solving from their native countries (Jao, 2012); much research was conducted on ELLs' deficits, not their problem-solving skills. Also, studies analyze ELLs' achievement gap on standardized testing, but the trends in the achievement gap between ELLs and non-ELL populations have not been explored (Polat et al., 2016).

Secondly, studies conducted minimal research to examine the effect of their primary language and socioeconomic status on student learning (Roberts & Bryant, 2011). My research fills this gap as it was conducted in a Title I school where most students come from impoverished backgrounds, and more than three-fourths of the students speak English as their second language. Furthermore, while many researchers have examined the various mathematical experiences and knowledge ELLs bring to this country, many haven't studied how these children use these strengths in their new mathematics learning. Fruitful research on knowing ELLs' strengths and mathematics abilities can provide educators with more insight into how to leverage those to improve academic achievement.

Moreover, many researchers examined ELLs' learning through the lens of Vygotsky's social constructivism theory. There is minimal research on critical sociocultural theory with

ELLs in mathematics setting. Many ELLs in American schools are immigrants and face several challenges related to cultural and immigration issues, which can negatively impact their educational opportunities. In addition, most research studies conducted on diverse children's low mathematics performance and overlooked their cultural differences. This research study stressed the importance of considering ELLs' cultural diversity component for education equity when teachers teach them. Thus, this research was built three theories: Vygotsky's social constructivism and sociocultural theory, and critical sociocultural theory.

Another gap, as Park (2005) declares, is a lack of research supporting the idea of implementing metacognitive strategies during problem-solving and how it impacts students' mathematics performance. This study may have filled that gap in the literature by examining the positive effects of the think-aloud approach on students' problem-solving skills in mathematics. Similarly, substantial research was done on the metacognitive function of students during reading comprehension. However, according to Rosenzweig et al. (2011), there was limited research on students' metacognitive functions during mathematical problem-solving tasks. This research could have filled that gap in examining ELLs' metacognitive abilities during the problem-solving process.

Finally, the study of Özcan et al. (2017) indicate that there is limited research that examines the thinking processes in solving mathematical problems by the think-aloud method, especially in the first years of middle school. At this age, students are transitioning from concrete to abstract thinking required for developing problem-solving techniques, and more research is needed about this age group. This research was conducted in middle school mathematics classrooms to fill this gap in the literature. Again, it is unclear from the literature whether the think-aloud can improve high-order comprehension, especially in a second language, for ELLs

(Ghaith & Obeid, 2004). This study's findings could have provided evidence of whether the think-aloud strategy can improve ELLs' comprehension skills in English.

Chapter 2 Summary

Chapter 2 examines the effect of the think-aloud instructional approach on ELLs' problem-solving in middle school mathematics classrooms. Problem-solving is a crucial aspect of mathematics instruction. Telli et al. (2018) state that the problem-solving process involves students' mathematical thinking and linguistics factors, such as understanding the problem, planning and implementing the solution, and evaluating the process. Problem-solving is a challenge for most middle school mathematics students, particularly for the subgroup ELLs. Since bilingual students need to perform two jobs, learning language and content, at the same time, they often struggle with mathematics performance (Slavit & Ernst-Slavit, 2007). However, ELLs bring several beliefs and experiences to the mathematics classrooms. Hence, teachers need to provide them with opportunities for utilizing those experiences while learning a second language. Moreover, as Celedon-Pattichis (2004) argues, school leaders and educators may need to focus on their existing mathematics abilities instead of their language proficiency to make their placement decision.

Moreover, this chapter investigates the strengths and challenges of ELLs. Many ELLs have the strong content knowledge and literacy skills in their first language (Slavit & Ernst-Slavit, 2007). When teachers provide scaffolding for these students, they perform well and succeed in mathematics. However, ELLs that come from low-income families might lack sufficient education, and these children need more opportunities to learn and succeed. The required instructional scaffolding includes the teacher's modeling of the problem-solving thought process, collaborative learning, and breaking down the problem into pieces, enhancing ELLs' problem-solving skills and mathematical competence (Cardimona, 2018). The research study focused on such a modeling technique called think-aloud instructional strategy. In this process, the teacher models the problem-solving thought process using the required academic language. Students acquire the vocabulary, language, and skills through watching and listening to their teachers' modeling. The study utilized Vygotsky's teaching theory of ZPD, and ELLs' mathematical thinking improves under teachers' and peers' guidance through interactions in the classrooms (Vygotsky, 1978).

In conclusion, this chapter explains implementing the think-aloud instructional approach in mathematics classrooms and its benefits for ELL's mathematics achievement and its challenges. Furthermore, this chapter examines the specific gaps in the literature review. It also suggests that researchers conduct further investigations on ELLs' positive attributes, mathematics abilities, and skills rather than focus on their deficiencies. The last component of this chapter examines the implications of the study. Chapter 3 discusses the methodology, including the study sample and methods of data collection and data analysis.

CHAPTER 3 METHODOLOGY

The purpose of this research study was to examine the effect of the think-aloud instructional strategy using academic language and problem-solving thought process on ELL student performance with solving word problems when teachers implement the protocol in middle school mathematics classrooms. The research study drew on Vygotsky's theory of social constructivism in which ELLs learn the content and mathematical language through interactions with teachers and peers. Also, Vygotsky's sociocultural theory and the critical sociocultural theory were recognized and addressed in the conceptual framework due to the nature of ELLs' diverse backgrounds.

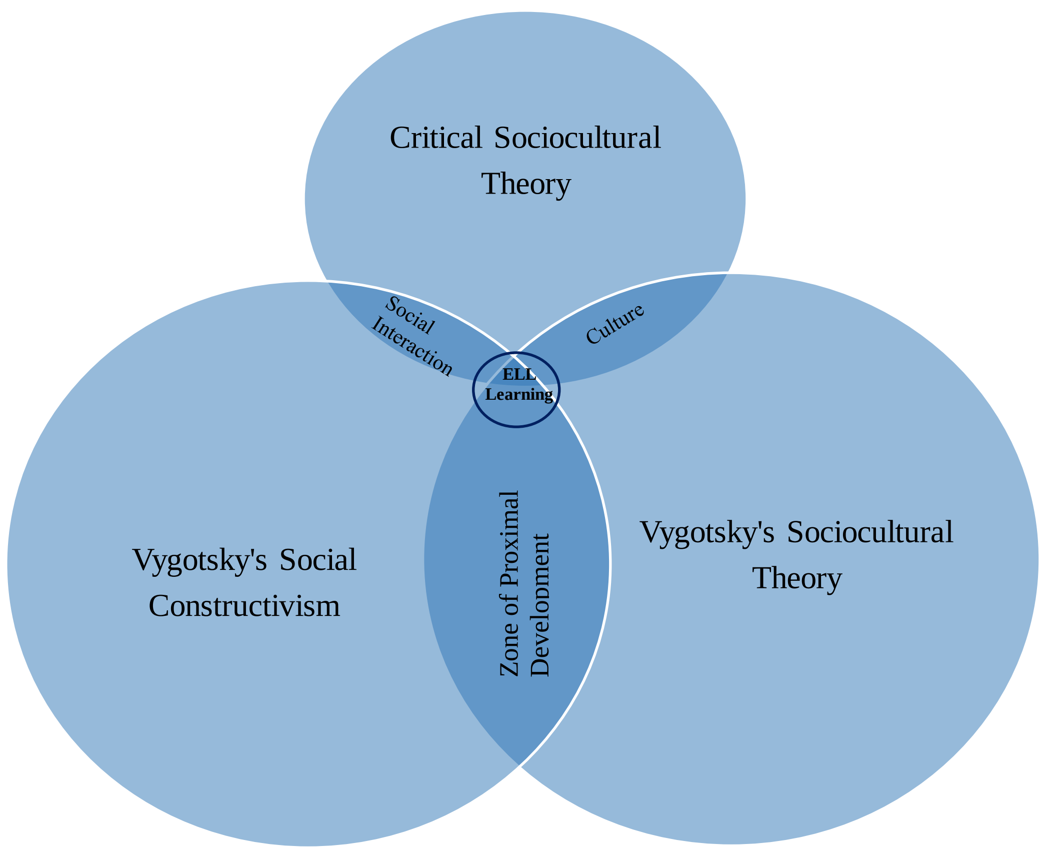
Conceptual Framework

This research was based on the philosophical idea of metaphysics. In other words, knowledge is concerned with the mind and essence of reality (Egbert & Sanden, 2014). Human beings continuously construct reality in a social world through interactions with other people, but they still need guidance from an expert (Eun, 2011; Siyepu, 2013; Vygotsky, 1978). In this study, mathematics students acquire basic conceptual knowledge from the instructors as guides, and then they develop their expertise along with their peers through social interactions. The philosophical theory of Vygotsky's social constructivism was the foundation for this research.

Vygotsky's social constructivism suggests that students' social interactions in a mathematics classroom through their participation in cooperative learning groups provide them with intellectual development and language acquisition if a teacher or a peer guides them (Bozkurt, 2017; Shabani et al., 2010). However, the learning theories of Vygotsky's sociocultural theory, Vygotsky's zone of proximal development (ZPD), and critical sociocultural theory were also addressed in the investigation due to participants' cultural and linguistic differences. Although there were multiple theories recognized and discussed in this study, ZPD was the leading theory that influenced ELL learning. Figure 4 shows the conceptual framework that underpinned this research study.

Figure 4

Conceptual Framework



Vygotsky's Theory of Social Constructivism

Constructivist theorists believe that knowledge reflects a representation, a portrait, and/or an objective world. Individuals construct their own reality with those belongings to the social circle (Egbert & Sanden, 2014; Ultanir, 2012). In this study, students might have constructed their knowledge and cognitive skills by interacting with teachers and peers and developed their conceptual understanding. Since this research study depends on Vygotsky's social constructivism theory, students develop mathematical academic language and problem-solving skills by observing their teacher's thought process during the think-aloud lesson delivery. Then, they construct their own knowledge by interacting with their peers during collaboration, as individuals discover truths through interacting with others (Egbert & Sanden, 2014; Ultanir, 2012). Simultaneously, the teacher provides scaffolding for students who need help with acquiring essential vocabulary and conceptual understanding. When students are actively engaged in the problem-solving thought process, they improve their thinking skills and problem-solving performance more (Hastuti et al., 2016; Purnomo et al., 2017; Wilson & Smetana, 2009).

Social constructivists believe that social interaction and individual meaning-making are two critical aspects of learning mathematics. As Bozkurt (2017) positions, “Learning, in particular, the learning of mathematics is considered as social construction by social constructivists” (p. 211). Also, Vygotsky’s theory believes that teachers’ and parents’ contributions play a significant role in stimulating students’ learning and understanding in a more sophisticated way (Davis, 2009). Vygotsky’s social constructivism suggests that students’ social interaction in a mathematics classroom through their participation in cooperative learning groups provides them with intellectual development and language acquisition if a teacher or a peer guides them (Bozkurt, 2017; Shabani et al., 2010; Vygotsky, 1978). Also, students tend to transfer knowledge between each other to develop their understanding of the content. The interaction between peers allows ELLs to hear more of the target language and improve their language and higher order thinking skills (Ghaith & Obeid, 2004; Sachs et al., 2003).

Moreover, this research was based on social constructivism theory because, in this study, teachers provided opportunities for students to collaborate to solve problems in different ways. Furthermore, the teacher guided them and helped them be successful problem-solvers. Social interactions enhance students' knowledge and understanding and promote individual cognitive development (Cummins, 2001; Lewis et al., 2007; Sachs et al., 2003). A teacher is a guide who creates a classroom environment that motivates students to learn and engages them with their peers in mathematical problem-solving. Mathematics teachers can use the idea of social constructivism more effectively when they know the prior knowledge of their students and how the students create personal meaning when new information is given to them (Bozkurt, 2017; Hanham & McCormick, 2018; Herges et al., 2017; Powell & Kalina, 2009). Individuals construct the meaning and understand the concepts through their unique experiences. Through social constructivism, teaching has a positive impact on students, both cognitively and socially (Bozkurt, 2017; Cardimona, 2018).

Vygotsky's Sociocultural Theory

The second theory that supported this research is Vygotsky's sociocultural theory. Since this research primarily focused on ELLs' achievement, a researcher needs to consider their cultural and linguistic backgrounds and individual learning methods before conducting the study. Social and cultural aspects have a greater impact on students' experiences at home, school, and community. ELLs can succeed both academically and socially when they are provided with a supportive socio-cultural environment. In his research study, Cummins (2001) examined that the key for ELLs' success in the classroom are the skills that they bring to the classrooms from their cultures and experiences, not their English language proficiency. As Cummins (2001) says, when the schools affirm the value of ELLs' primary language and encourage them to take pride in their cultural background, students become more engaged in their learning.

Vygotsky believes children's intellectual functions develop through social interactions and language usage, and children learn from talking. Thus, teachers who provide ELLs abundant opportunities to converse in the ELL classrooms, both in their first language and in English, could improve their communication in the content (Allahyar & Nazari, 2012; Dominguez, 2011; Mendez et al., 2017). When teachers offer scaffolding opportunities to students, and teachers and ELLs work collaboratively, student participation and cognitive development increase.

Moreover, mediation is key to understanding how human cognitive functioning is related to cultural and historical settings (Cummins, 2001; Muhammad, 2020). Vygotsky explains that humans do not react to the physical world directly without mediator tools related to their cultures, such as symbols or signs. Vygotsky's sociocultural theory also says that parents, as representatives of the culture, tent to pass their cultural values and tools onto the child. The sociocultural environment engages the child in his world through these tools (Cummins, 2001; Turuk, 2008). Using the tools and signs to mediate human activity leads to language acquisition and cognitive development (Mahn, 1999; Yildirim, 2008).

The students with diverse cultural backgrounds do not copy teachers' capabilities (Turuk, 2008); instead, they transform what teachers provide using their cultural background. Students' own cultural perspectives can help them function better in the classroom, where they are more comfortable applying their experiences and cultural beliefs to learn the new content. Also, ELLs may perform better if teachers focus on the process instead of the product to understand ELLs' learning and development (Mahn, 1999; Yildirim, 2008). This theory emphasized that what a learner brings to a multicultural classroom can impact how they perform when interacting with teachers and peers. However, whether these interactions are empowering or disempowering for both educators and children depends on how culturally diverse students were treated in their historical societies. Therefore, Cummins (2001) proposes that teachers need to commit to helping these children succeed academically in schools, considering their cultural backgrounds.

Vygotsky's sociocultural theory suggests that if teachers want to see ELLs' real progress, they should not assess their content knowledge only through testing; instead, they should focus on what they can achieve with teachers' and peers' help through interactions (Mahn, 1999; Yildirim, 2008). When students accomplish a task with others' help, they will be able to achieve it by themselves. Testing only allows teachers to determine students' cognitive development but not to measure the child's potential ability (Turuk, 2008; Yildirim). Since context plays a significant role in student learning, teachers may increase ELL student engagement and mathematics performance by creating a classroom environment as interactive as possible.

Vygotsky's Zone of Proximal Development Theory

This research study involved Vygotsky's teaching and learning theory ZPD. It is defined as the distance between the actual development of a child with the independent problem-solving ability and the potential development as determined through problem-solving under adult guidance or in collaboration with a more capable peer (Bozkurt, 2017; Cardimona, 2018; Shabani et al., 2010; Sharkins et al., 2017). Instructional scaffolding is the main component in the theory of ZPD. In my research study, mathematics teachers provided students with scaffolding by modeling academic language and problem-solving skills through the think-aloud protocol to learn more than they could learn independently. In addition, students may develop their conceptual understanding by interacting with teachers and peers. Vygotsky's theory of ZPD has direct implications on a child's performance. The child learns in their true comfort zone, but teachers provide the essential scaffolding for their learning to move them to the next level of mastery (Cardimona, 2018; Sharkins et al., 2017).

Siyepu (2013) states that the ZPD is the difference between what a learner can do without help and what a learner can do with help. A child's cognitive development involves a significant amount of assistance from the teacher to understand the new task. Then the child starts learning to complete the task with less and less support and eventually with no assistance (Doolittle, 1995; Siyepu, 2013). The cognitive development of a child appears in two stages, first on the social plane, then on the psychological plane, i.e., first between people as an inter-mental category, and then within the child as an intra-mental category (Shabani et al., 2010). Thus, the function is initially social, and then it becomes an internal function, known as internalization. Therefore, Vygotsky's theory of ZPD illustrates this internalization process where the adult gradually removes assistance and transfers responsibility to the child (Barrera et al., 2006; Shabani et al., 2010). As the learner continues to practice, they can complete the tasks independently that were performed previously with the teacher's assistance (Bozkurt, 2017; Siyepu, 2013).

The central aspect of the theory of ZPD is the social system in which the child learns. The social system is actively constructed by both the child and the teacher (Doolittle, 1995; Siyepu, 2013). A child's cognitive development is an establishment of a shared perspective between an expert, and a learner in the problem-solving process (Shabani et al., 2010; Barrera et al., 2006). Over time, students internalize the process and solve the problem independently using the essential steps. In my research, the teacher modeled the problem-solving thought process through the think-aloud strategy using academic language. Students tended to grasp the academic language and problem-solving process and used it during independent task completion.

According to Sharkins et al. (2014), scaffolding support from adults improves a child's learning by discovering skills and concepts, ultimately leading to cognitive development. Children use the knowledge and skills experienced during social interaction with peers and teachers to guide and direct their own learning and behavior. Moreover, teachers' understanding, embracement, and incorporation of Vygotsky's theory in a mathematics classroom support students' construction of knowledge and development of their thought process and conceptual understanding. Teachers' sense of Vygotsky's social constructivism theory contributes to building a classroom where student-student interactions and teacher-student interactions are prominent (Bozkurt, 2017; Powell & Kalina, 2009; Shabani et al., 2010).

Quality teaching is a crucial component of improving student learning. An effective professional development provides teachers with opportunities for learning new knowledge and skills to enhance their teaching. As Vygotsky's theory of ZPD states, individuals develop their knowledge through support and guidance from adults, and teachers receive this guidance from both professional development and colleague teachers (Eun, 2011; Siyepu, 2013). Moreover, collaboration among teachers allows them to share various types of expertise and internalize their professional development. This collaboration may result in building their confidence and implementing new instructional practices in their instruction.

Critical Sociocultural Theory

The ELLs may face several challenges related to race and immigration in American schools. Researchers are required to recognize the critical component of sociocultural theory when addressing students' needs. Socio-cultural perspectives and cultural identities are essential tools for ELLs to demonstrate their knowledge when interacting with their peers (Cummins, 2001; Lewis et al., 2007). The curriculum and assessment instruments are perhaps inherently biased and don't consider the unique socio-cultural backgrounds of students of color. Often, pedagogical practices ignore the experiences, motivation, aspirations, and views of students of color and mainly reflect White students' academic capabilities (Bernal, 2002).

Learning involves and requires participation (Lewis et al., 2007). Students learn better if they feel connected to the content they are learning, allowing them to reflect on their identities. Often, ELLs are disengaged from learning because school policies reinforce the inherent inferiority of culturally diverse students (Bernal, 2002; Cummins, 2001). However, as Muhammad (2020) says, the current educational policies and curriculum are focused on improving every child's skills and knowledge regardless of race or ethnicity. The curriculum may need to include the learning goals with which diverse students can develop their identity and skills, gain new knowledge, and develop the ability to understand the power and authority to succeed in society (Cummins, 2001; Muhammad, 2020). Research indicates that curriculum reform may radically improve ELLs' schooling, and thus, teacher preparation for multilingual and multicultural instruction may require more than minor pedagogical and curricular adjustments (Teemant, 2015).

Although students of color hold abundant knowledge, their histories, experiences, languages, and cultures are often devalued and omitted from the educational settings (Bernal, 2002; Cummins, 2001; Muhammad, 2020). In a diverse classroom, mathematics teachers may often ignore the experiences and beliefs of students of color and set the same academic expectations for all students. This issue may negatively impact student learning and participation. Standard teaching practices typically cannot improve ELLs' achievement (Teemant, 2015). Schools and educators may need to know, understand, and value cultural differences and improve students' educational experiences (Bernal, 2002; Cummins, 2001; Muhammad, 2020).

Teachers are required to provide instructional frameworks written by authors of color and designed for students of color to improve student learning and achievement of diverse students (Cummins, 2001; Muhammad, 2020).

ELL student learning depends on the degree of relationships between the teachers and the students, and students develop their identities through social interactions (Cummins, 2001; Lewis et al., 2007; Muhammad, 2020). When students work collaboratively in a multicultural classroom and build content knowledge under the guidance of teachers and peers, ELLs may feel safe and included. Mathematics teachers can make problem-solving fun and meaningful by making connections with real-world issues related to diverse students (Muhammad, 2020). This interactive problem-solving process helps students establish respect, trust, and affirmation with their teachers and peers and reflect critically on their own experiences and identities. Moreover, teachers may need to provide opportunities for these children to express themselves in mathematics classrooms. Learning can make and remake oneself and identities (Cummins, 2001; Lewis et al., 2007). The ELLs may participate competently in instruction if their identities and knowledge are recognized, and their voices are heard and respected within the school.

Research Design

This research study was primarily based on the theory of social constructivism. Research shows that a qualitative approach is appropriate for a constructivist worldview (Creswell, 2009). In contrast, the research design contained a quantitative method, a single-case research study. The single-case research study consists of various designs, including multiple baseline design across individuals, behaviors, and settings (Kazdin, 1982; Sealander, 2014). This study utilized a multiple baseline design (MB) across individuals composed of a baseline of student performance and treatment of the think-aloud strategy to answer the research question. I selected this design because my study investigates the impact of an independent variable (think-aloud) on a dependent variable (ELL student performance).

Research Question:

What is the effect of the think-aloud instructional strategy *using academic language and problem-solving thought process* on ELL student performance with solving word problems when teachers implement the protocol in middle school mathematics classrooms?

Most social constructivists used a qualitative research design for similar studies. However, this research's main focus was to examine an independent variable's effect on a dependent variable for individual ELLs. Since the methodology and methods used depend on the question being asked and the purpose of the research, a single-case design was suitable for answering the research question. Thus, multiple baselines across individuals were conducted for data collection and data analysis.

Single-Case Design: Multiple Baseline Across Individuals

For the multiple baseline design, I collected data through visual inspection and observing/analyzing problem-solving skills and academic language usage of six participants. This design examined students' problem-solving techniques such as defining the problem, developing a plan, collecting and analyzing the information, and solving the problem. Students' problem-solving skills were measured using teacher-created mathematics formative assessments and a rubric range from 0-12 (Appendix A) and analyzed with a multiple baseline (MB) design. Additionally, students' think-aloud processes during the problem-solving of the task were audio-recorded and transcribed to examine the number of academic language words they used in their think-aloud, such as like terms, add, multiply, eliminate.

In this MB design, the baseline for student performance was shown, and the treatment was introduced on a staggered basis to the participants. The only variable of difference between baseline and treatment measurements was the introduction of the think-aloud strategy. In other words, the MB design started with the baseline and then proceeded with the treatment. The detailed MB design will be discussed in the data collection and data analysis sections below. Figure 5 shows a sample MB graph, and Figure 6 displays the formative assessment rubric. Baseline 1 and Treatment 1 represent their formative task performance during the baseline and treatment phases. In contrast, Baseline 2 and Treatment 2 represent the number of academic language/vocabulary words used in their problem-solving during the baseline and treatment phases.

Figure 5

Sample Multiple Baseline Graph

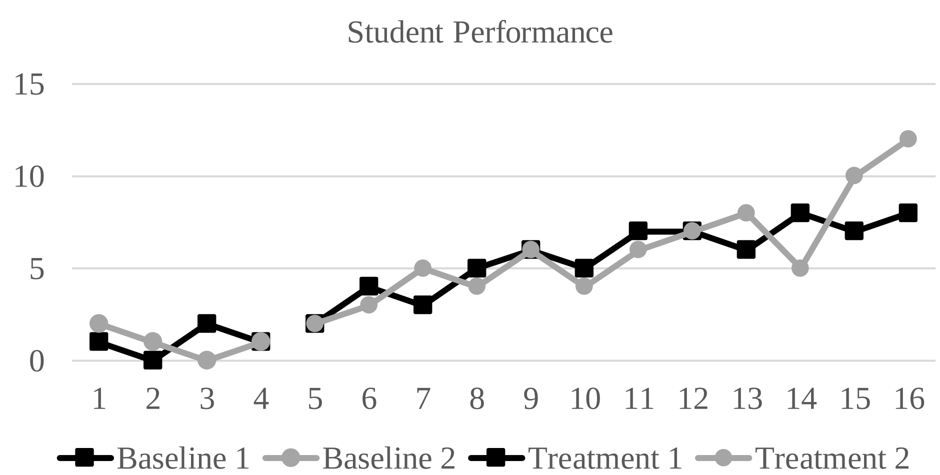


Figure 6

Formative Assessment Rubric

Problem-Solving Skills Rubric

Name: ________________________ **Grade:** _________ **Date:** _______________

Performance Area	Rating = 3	Rating = 2	Rating = 1	Rating = 0	Score
Defining the Problem	Student states the problem clearly and identifies underlying issues.	Student adequately defines the problem.	Student fails to define the problem adequately.	Student does not identify the problem.	
Developing a Plan to Solve the Problem	Student develops a clear and concise plan to solve the problem, with alternative strategies, and follows the plan to conclusion.	Student develops an adequate plan and follows it to conclusion.	Student develops a marginal plan and does not follow it to conclusion.	Student does not develop a coherent plan to solve the problem.	
Collecting and Analyzing Information	Student collects information from multiple sources and analyzes the information in-depth.	Student collects adequate information and performs basic analyses.	Student collects inadequate information to perform meaningful analyses.	Student collects no viable information.	
Interpreting Findings and Solving the Problem	Student provides a logical interpretation of the findings and clearly solves the problem, offering alternative solutions.	Student provides an adequate interpretation of the findings and solves the problem but fails to provide alternatives.	Student provides an inadequate interpretation of the findings and does not derive a logical solution to the problem.	Student does not interpret the findings/reach a conclusion.	
				Total	
				Overall Score	**12**

Context

The research study was conducted at Hope Middle School, a Title I school located in a diversely populated neighborhood. The city cluster has two high schools, two middle schools, and six elementary schools. This school contains students with diverse backgrounds and teachers of different races and ethnicities, some of whom are bilingual. Each grade level consists of six mathematics teachers, and each mathematics classroom serves about 30 students. The school building is five years old, and it holds many mathematics instructional resources such as computer labs, laptops, mathematics manipulatives, calculators, graphing calculators, small whiteboards, LCD projectors.

Moreover, mathematics teachers incorporate technology in their instruction almost every day. These technology resources include Khan academy, Desmos, Quizizz, Kahoot, and Quizlets to promote student learning. The ELL direct classes and push-in classes have Spanish-to-English dictionaries available for students, and the direct ELL class teachers are bilingual. All mathematics teachers create and follow common lessons daily, and the mathematics administrator and the instructional coach are actively involved in the instructional planning. Teachers use district-made teaching resources, sample lessons, and unit assessments. Also, teachers use common rubrics to assess formative tasks and constructive response questions on the unit assessments to maintain consistency in evaluating student work across the grade level. The school runs several clubs and after-school programs. The school culture is positive and instruction-focused, and the school encompasses hard-working teachers and staff with plentiful resources.

The mathematics department follows the Balance Numeracy Framework (BNF) for planning the daily lessons, and each class period is 60 minutes long. The district introduced this framework two years ago. This framework is well structured and divided into four sections: 1) Activating strategy (5 minutes), 2) Think-aloud mini-lesson (20 minutes), 3) Differentiated small groups (30 minutes), and 4) Summarizing (5 minutes). Teachers follow this lesson format to create the lessons, and students are very accustomed to this framework. In this framework, the teacher models the problem-solving thought process using essential academic language by thinking aloud. Then students learn the concepts and practice problem-solving techniques in collaborative small groups.

The district school system believes that the think-aloud strategy develops students' academic language and problem-solving skills and improves student achievement. As a result, the think-aloud teaching strategy is mandatory for daily mathematics instruction, and the teachers are expected to teach mathematics concepts using this protocol. However, some teachers have been modeling the think-aloud effectively using essential academic vocabulary and a problem-solving thought process, while others, especially the novice teachers, haven't. Overall, every mathematics teacher uses the think-aloud protocol in their mini-lesson section of the BLN.

However, this research study occurred during the COVID-19 pandemic. Due to the epidemic outbreak, schools implemented several protocols that restricted teachers' autonomy of using various instructional practices, including teacher-student and student-student collaboration. The instruction was entirely digital, and teachers taught the daily lesson using the Desmos platform or a document camera. The students did not use any paper or pencil, manipulatives, or small whiteboards. Instead, they completed their work using Desmos each day on their personally assigned student laptops. Moreover, their collaborative learning was accomplished through zoom break-out rooms.

In addition, students were also not allowed to use handheld graphing calculators; instead, they used the Desmos online calculator, which they were not familiar with in their previous grades. Also, ELLs in the push-in and direct classes used Google Translate instead of word-to-word dictionaries. The digital teaching model restricted teachers from implementing high-level and rigorous word problems in their instruction due to students who struggled with learning the content digitally. Despite all these issues, this research study examined whether the think-aloud approach is the possible cause that improved ELLs' performance with solving word problems. Furthermore, this research examined whether the think-aloud process impacted ELLs' academic language usage.

Participant Selection

The school serves around 1500 students, including sixth, seventh, and eighth grade. Each grade level contains approximately 500 students. The school demographics show that this school consists of 46% ELLs. However, this percentage includes both former ESOL students, who were in ELL mathematics classes before but have now exited the program, and the current 30% of students who are placed in the current mathematics ELL classes. In other words, 16% of ELLs are not placed in mathematics classrooms anymore as ELLs. The study utilized a multiple baseline design across individuals with six participants. The research mainly focused on ELLs from 8th-grade Algebra 1 because the advanced mathematics classes contain adequate academic language and vocabulary, which is the study's primary component. Also, the Algebra 1 course is considered as a gatekeeper (Stinson, 2004) for higher learning, and the difficulty of the course steadily increases from unit after unit. Algebra 1 course provides a foundation for middle schoolers in terms of increased complexity in content and the academic language to prepare them for higher education in mathematics.

Criteria

This school consists of five Algebra 1 teachers, and only two teachers teach ELLs in integrated classes. These two teachers have at least two years of experience implementing the think-aloud instructional strategy and teaching ELLs. Teacher 1 has 28 years of teaching experience, and Teacher 2 has 15 years. The sample of this study consisted of six Algebra 1 ELLs: four male and two females. The selection of three from each teacher's Algebra 1 classes occurred through purposeful sampling. The criteria were based on three main factors: gender (both males and females), 7th-grade ACCESS test composite scores, and 7th-grade mathematics semester-one district-developed post-assessment scores. Since they didn't take the semester two post-test in 7th-grade because of the pandemic, semester one scores were used in the selection. The district-developed assessment (DDA) scores have four achievement levels based on students' performance: Beginning, Developing, Proficient, and Distinguished. According to WIDA, there are six proficient scores based on students' performance on the ACCESS test. Also, the six participants are Spanish-speaking students who are literate in their first language. Table 1 describes the four levels of the district assessment and the six levels of ACCESS test scores.

Table 1

Levels of Assessments

ACCESS		Mathematics DDA	
Proficiency Level	Description	Level	Score Range
1	Entering	Beginning	0 - 54
2	Emerging	Developing	55 - 69
3	Developing	Proficient	70 - 84
4	Expanding	Distinguished	85 - 100
5	Bridging		
6	Reaching		

Procedure

After the Institution Review Board (IRB) and the district/local principal approved, I started conducting the study. For participant selection, each Algebra 1 teacher first provided a list of their ELLs from their class rosters. Then, I checked those ELLs' records on the system for students' 7th-grade mathematics scores and 7th-grade ACCESS test scores to select three ELLs from each teacher. Once the six ELLs were chosen, I contacted parents through phone calls using the school's translation service and informed them about the research details, process, and student recruitment process. If the parents were willing to let their children participate in the study, I met with individual students virtually and explained the research process details. If students were also keen to participate, then I mailed the IRB-approved translated consent and assent forms to their home address for signatures. I have not used any flyers in this process except for a verbal conversation of the IRB-approved recruitment scripts for parents (Appendix F) and students (Appendix G). Once the consent and assent forms were collected, I started the data collection process for 16 different days across 15 weeks from the second week of August until the second week of December. I met with students once or twice weekly to collect 16 data points.

Mathematics teachers create common lessons in this school, and they make the weekly lessons and formative assessment tasks a week in advance before implementation. Each week, I submitted teacher-created formative tasks for the upcoming week to the IRB for approval before using them for data collection. Due to the pandemic, schools began with 100% online learning and continued for the first five weeks of semester 1. On the first day of baseline data collection, I explained to each participant how I would collect baseline and treatment data using the formative task and rubric. However, after the 5th week, the schools started operating in a concurrent model, where the learning is either digital learning (DL) or face-to-face (F2F) for students based on what their parents signed up for. The baseline phase occurred in the online model, and the treatment phase happened in the concurrent model. Out of six participants, four were F2F students, and two were DLs for the treatment phase.

Participants

The study involved six ELLs, four male and two females. I grouped the students into two groups based on their mathematics DDA score range. Group 1 included proficient and developing students, and Group 2 had all beginning level students. Table 2 shows participants' information, including their 7th-grade ACCESS composite scores and 7th-grade first-semester mathematics DDA scores. Pseudonyms are used for each participant, and the test scores are displayed with a range of numbers instead of using the exact scores for privacy purposes.

Table 2

Participant Information

Group	Name	Learning Model	DDA	ACCESS
1	Ximeno	DL	Proficient (70-75)	Expanding (4.0-4.5)
	Yasmin	F2F	Proficient (70-75)	Expanding (4.0-4.5)
	Alejandro	F2F	Developing (60-65)	Developing (3.5-4.0)
2	Marisol	F2F	Beginning (40-45)	Developing (3.5-4.0)
	Emilio	F2F	Beginning (30-35)	Emerging (3.0-3.5)
	Leo	DL	Beginning (25-30)	Emerging (3.0-3.5)

Ximeno

Ximeno, a 13-year male, was a digital learner during the study. His 7th-grade mathematics DDA scores, ranging from 70 to75, and 7th-grade ACCESS test scores, ranging from 4.0 to 4.5, indicate that he was at a proficient level in mathematics and expanding level in English language proficiency. His speaking ACCESS score was slightly higher than his writing

ACCESS score. However, his comprehension ACCESS score (5.6) was much higher than speaking and writing. His high comprehension score shows that he should be able to comprehend word problems very well. Ximeno was a hardworking, bright, and respectful student. However, he had an excessive number of absences during the 15 weeks. Also, he missed a lot of think-aloud instruction due to his tardiness during the treatment phase. He performed well on the formative tasks when he was present during the instruction. Also, he was absent for two consecutive weeks due to his family responsibilities, which resulted in missing instruction for one entire unit. His homework environment was noisy and distracting due to the proximity of his siblings. Despite these issues, he completed the four baseline and 12 treatment data points.

Yasmin

Yasmin was a 13-year-old female student. She was a F2F learner during the treatment phase. Her 7th-grade mathematics DDA scores, ranging from 70 to 75, and 7th-grade ACCESS test scores, ranging from 4.0 to 4.5, indicate that she was at a proficient level in mathematics and expanding level in English language proficiency. Yasmin's writing ACCESS score was slightly higher than the speaking ACCESS score. However, her comprehension ACCESS score (6.0), which was much higher than speaking and writing, shows that she should comprehend word problems very well. Yasmin was a quiet, hardworking, highly motivated, and intelligent student. Yasmin's attendance was excellent, except for a few absences for illness due to her illness due to Covid-19. She was less confidant at the beginning of the treatment phase, but her confidence improved over time.

Alejandro

Alejandro was a 13-year-old male, and he was a F2F learner during the treatment phase. His 7th-grade mathematics DDA scores, ranging from 60 to 65, and 7th-grade ACCESS scores, ranging from 3.5 to 4.0. These scores show that he was a developing student in 7th-grade mathematics and English language proficiency. Alejandro's writing ACCESS score is higher than his speaking scores, but his comprehension score (6.0) indicates that he can understand the text very well. Alejandro was a highly respectful, motivated, confident, and calm student. He had no absences in the entire semester. He always pays attention in class and asks questions if he doesn't understand. Alejandro also double-checks his work using the rubric before turning in the assignment.

Marisol

Marisol was a 14-year-old female, and she was a F2F student during the treatment phase. Her 7th-grade DDA scores, ranging from 40 to 45, indicate that she was at the beginning level in mathematics, but her language proficiency is at a developing stage, ranging from 3.5 to 4.0. Marisol's speaking level was at an emerging level, which was much lower than her writing score. Her comprehension (3.8) was also at a developing stage. She was an active, talkative, and respectful student. Marisol attended digitally for a couple of weeks until she had to quarantine due to her COVID -19 illness. However, Marisol focused on her work even during the DL and performed an excellent think-aloud when she completed the data collection task.

Emilio

Emilio, a 13-year-old male student, was a F2F student during the treatment phase. His 7th-grade DDA scores, ranging from 30 to 35, and ACCESS composite scores, ranging from 3.0 to 3.5, indicate that he was at a beginning level in mathematics and developing in English language proficiency. Emilio's speaking skills were at the entering level, whereas his writing was at developing. However, his comprehension (5.0) was much higher than the other domain, which indicates that he can comprehend the word problems well enough. Emilio was a respectful, hardworking, but less confident student. Emilio thinks mathematics is a difficult subject and he is not good at it. Emilio pays attention in the class, but he is reluctant to ask questions or ask for help. His attendance was excellent, but he was struggling to complete his class assignments during class. Emilio completed his formative tasks in the treatment phase, but his work was incomplete during the baseline due to remote learning. To be successful, he requires one-on-one instruction.

Leo

Leo is a 14-year-old male student who was a digital learner during the treatment phase. Leo's 7th grade DDA scores, ranging from 25 to 30, and ACCESS composite scores, ranging from 3.0 to 3.5, indicate that he is at the beginning level in mathematics and lower end of developing in English language proficiency. His speaking skills were at the entering stage, but his writing and comprehension were at the emerging stage. His comprehension score (2.8) indicates that he would have difficulty in understanding the text. Leo was a respectful, social, but less motivated student. Mathematics was not Leo's strength, and he thinks this subject is very hard. Leo was a digital learner throughout the semester. His attendance was good, but he was logging in at least 15 minutes late due to the slow internet, which resulted in him missing the first half of the think-aloud instruction. Also, since Leo was missing the lesson, he was struggling to complete the assignments on Desmos. He also had technical issues during the data collection. Leo works well if he gets one-on-one instruction. He needs encouragement while completing the tasks.

Instrumentation

The main instruments used for the data collection and the data analysis were Microsoft Excel and the transcription software (Rev, 2020). The collected data was stored, and the multiple baseline graphs were created and stored using the Microsoft Excel software. Finally, Rev software transcribed the audio recordings of students' problem-solving thought processes. The detailed procedures will be discussed in the sections of the data collection and the data analysis below.

Methods of Data Collection

As discussed above, this research used a single-case study with a multiple baseline design across individuals. The study utilized student problem-solving thought process and their academic language usage for 15 weeks. Students' think-aloud processes were also audio recorded to examine the number of academic vocabulary words students used each time to complete the formative assessment task.

Multiple Baseline Design

The MB design process is a visual inspection, and it is used to decide whether treatment effects are consistent and reliable (Kazdin, 1982). Also, visual analysis is a practical method because it's the most-published analytic technique for single-case design (Brossart et al., 2006). During the treatment, the MB design data were collected for 16 days across 15 weeks of school, which provided 16 data points. The participants were six ELLs from two 8th-grade Algebra 1 classes, and these six students' problem-solving skills were measured individually for 16 days across 15 weeks, both in baseline (4 days) and treatment (12 days).

In an ideal MB design, the treatment's introduction is staggered over 16 days of measurements, and the students in each group are more than the other students in the baseline period. However, this study modified the MB design due to the mandatory implementation of the think-aloud across the school. Hence, it was not possible to keep students in the baseline for more than two weeks. In other words, all six students were in the same baseline period, and I collected data for four days in the first two weeks of school before the teachers introduced the think-aloud strategy. Once teachers introduced the think-aloud strategy, I waited for two weeks to give the students and teachers some adjustment time to the introduction of the new strategy and to allow for the students to process the different strategy that they learned. Then, I started collecting the treatment data. Students' problem-solving skills were assessed using teacher-created formative tasks and a rubric on a scale of 0 to 12 (Appendix A). Both baseline and treatment data were collected for every individual student in a private setting, either in the school building for face-to-face instruction or in a zoom break-out room for DLs to control the environmental changes.

Procedure. After the student enrollment, data collection occurred for 16 different days across 15 weeks from the second week of August until the second week of December. This amount of 16 data points provided greater reliability for the multiple baseline design (Kazdin, 1982).

Due to the pandemic, the first semester started with 100% online learning and continued for five school weeks. The district provided its own secured zoom platform for teachers to teach daily synchronous digital lessons. Students followed the regular bell schedule and attended the classes using the live zoom link. Teachers taught the instruction with the Balance Numeracy Framework (BLN) discussed in the Context Section. During the first two weeks of the semester, teachers taught the lesson using the document camera without introducing the think-aloud strategy. Then they started the think-aloud approach in their instruction as well as in the small collaborative groups. However, based on direct observation, all students, including the ELLs, were not engaged actively in the zoom break-out sessions. Thus, student-student interactions were not visible because they did not seem to be comfortable with the zoom platform.

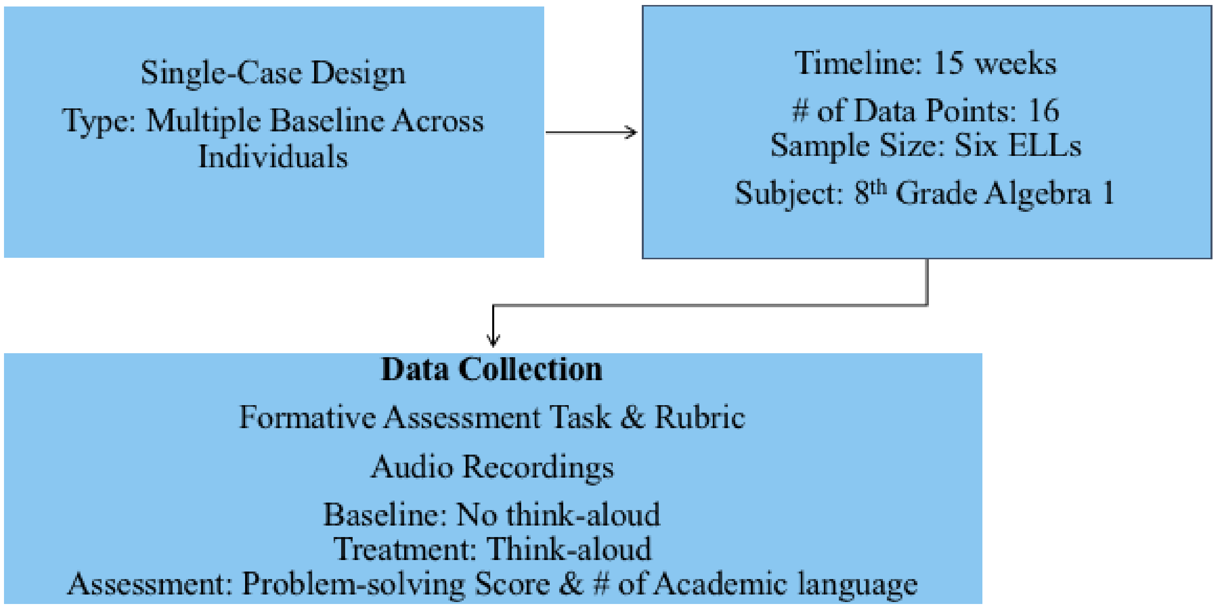
In the baseline phase, teachers taught the lesson without implementing the think-aloud strategy. They utilized PowerPoint presentations and document camera to teach the concepts, but they never introduced the think-aloud protocol until after the first two weeks of school. Once the teacher finished teaching the lesson in the baseline phase, I met with students in the teacher-created zoom-breakout rooms and explained the instructions by providing the Google link to the rubric to self-verify their work. Then, I set the timer for 20 minutes and asked them to complete the task. Once students said they had finished, I collected their work, then we both left the break-out room. Students always finished the assignment within 10 minutes during this phase. Some of them didn't provide answers in Desmos, even though they said they were finished. Next, I assessed their completed formative task using the rubric and counted the number of academic language/vocabulary words written on their assignment. As shown in Figure 6, the grading rubric included four components: defining the problem, developing a plan, collecting and analyzing the information, and solving the word problem. Therefore, the rubric was used not to assess only the accuracy of the solution but to evaluate their problem-solving step-by-step procedure and conceptual understanding. I stored the data in Microsoft Excel on a password- and firewall-protected computer. I followed these procedures for all six students during the baseline and the treatment. Also, I randomly pulled the participants for the data collection every week, creating variations in content complexity and student performance. In other words, I shuffled students each week so that I don't work with the same students on the same day of each week, making sure that they complete the formative tasks on multiple days of the week.

Teacher's Think-Aloud. After two weeks of the baseline phase, teachers introduced the think-aloud strategy in their instruction. As discussed before, in the think-aloud approach, teachers taught the mathematics concepts through solving the problems by thinking aloud the essential academic language and their problem-solving thought process. For instance, when the teacher taught the concept of solving a multi-step equation, they first determined the required academic vocabulary students need to learn, such as like-terms, unlike-terms, variables, and constants. The teacher then planned what problem-solving steps students need to perform, such as combining the like terms, distributing, and undoing the operation on both sides. In their think-aloud, teachers defined the problem, developed and implemented a plan by analyzing the given information, and found the solution, the four essential problem-solving steps (El Sayed, 2002; Montague & Applegate, 1993; Tambychik & Meerah, 2010). Once the teacher prepared the effective think-aloud, they delivered the instruction by solving word problems using the academic language and problem-solving thought process. Students seemed to listen to the teacher's vocabulary and language usage and watched their problem-solving approach and tended to grasp them. Ultimately, students tried to use the procedural steps in their independent problem-solving task completion.

Due to the time constraint, I started collecting the treatment data two weeks after teachers' introduction of the think-aloud strategy to students. However, in the treatment phase, I had four F2F students and two DLs. I met with F2F students at their mathematics classroom door, walked them to my office, and walked them back to their classroom after data collection. I continued meeting with DLs during the treatment phase in the zoom break-out room. When I explained the instructions to them during the treatment phase, I informed them about the audio-recording of their think-aloud problem-solving process. Also, I guided each student to solve the teacher-created Desmos formative task by thinking-aloud in a similar way as their teachers. This thinking-aloud process included reading the problem, figuring out what they know and what they need to find out, planning for a solution, and implementing it. While they were thinking aloud, I made an audio recording of their entire problem-solving thought process. Figure 7 explains the summary of the MB design's data collection.

Figure 7

Summary of Multiple Baseline Data Collection



Methods of Data Analysis

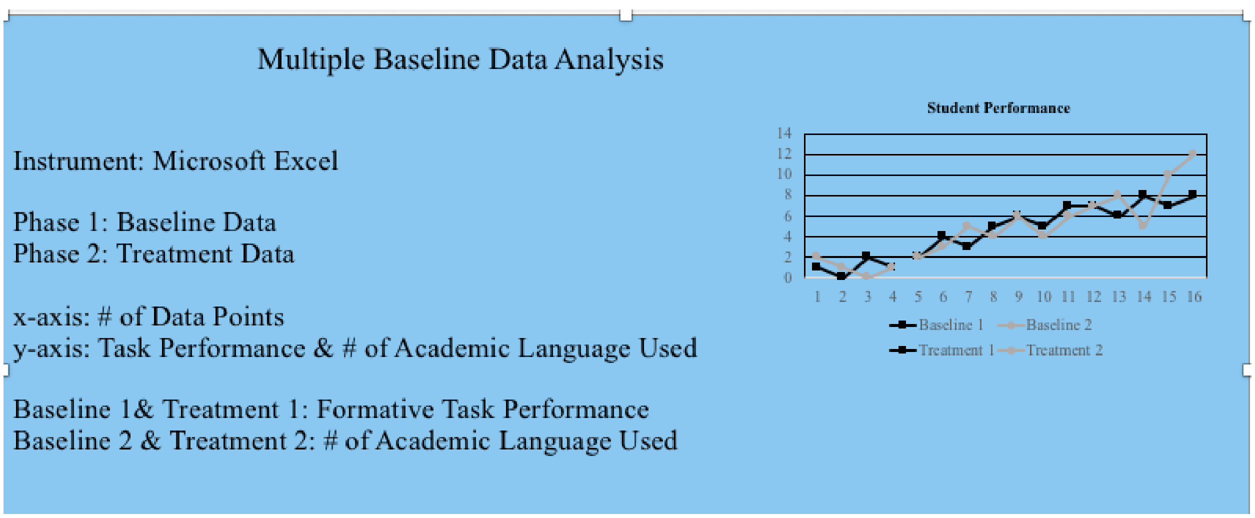
The research study used the analysis of multiple baseline graphs consistent with the purpose of the study. Also, various statistical measures, including mean (*M*), standard deviation (*SD*), range (*R*), and coefficient of variation (*CV*), were demonstrated in the data analysis. Moreover, trend lines were drawn with calculating slope (m) and R^2 value, and a few bar graphs were used to compare average scores of individuals within groups. The audio recordings were transcribed and analyzed to examine the number of vocabulary words used by the participants in their problem-solving thought process.

Multiple Baseline Analysis

I analyzed the scores of students' problem-solving performance using MB graphs on the Microsoft Excel sheet. The data collection occurred for 16 days to examine the improvement of ELLs' problem-solving skills on a scale of 0 to 12. The MB graphs were drawn with number of data points on the x-axis and task performance score and the number of academic words on the y-axis. The graphs were analyzed to examine the effects of the treatment at different points over time to make a judgment based on the overall data (Kazdin, 1982). The transcriptions of audio recordings determined the number of academic language/vocabulary words used in their think-aloud. The data analysis also investigated the relationships between the students' problem-solving performance and academic language usage. Moreover, the data analysis inspected the patterns between language usage and problem-solving techniques across the six ELLs. Figure 8 shows how the MB data was analyzed.

Figure 8

Summary of Multiple Baseline Analysis

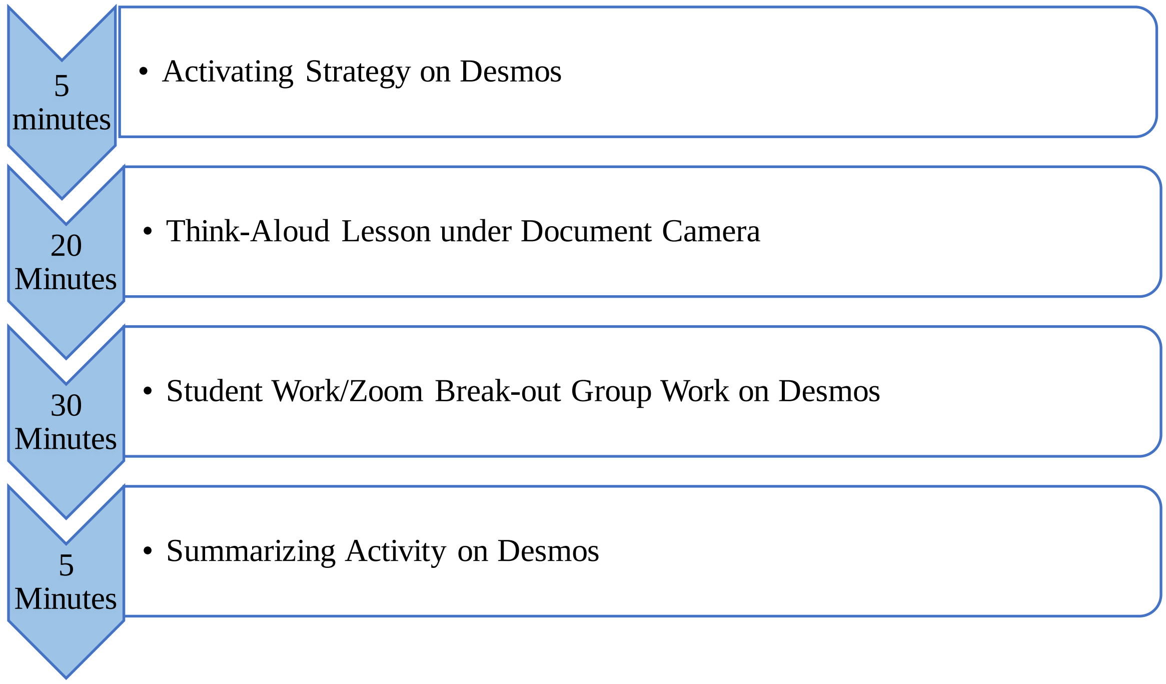


Analysis of Problem-solving Skills

Algebra 1 teachers created the formative assessment tasks used in this study. Due to the pandemic, teachers uploaded the daily formative tasks onto the Desmos digital platform. Figure 9 shows the concurrent model's lesson format, similar to the BLN format that the school uses. However, there was neither paper-pencil usage nor the graphing calculator by students. The teachers used document cameras rather than whiteboards to teach the lessons, and students were working in the Desmos platform. Also, there were no small group activities in the classroom between face-to-face students due to social distancing requirements. However, the teachers encouraged students to work in groups in the zoom-breakout rooms, which was a struggle for the students, especially for ELLs. When I collected the data in the baseline phase, all six students had to type their answers in Desmos because the learning was digital-only. Since the treatment phase occurred in the concurrent model, the two DLs continued typing their work in Desmos. The F2F students completed their formative assessment tasks on a paper worksheet printed from Desmos. I provided them with hard copies of worksheets because they chose paper and pencil over the Desmos platform.

Figure 9

Lesson Format of Concurrent Model



Once students completed their work either on Desmos or paper, I graded their work using the rubric ranging from 0 to 12 (Appendix A) and uploaded the scores in Microsoft Excel.

Analysis of Academic Language

When students completed each formative task by thinking-aloud, I collected the data including their audio-recordings of the think-aloud and their task performance score and stored them in Microsoft Excel. Then, I transcribed the audio recordings using the Rev software. In the transcriptions, I highlighted the academic vocabulary used by each student and counted the number of academic vocabulary words used while solving the word problem. This vocabulary number did not include any numerals or repetitive vocabulary words. Also, I counted the vocabulary words only while solving the problem but not while the reading the text of the given word problem. Moreover, the transcriptions are modified with deletion of pauses, affirmatives, and inaudible content. The following Table 3 with a student sample displays the analysis of transcription for academic language. This figure shows that no academic words are highlighted in the given problem, but the words are highlighted in the solving part.

Table 3

Analysis of Transcription for Academic Language

Transcription of Student Think-Aloud	# of Academic Vocabulary/Language
Convert the following quadratic equation into intercept form by factoring and state the zeros. So we have Y equals X plus eight X minus 20. First, I'm going to do the custom. So I have the X, and we're going to try to find... For 20, negative 20 and positive eight. Two factors that multiply to make negative 20, and two factors added to make positive eight. First, we're going to find the factors of negative 20. Negative 20 is one times 20, five times four, and 10 times two. We could use 10 times two, and we have to figure out which one is negative because we have a negative 20. So the negative will be 10. Negative 10 times two. Okay. So it's not going to be negative 10 because we have a positive eight. If 10 minus two is eight and 10 times negative two is negative 20, that means the two will be negative. Now we're going to solve it. First we have X and X, which is going to give us X [inaudible 00:00:10] two. And then we've got our factors which is 10 and two, which is going to give us two X, 10X, and two times 20... Actually, it's negative two. So it's going to give us negative 20, which this is going to be negative two X times X negative two X, 10X. Okay. In the area model puzzle, we have X and X, which is going to give us X square root of two, and then we've got X and 10, which is going to give us 10X. We got negative two, which is going to give us negative two X, and then we got negative two and 10, which is going to give us negative 20. Now, here's it says the factor form of the equation is Y equals [inaudible 00:03:22]. The zeros are... Now we're going to figure out the zeros. First, we've got the first equation, which is negative two X and positive 10X. Well, now we're going to do it. So Y equals X minus two, and then we have X plus positive 10. Now we're going to subtract that... No, we're going to convert it, which is going to give us Y equals X minus two equals zero. The factor form, we're going to take the parenthesis out and we're going to put X minus two equals zero, then we're going do the same to the 10 but first we're going to subtract this. It's negative two plus two will give us zero. And then zero plus two will give us X equals positive two. And then we've got X plus 10 equals zero. So we're going to find the zero pair of 10, which the zero pair is negative 10... So when we add negative 10 and positive 10 will give us zero. That is our zero pair. Then we're left with X, and then we're going to subtract negative 10 to zero. We get X equals negative 10. Our zeros are two or negative 10. So Y equals two and negative 10.	Factors, multiply, negative, added, positive, times, figure out, solve, area model, square root, factor form, equation, equals, zeros, subtract, convert, parenthesis, zero pair Total = 18

Ethical Considerations

Researchers are required to consider several ethical considerations in every part of the design, including sampling, data collection, data analysis, and reporting. Providing sufficient information to the participants to allow them to decide whether they wish to join the study is a crucial ethical consideration (Vogt et al., 2012). It is necessary to explain to the participants what baseline and treatment phases are and how the data will be collected using the rubric. Researchers need to use informed consent and assent forms and ensure that they are genuinely voluntary to establish the study's trustworthiness (Marshall & Rossman, 2006; Vogt et al., 2012). I attained participants' permission by obtaining parental consents (Appendix B) and student assents (Appendix D). Since the participants and their parents are linguistically diverse in this study, I had the consent forms translated (Appendix C & Appendix E) into their first language by a reputable organization and used the appropriate reading level to maintain ethical responsibility.

Also, I provided special protection as required by the internal and external review boards to the participants since they belong to the vulnerable populations in terms of socioeconomic status and racial and ethnic minorities. Building trust and sustaining relationships is crucial for participants to engage with the research process (Marshall & Rossman, 2006). Therefore, I made sure that I invested quality time to build trust with participants and make them comfortable to facilitate their active engagement in the research study. I created close rapport with the participants by greeting F2F learners during homerooms and lunchtime and meeting with the DLs during small group instruction. All six participants expressed their enjoyment to be working with me during the research. This relationship-building helped boost their motivation.

Limitations

There were a few potential limitations in this research study. The most significant limitation was the differences in experience, preparation, and implementation of the think-aloud strategy between the two Algebra 1 teachers. Teacher 1 is more experienced in teaching Algebra 1 than Teacher 2. It might have caused disparities in student performance in solving word problems. Also, the complexity of the content and the word problems vary from day to day, and not all students completed the same formative tasks the same day.

Most importantly, during the COVID-19 crisis, digital learners might not have acquired as many vocabulary words and problem-solving techniques from their teachers' think-aloud instruction as those who attended the face-to-face instruction. These differences could be due to their inconsistent attendance, tardiness, or muted videos that may have led to not being attentive to teaching. The ELLs who worked online could have faced several technical issues during class, restricting their learning through the teacher's think-aloud. These factors could have created disparities in their performance in solving word problems. This research involved six ELLs, and this small sample size is a limitation to generalizing the results. Therefore, many factors affected ELLs' student performance outside of the think-aloud instructional strategy. Further research is needed to investigate the effect of the think-aloud process on ELL student academic performance in mathematics education.

Although students were given opportunities to work with their digital peers during small, differentiated groups, they could not interact as effectively as a face-to-face situation with their peers. As a result, collaboration and student-student interaction were not sufficient or productive for this research. Most of the students either turned off their cameras or did not speak with their peers in the zoom break-out rooms, negating true collaboration. The lack of collaboration might have caused disparities in ELLs' learning opportunities.

Chapter 3 Summary

Chapter 3 described the methodology and conceptual framework on which this research study was built and conducted. This study involved three theories though the main focus was on the philosophy of Vygotsky's social constructivism. Since the ELLs come from various cultural and linguistic backgrounds, they develop their English language and academic vocabulary during peer interactions (Bozkurt, 2017; Cardimona, 2018). Teachers are suggested not to ignore these diverse students' experiences and cultural differences during their learning process, and instead encourage them to enhance their learning by sharing their ideas and knowledge with one another (Cummins, 2001; Muhammad, 2020).

The methodology involved a single-case design. The study context involved a Title I school with a majority of the Hispanic population from different cultural backgrounds. However, the school holds plentiful instructional resources and highly qualified teachers and administrators. The study sample focused on the 8^{th}-grade Algebra 1 ELLs who were placed in the integrated classes.

Moreover, this chapter delineated the methods of data collection and data analysis. The data collection methods comprised multiple baseline designs across individuals with various ELLs' academic levels to examine their problem-solving techniques. The study's primary issue was that data collection occurred in the COVID-19 pandemic, which restricted teachers' instructional practices and ELLs' learning strategies. The data analysis methods included various MB graphs, statistical measures, and a few bar graphs. Potential limitations were examined and addressed. Chapter 4 presents the findings of the study including the emerged possible trends during the data analysis.

Chapter 4 Results

The purpose of this study was to examine the effect of the think-aloud instructional strategy using academic language and problem-solving thought process on ELL student performance with solving word problems when teachers implement the protocol in middle school mathematics classrooms. The following research question guided the inquiry of the study: What is the effect of the think-aloud instructional strategy *using academic language and problem-solving thought process* on ELL student performance with solving word problems when teachers implement the protocol in middle school mathematics classrooms?

The research study primarily utilized Vygotsky's social constructivism theory with an amalgamation of Vygotsky's sociocultural theory, Vygotsky's learning theory of ZPD, and critical sociocultural theory. However, because of the pandemic, there was minimal student interaction occurring in the classrooms during the data collection phase, which ultimately reduced the effect of sociocultural component and the aspect of knowledge construction through interaction with each other on ELL student learning. In the data collection process, student learning mainly depended on the theory of ZPD. Students learned the content through teachers' modeling and thought process but never had opportunities to develop their knowledge in the small collaborative groups due to the pandemic restrictions. Therefore, the six participants learned the think-aloud from their teachers and executed it during their independent task completion during the data collection.

Findings

All six participants completed 16 planned sessions within the baseline and treatment phases in the 15 weeks of the data collection process. Participants completed one formative task in each sitting of the baseline and treatment phases. The task was graded using the rubric ranging from 1 to 12. Also, participants completed the treatment phase tasks using their think-aloud, and each think-aloud was audio-recorded and then transcribed using the Rev software. Each transcription's academic vocabulary words were highlighted and counted by excluding the numerals and the repetitive vocabulary words. Also, the academic language count didn't include the vocabulary words of the given word problem text but for solving of the problem.

The mean (*M*), standard deviation (*SD*), coefficient of variation (*CV*), and range (*R*) of task performance scores and the number of academic vocabulary words used in their think-aloud by Group 1 and Group 2 were calculated and analyzed in this chapter. The standard deviation reveals how the data ranged from the average (mean) value, and the coefficient of variation, *CV,* explains the relative measure of variability within the data sets. In other words, *CV* can provide a degree of consistency in the student performance and their language usage over time. The trend lines were also drawn with calculated slope (m) and regression coefficient (R^2) to examine the relation between the independent and dependent variables, and the data sets' reliability. Bar graphs demonstrated the comparison between the average scores of individuals within groups. Also, I included the analysis of multiple baseline and treatment measures for individuals and the groups in this chapter.

Moreover, the study showed seven trends related to the think-aloud strategy on ELLs' academic performance and academic language acquisition. However, the effect of the pandemic was somewhat interrelated with the treatment within these seven trends. These trends emerged from various claims, and evidence was provided for each claim. The trends were:1) Task Performance: Groups' performance increased from baseline to treatment with the think-aloud; 2) Academic Language: Groups' academic language improved from baseline to treatment with the think-aloud; 3) Task Performance (Tsk) Vs. Academic Language (AcLa): Academic language usage was directly proportional to students' task performance score; 4) Gender Differences: Males used more academic language than females in their think-aloud; 5) Speaking Vs. Writing: ELLs used more academic language in their speaking than writing when asked to explain their reasoning; 6) Complexity of Content: The academic language used depended on the complexity of the problem; and 7) Learning Model: Face-to-face participants benefited from the think-aloud more than the digital learners. In this chapter, the treatment effect on individual performance is explained before discussing the trends within the groups.

Individual Participant's Performance

Each participant engaged and completed 16 formative tasks, four baselines, and 12 treatments over 15 weeks of the first semester. The multiple baseline graphs exhibit how the independent variable, think-aloud strategy, affected the dependent variables, student performance, and academic language usage over time. In the MB graphs, solid lines represent the task performance, and dotted lines represent the academic language usage. Since ELLs' performance associated with their ACCESS scores, it was essential to include their speaking, listening, writing, and comprehension. Table 4 displays the ranges of participants' ACCESS test scores of these four critical domains plus composite scores for this study.

Table 4

Participants' ACCESS Score Ranges

Group	Name	Speaking	Listening	Writing	Comprehension	Composite
1	Ximeno	3.5 to 4.0	5.5 to 6.0	3.0 to 3.5	5.5 to 6.0	4.0 to 4.5
	Yasmin	3.0 to 3.5	5.5 to 6.0	3.0 to 3.5	5.5 to 6.0	4.0 to 4.5
	Alejandro	3.0 to 3.5	5.5 to 6.0	3.0 to 3.5	5.5 to 6.0	3.5 to 4.0
2	Marisol	2.0 to 2.5	5.5 to 6.0	3.5 to 4.0	3.5 to 4.0	3.5 to 4.0
	Emilio	1.0 to 1.5	5.0 to 5.3	2.5 to 3.0	5.0 to 5.5	3.0 to 3.5
	Leo	1.0 to 1.5	5.0 to 5.5	2.5 to 3.0	2.5 to 3.0	3.0 to 3.5

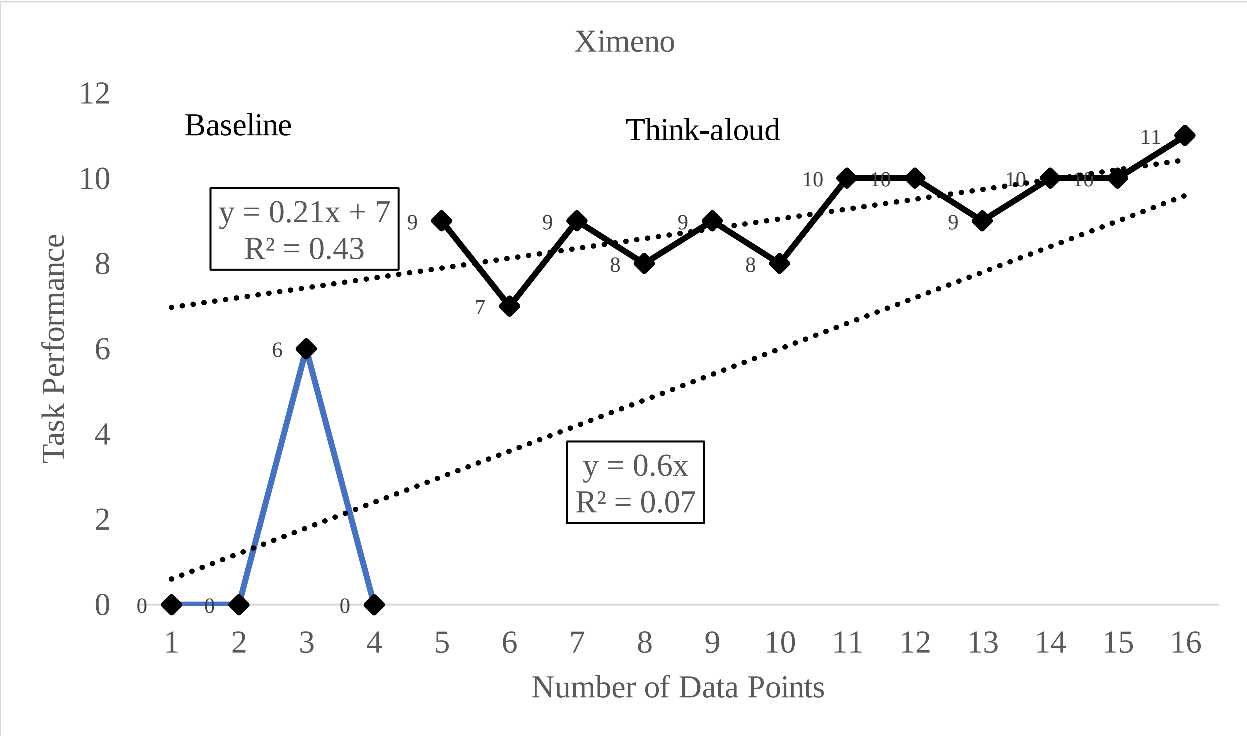
Ximeno

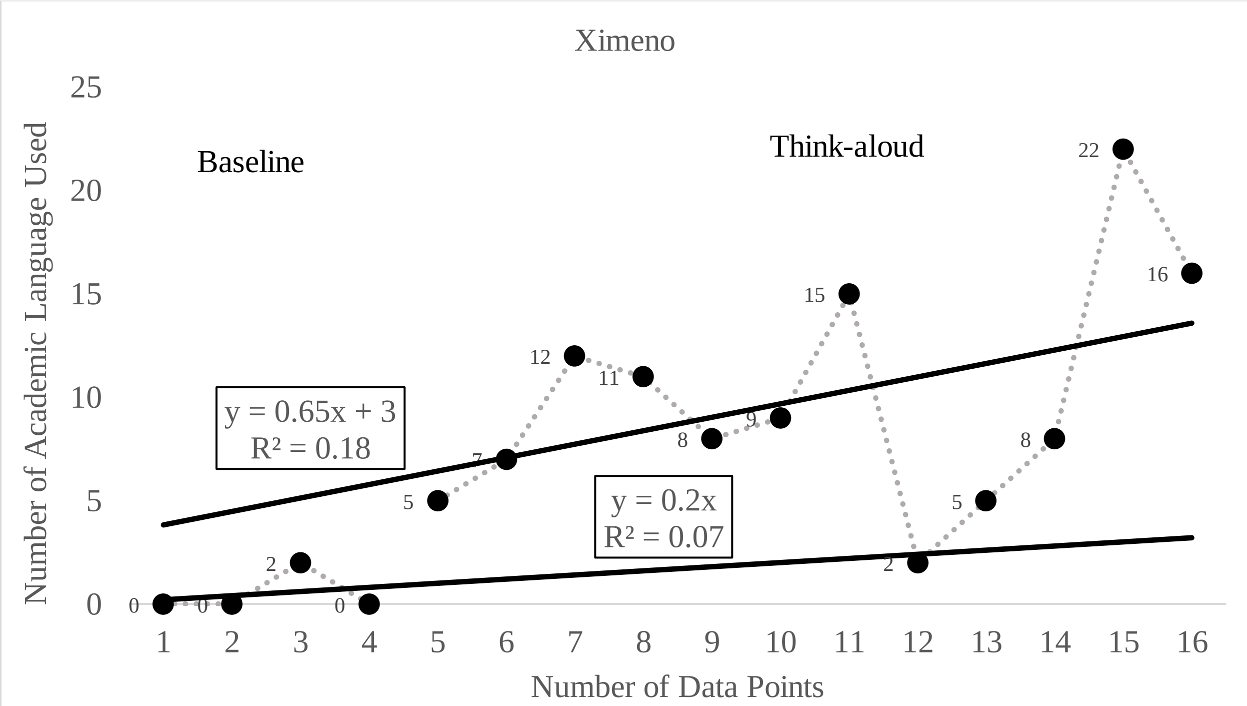
Ximeno was a digital learner both in the baseline and treatment periods. MB Graph 1 indicates that a rapid change occurred in Ximeno's performance shortly after the treatment was introduced, and there is more certainty in the data. Ximeno's performance on formative tasks during baseline was steady with a slightly positive trend (*M*= 1.5; *SD* = 3; *CV*= 2; *R*: 0 to 6). There was an immediate change in level when think-aloud was introduced. Ximeno responded to treatment and consistently performed at a positive tread except for a few declines (*M* = 9.16; *SD* = 1.11; *CV* = 0.12; *R*: 7 to 11). Also, Ximeno rarely used any academic language in the baseline (*M* = 0.5; *SD* = 1; *CV* = 2; *R*: 0 to 2), but his academic language usage drastically improved with treatment (*M* = 10; *SD* = 5.58; *CV* = 0.56; *R*: 2 to 22) and shown with a positive trend. The *CV* values for both task and language usage in the treatment indicate that there is relatively less variation in Ximeno's performance with think-aloud, which shows consistency.

Although the slope (m = 0.21) of the treatment's trend line is lower than the baseline (m = 0.6) in the task score, the R^2 value (0.07) of the baseline is very low, which means the indicated slope of the baseline was not a reliable measurement of data. However, the high slope and high R^2 value (0.43) of the treatment trend line shows that the trend line is a good fit for the data with the think-aloud, which means the data was reliable and consistent with the treatment. The academic language usage was consistent, marked by a high slope and R^2 value for the treatment. MB Graph 1 displays Ximeno's formative task scores and the number of academic words used during 16 days of data.

MB Graph 1

Summary of Ximeno's Performance over 16 Data Points





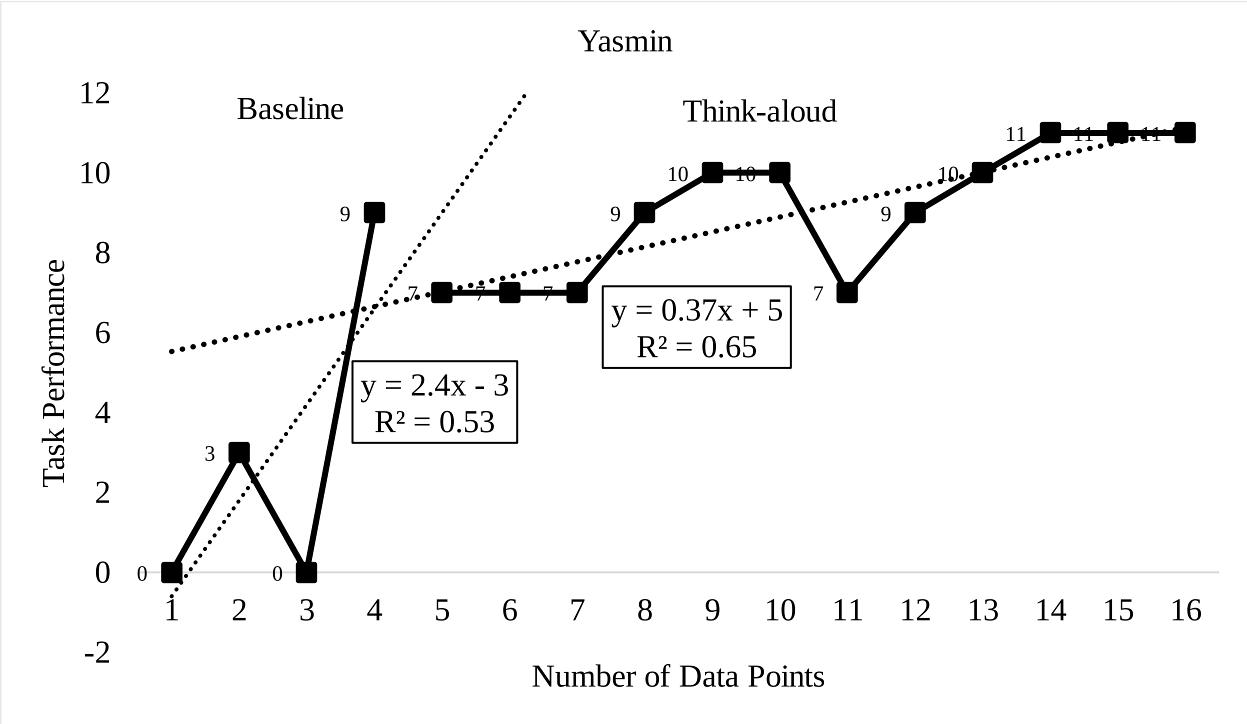
Yasmin

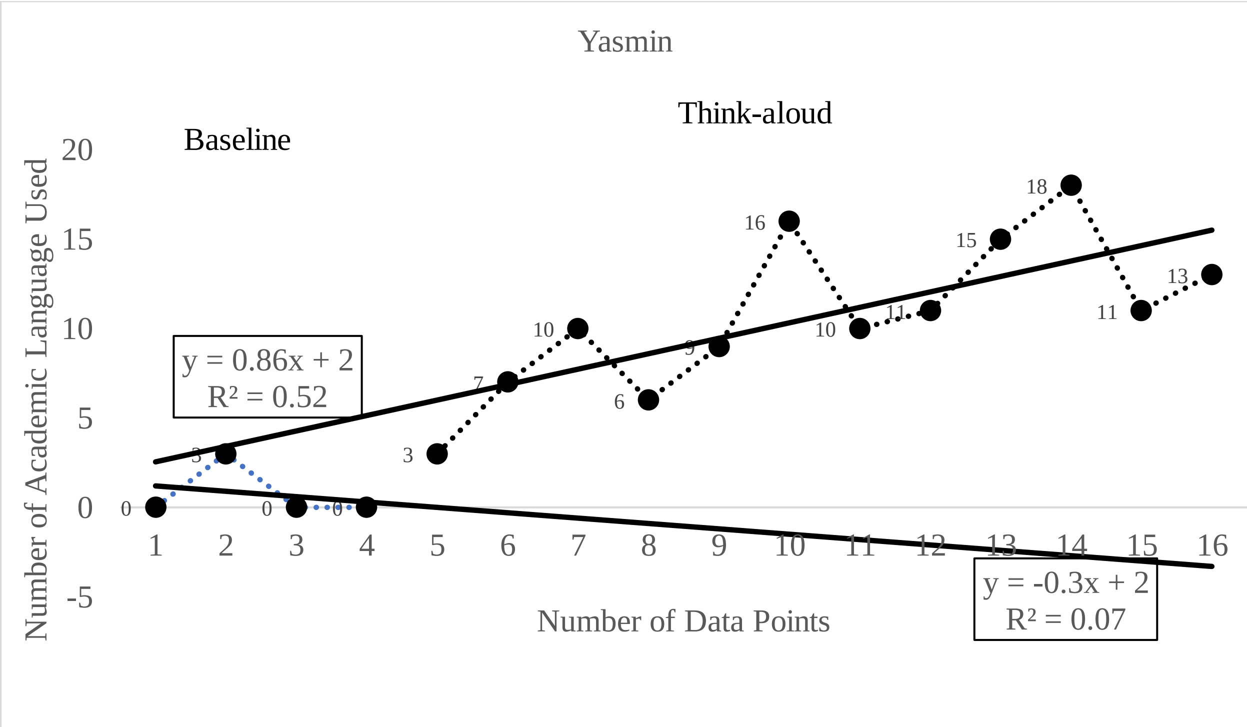
Yasmin was a digital learner in the baseline and a F2F learner in the treatment. MB graph 2 presents that the change in Yasmin's task performance did not occur immediately with the think-aloud but, a change started after a few data points, which results in less certainty. Yasmin's data indicates that her task performance significantly increased from the baseline phase (*M* = 3; *SD* = 4.24; *CV* = 1.4; *R*: 0 to 9) to treatment phase (*M* = 9.1; *SD* = 1.68; *CV* = 0.18; *R*: 7 to 11) with a positive tread. The number of academic vocabulary usage also increased and consistent throughout the treatment phase. In the baseline, she used an average of one word (*M* = 0.75; *SD* = 1.5; *CV* = 2; *R*: 2 to 3), which increased to an average of 11 words (*M* = 10.75; *SD* = 4.3; *CV* = 0.4; *R*: 3 to 18) with treatment. Overall, in 15 weeks of the semester, she progressed in her academic performance and academic language usage from the 5th data point to the 16th data point with less variability.

Even though the slope (*m* = 0.37) of the treatment's trend line is lower than the baseline (*m* = 2.4) in the task score, there was less consistency in the baseline data. The high R^2 value (0. 65) of the think-aloud indicates that the trend line is a good fit for the data, which means the data is reliable and consistent across all 12 days of treatment data. The academic language usage was constant, marked by a high slope (*m* = 0.86) and high R^2 value (0. 52) for the treatment. MB Graph 2 displays Yasmin's formative task scores and the number of academic language words used during 16 days of data.

MB Graph 2

Summary of Yasmin's Performance over 16 Data Points





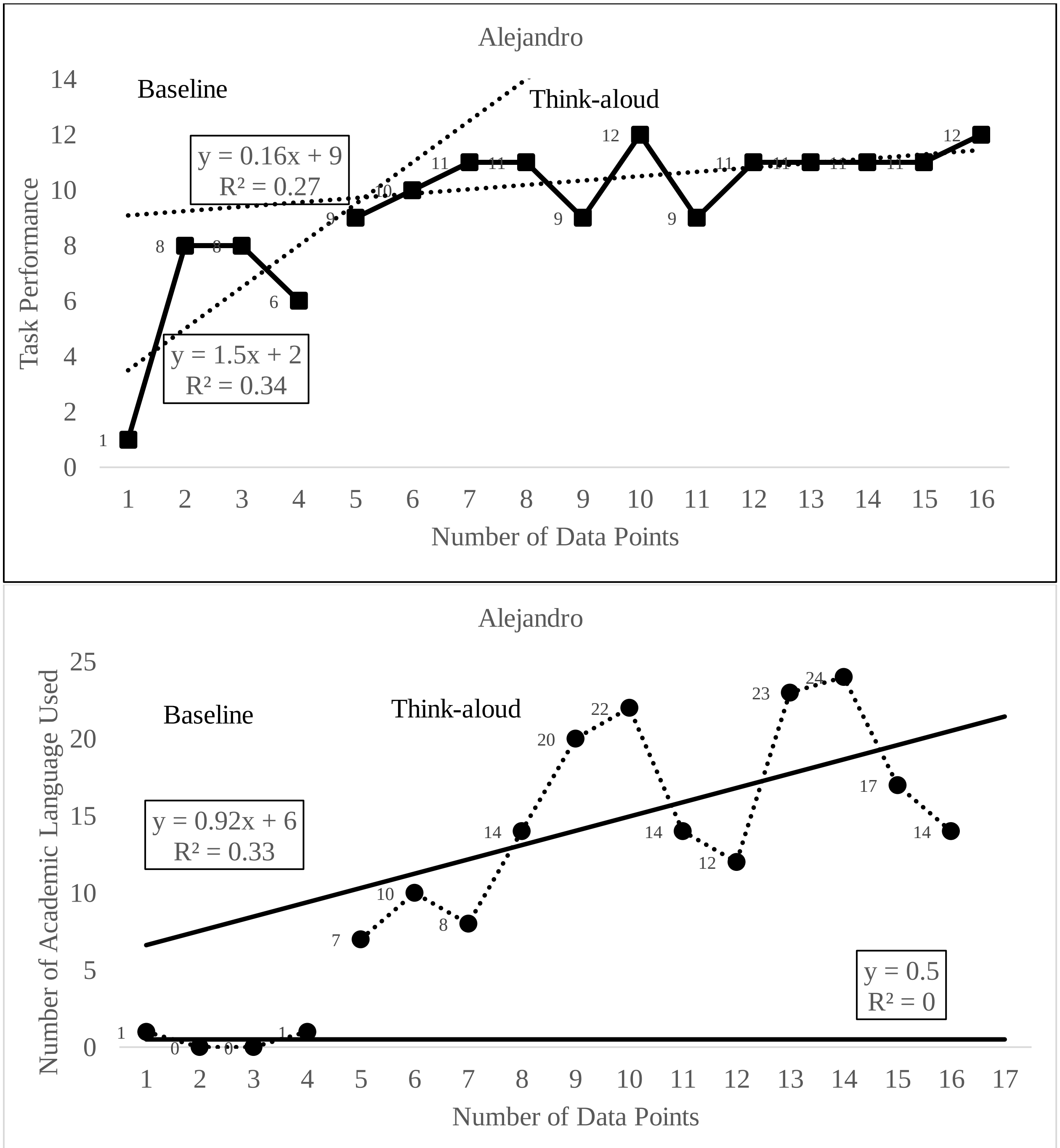
Alejandro

Alejandro completed four baseline and 12 treatment data points without any absences. The following MB Graph 3 displays the consistency in his task performance across 12 treatment data points. Also, the graph indicates that a change occurred in Alejandro's performance instantly after the treatment was introduced, and there is more certainty in the data. Also, the baseline and treatment graphs show a significant difference in academic language usage. Alejandro's task performance had a positive trend *(M* = 5.75; *SD* = 3.3; *CV* = 0.57; *R*: 1 to 8*)* but once the treatment was introduced, the performance started increasing consistently with a positive trend *(M* = 10.6; *SD* = 1.08; *CV* = 0.1; *R*: 9 to 12) and reached the maximum score of 12 twice. Alejandro used the highest number of vocabulary words out of all participants in the treatment phase. Although he had a few declines for academic language usage, Alejandro had a positive trend line in the treatment with an average of 15 words *(M* = 15; *SD* = 5.8; *CV* = 0.38; *R*: 7 to 24) unlike the baseline *(M* = 0.5; *SD* = 0.58; *CV* = 1.16; *R*: 0 to 1). Thus, the coefficient of variation (*CV* = 0.38) indicates that Alejandro consistently used the academic language throughout the treatment phase.

Although the slope (*m* = 0.16) and the R^2 value (0.27) of the treatment's trend line is lower than the baseline's slope (*m* = 1.5) and the R^2 value (0.34) in the task score, his low *CV* value and the high mean (*M* = 10.6) in the treatment phase prove that there is a slight improvement and performance consistency with the think-aloud. The academic language usage was consistent, marked by a high slope (*m* = 0. 92) and R^2 value (0. 33) for the treatment. MB Graph 3 displays Alejandro's formative task scores and the number of academic language words used during 16 days of data.

MB Graph 3

Summary of Alejandro's Performance over 16 Data Points



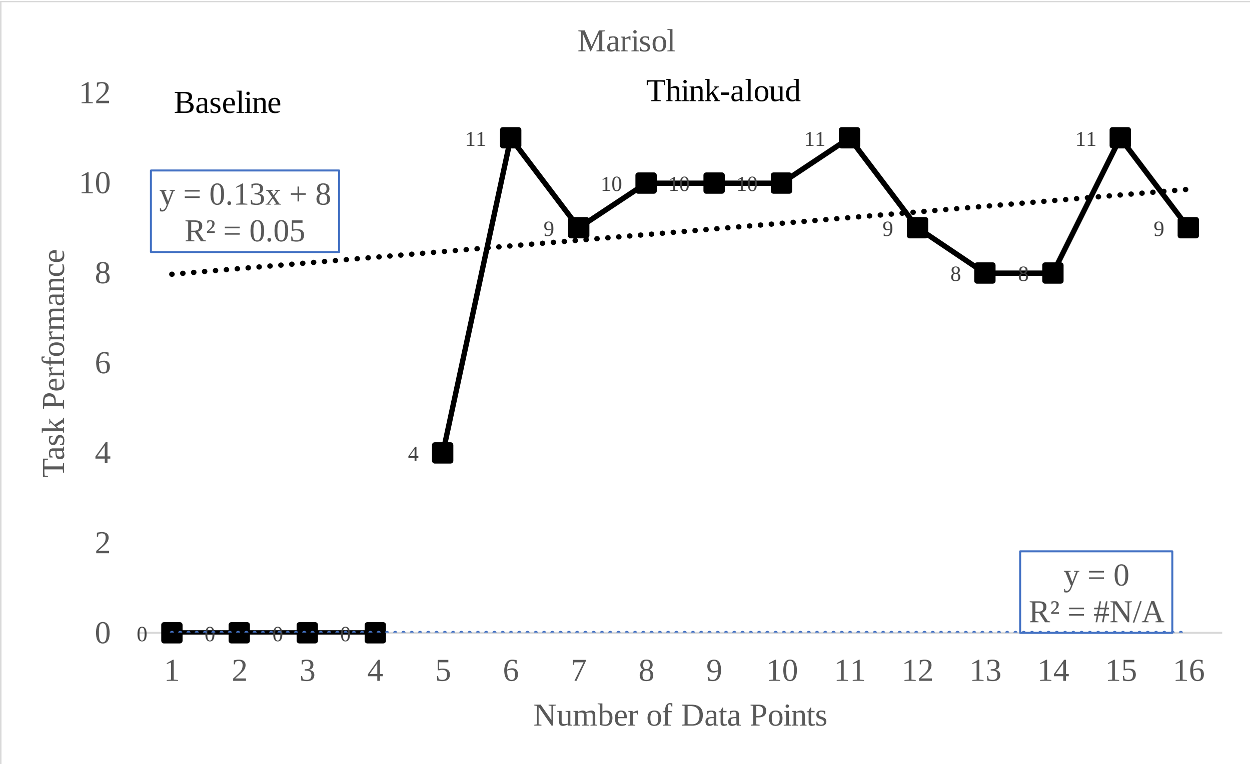
Marisol

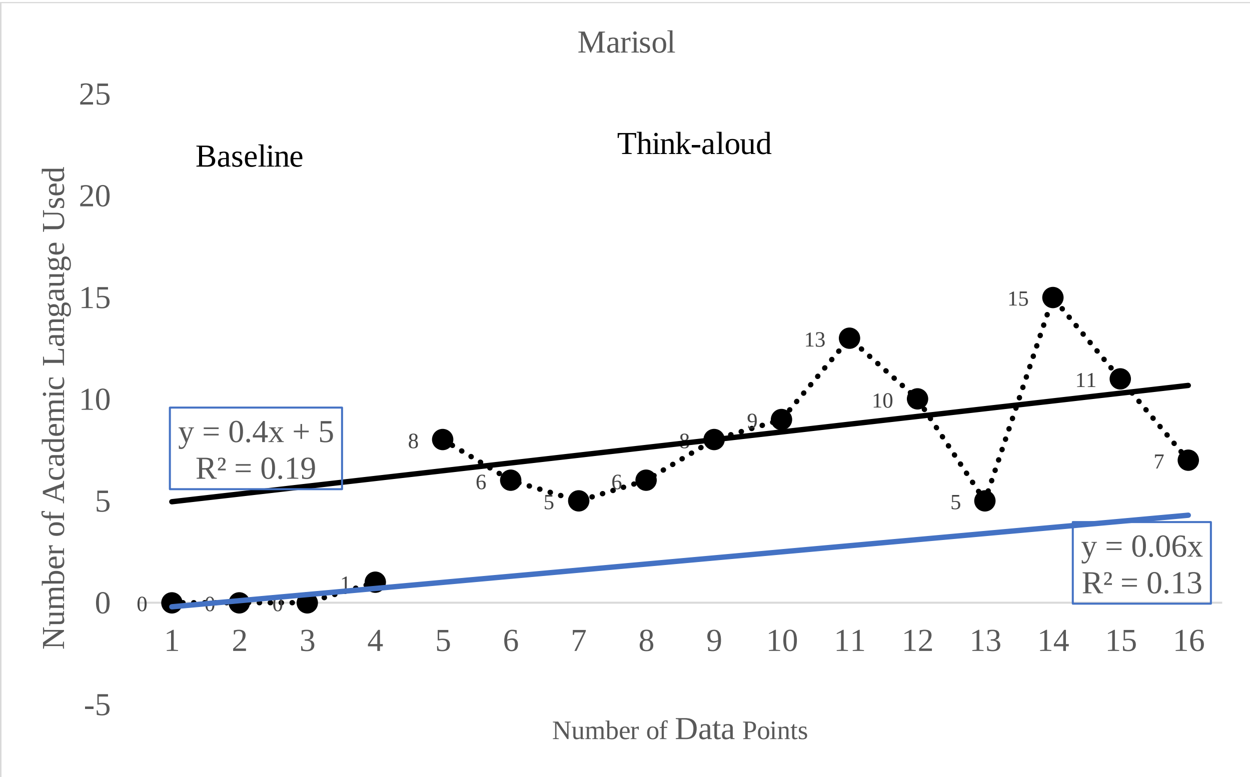
MB Graph 4 indicates that Marisol improved substantially in her task performance from baseline to the treatment phase. Also, a rapid change occurred in her performance shortly after the treatment was introduced, and there is more certainty in the data. She made all zeros in the baseline phase (*M* = 0; *SD* = 0; *CV* =0; *R*:0) with a trend line of zero slope, but she started with a score of 4 and went up to 11, out of 12, on three formative tasks, which is a significant improvement. Overall, she improved her task performance to a mean score of 9.2 (*M*= 9.2,1 *SD* = 1.94, *CV* = 0.21; *R*: 4 to 11) with the think-aloud. The treatment also showed a positive trend with a slope of 0.13, which indicates an increase in performance. Also, the maximum academic language used in the baseline was almost none (*M* = 0.25; *SD* = 0.5; *CV* = 2; *R*: 0 to 1) with slightly a positive trend (*m* = 0.15) and it increased slowly and reached a maximum of 15 words (*M* = 8.6; *SD* = 3.18; *CV* = 0.37; *R*: 5 to 15), which was a great improvement in her academic language usage. Although Marisol's speaking was in the range of 2.0 to 2.5, the positive trend line (*m* = 0.15) increased to 0.38 in the treatment phase. While her language usage declined in the first few think-alouds; it eventually increased from the 4th data point in the treatment stage except for a couple of declines.

Marisol made zeros in her baseline performance, which led to zero slope (*m* = 0; R^2 = N/A). However, her treatment performance had a slightly positive trend line with a slope of 0. 13 and an R^2 value of 0.05, which shows less consistency in her task performance. Although there was inconsistency in her academic language usage (R^2 = 0.19) with the think-aloud, overall, Marisol's language usage improved because the value of the positive trend line's slope increased from 0.06 to 0.4 with the treatment.

MB Graph 4

Summary of Marisol's Performance over 16 Data Points





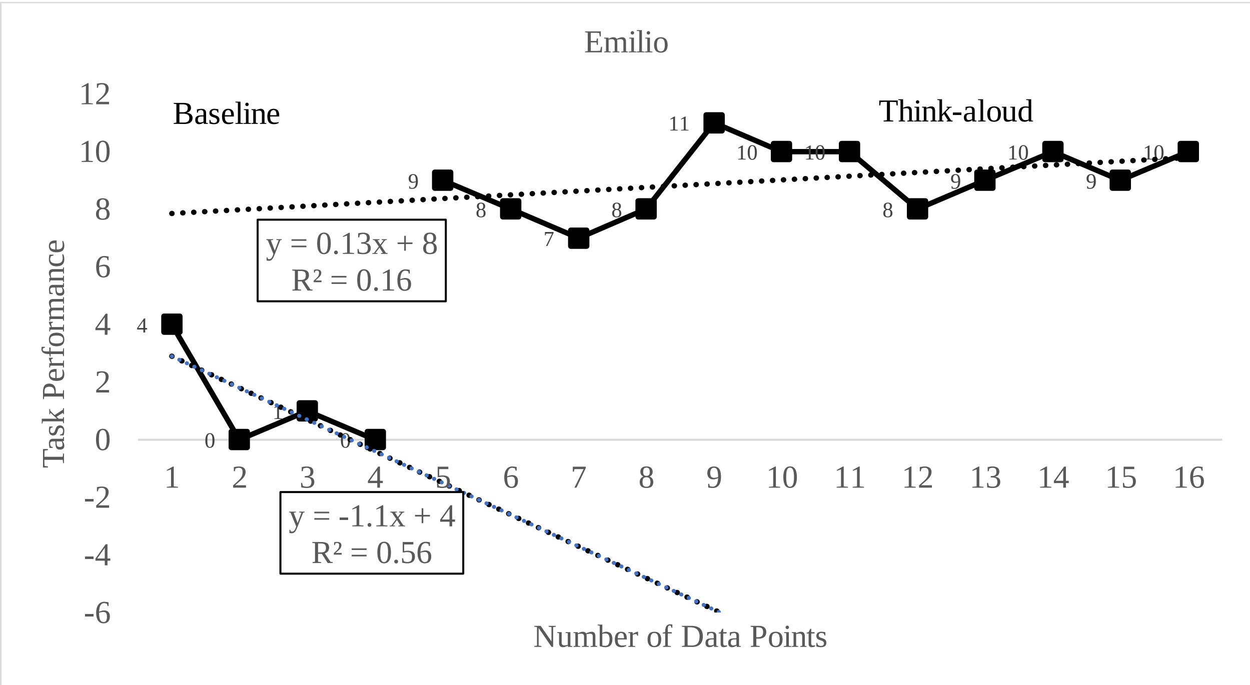
Emilio

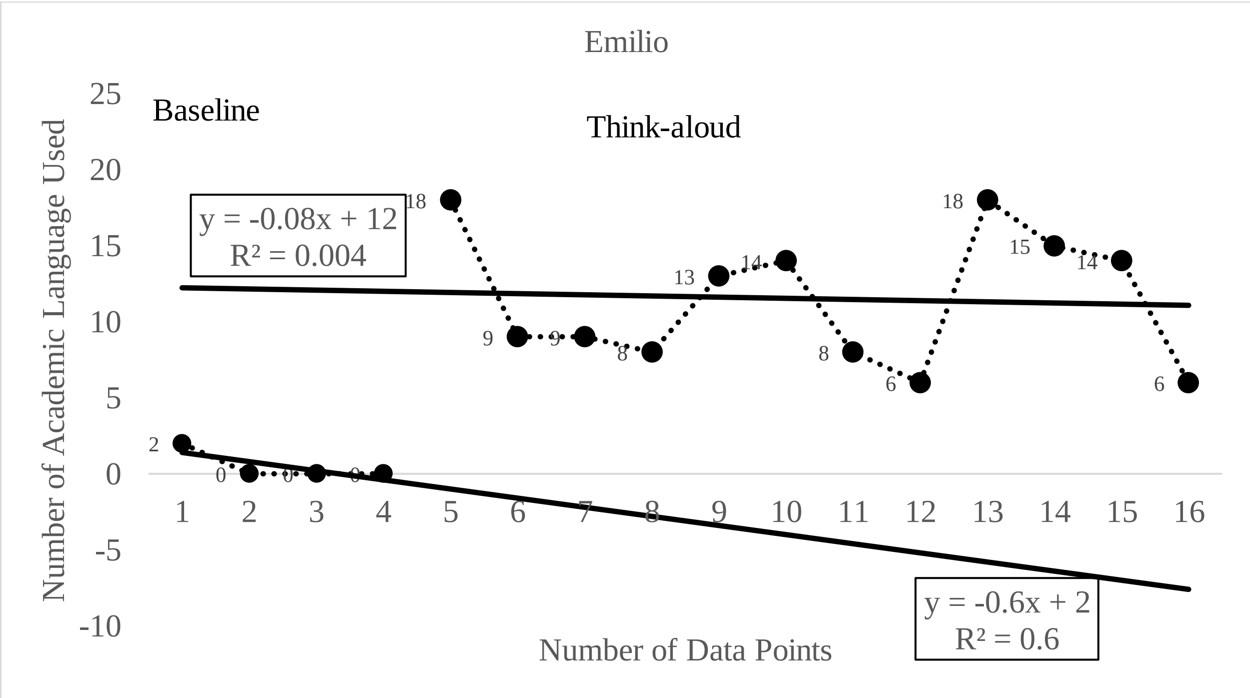
MB Graph 5 displays that a rapid change occurred in Emilio's performance immediately after the treatment was introduced, and there is more certainty in the data. Emilio performed with a mean task score of 1.25 (*SD* = 1.89; *CV* = 1.5; *R*: 0 to 4) without the treatment. Then, the think-aloud improved his mean score to 9.1 (*SD* = 1.16; *CV* = 0.13; *R*: 7 to 11), which indicates that his performance was consistent throughout the 12 treatment data points. Also, the linear trend line slope went from a negative value (*m* = -0.55) to a positive value (*m* = 0. 13). Despite ups and downs in the graph, his performance had a significant improvement. Also, Emilio's academic language escalated substantially from an average of using less than a word (*M = 0.5; SD* = 1; *CV* = 2; *R*: 0 to 2) without treatment to an average of 11.5 words (*SD* = 4.36; *CV* = 0.38; *R*: 6 to 18) with the think-aloud. However, there are several declines in language usage. The dotted graph indicates that Emilio learned many vocabulary words during this semester and could use them in his think-aloud despite his low ACCESS speaking scores (1.0 to 1.5). Emilio's negative trend line with slope (*m* = -0.3) went up to -0.08, which shows that his consistency in using the language improved from baseline to treatment.

The following MB Graph 5 shows that Emilio's baseline data had negative task performance trends (*m* = -1.1) and language usage (*m* = -0.6). However, the former turned positive (*m* = 0.13) with the treatment, and the latter (*m* = -0.08) stayed still in the negative trend but with a reduced slope. Even though the R^2 value for both task and language declined from the baseline and the treatment, the slope value's drastic increase indicates that Emilio improved his performance and language with the treatment.

MB Graph 5

Summary of Emilio's Performance over 16 Data Points





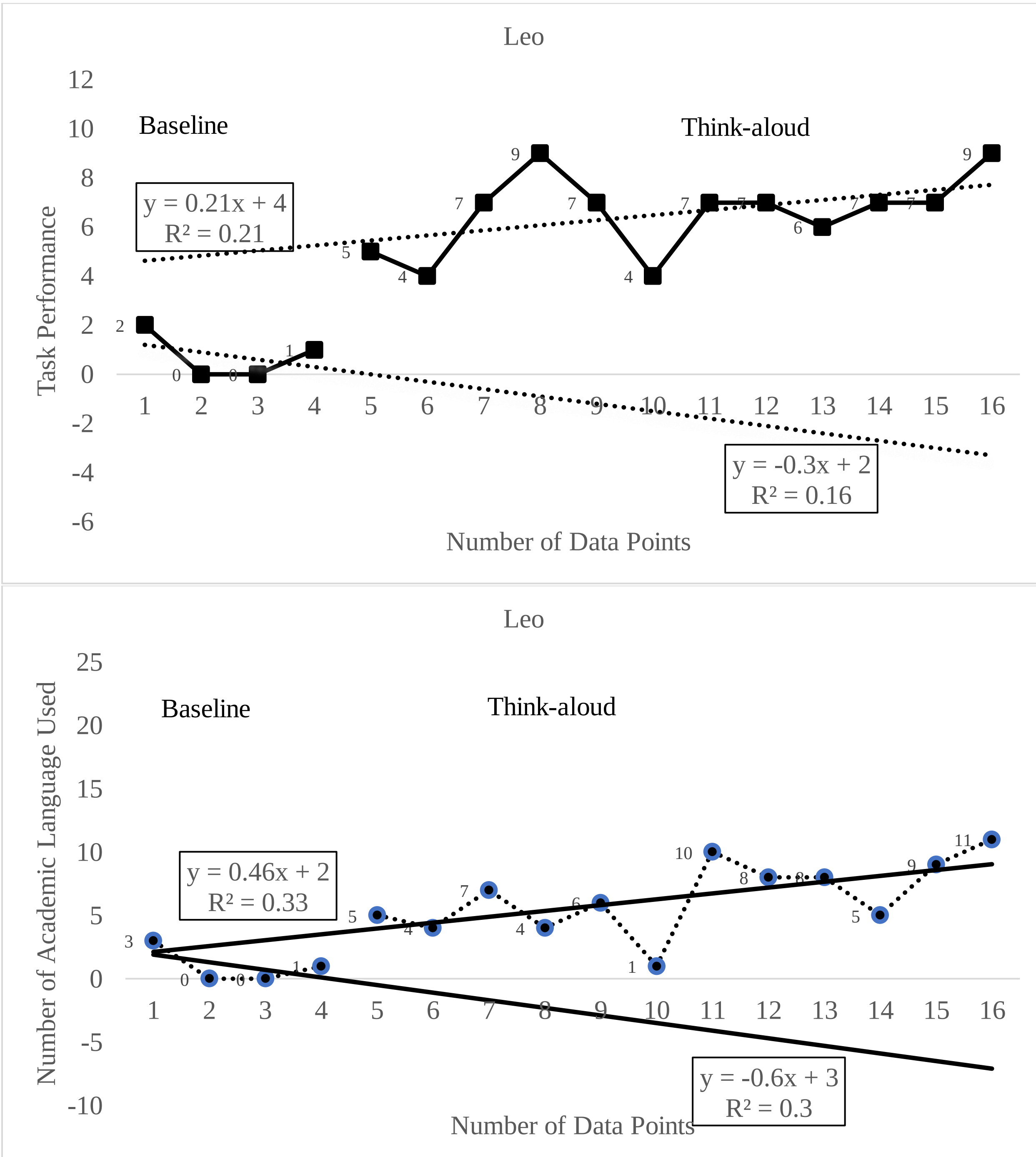
Leo

MB Graph 6 indicates that a rapid change occurred in Leo's task performance shortly after the treatment was introduced, and there is more certainty in the data. Leo's task performance and academic language usage in the baseline was inconsistent and had a negative trend line, as shown in MB Graph 6. Without the think-aloud strategy, Leo earned a mean score of 0.75 (*SD* = 0.96; *CV* = 1.28; *R*: 0 to 2) and it went up to a mean of 6.6 (*SD* = 1.62; *CV* = 0.25; *R*: 4 to 9) with the treatment. The decline in the variation coefficient indicates that Leo benefitted from the think-aloud to improve his problem-solving performance. The baseline slope increased from -0.3 to +0.23 in the treatment, indicating consistency in his treatment performance.

Despite his low ACCESS speaking scores (1.0 to 1.5), Leo's academic language improved from using an average of one word in the baseline (*SD* = 1.41; *CV* = 1.41; *R*: 0 to 3) to an average of seven words (*SD* = 2.88; *CV* =0.44; *R*: 4 to 11) in the treatment phase. Again, the low *CV* value with the treatment and the increase in the slope from a negative value (*m* = -0.6) to positive (*m* = 0.46) indicate that Leo maintained consistency in using the academic vocabulary. Moreover, a slight increase in R^2 values in both graphs show that Leo's performance was somewhat consistent in the treatment phase. MB Graph 6 displays how Leo's task performance and academic language usage formed positive trend lines with the treatment.

MB Graph 6

Summary of Leo's Performance over 16 Data Points



Possible Trends in Data Analysis

There were two groups of students selected based on their 7th- grade mathematics performance and ACCESS test scores in the study. Group 1 performed at a range of DDA scores above 60%, and Group 2 performed at below 60%. Also, Group 1's ACCESS scores were relatively higher than Group 2 as shown in Table 4.

During data analysis, I discovered several trends in the data regarding the effect of the think-aloud strategy. The study with six students on 16 different days across 15 weeks produced adequate data and examined six various trends. Table 5 displays the trends found in the data analysis by categories.

Table 5

Summary of Trends found in Data Analysis

Trends	Category	Claim
1	Task Performance	Groups' problem-solving performance increased from baseline to treatment with think-aloud
2	Academic Language	Groups' academic language improved from baseline to treatment with think-aloud
3	Tsk Vs. AcLa	Academic language usage was directly proportional to students' task performance score
4	Gender Differences	Males used more vocabulary words than females in their think-aloud
5	Speaking Vs. Writing	ELLs used more academic language in their speaking than writing when asked to explain their reasoning
6	Complexity of Content	The academic language used depends on the complexity of the problem
7	Learning Model	F2F Participants benefited from think-aloud more than DLs

Evidence of Trend 1- Task Performance: Groups' problem-solving performance increased from baseline to treatment with think-aloud

The mean baseline task performance of Group 1 was 3.42 (*SD* = 3.7, *CV* = 1.08; *R*: 0-9) and the treatment mean was 9.64 (*SD* = 1.46, *CV* = 0.15; *R*: 7-12), thus, the difference in the averages was 6.22. However, the coefficient of variation was 1.08 for baseline, which went down to 0.15 in the treatment phase. The substantial decline in CV's value indicates less variation in the group's task score in the group, which shows consistency in their performance with the treatment. Group 2 performed at a mean of 0.67 (*SD* = 1.23, *CV* = 1.84; *R*: 0-4) in the baseline phase, whereas the treatment's mean was 8.28 (*SD* = 1.98, *CV* = 0.24; *R*: 4-11), thus, the difference was 7.61. Group 2 performed consistently in the treatment phase, indicated by the CV's drop from 1.84 to 0.24 with treatment. Although Group 1 maintained consistency with treatment, the mean task performance for Group 2 is higher than Group 1's performance, which could indicate that Group 2 benefitted slightly more than Group 1. Table 6 displays the summary of the statistical analysis of task scores of the baseline (BL) versus treatment (Trt).

Table 6

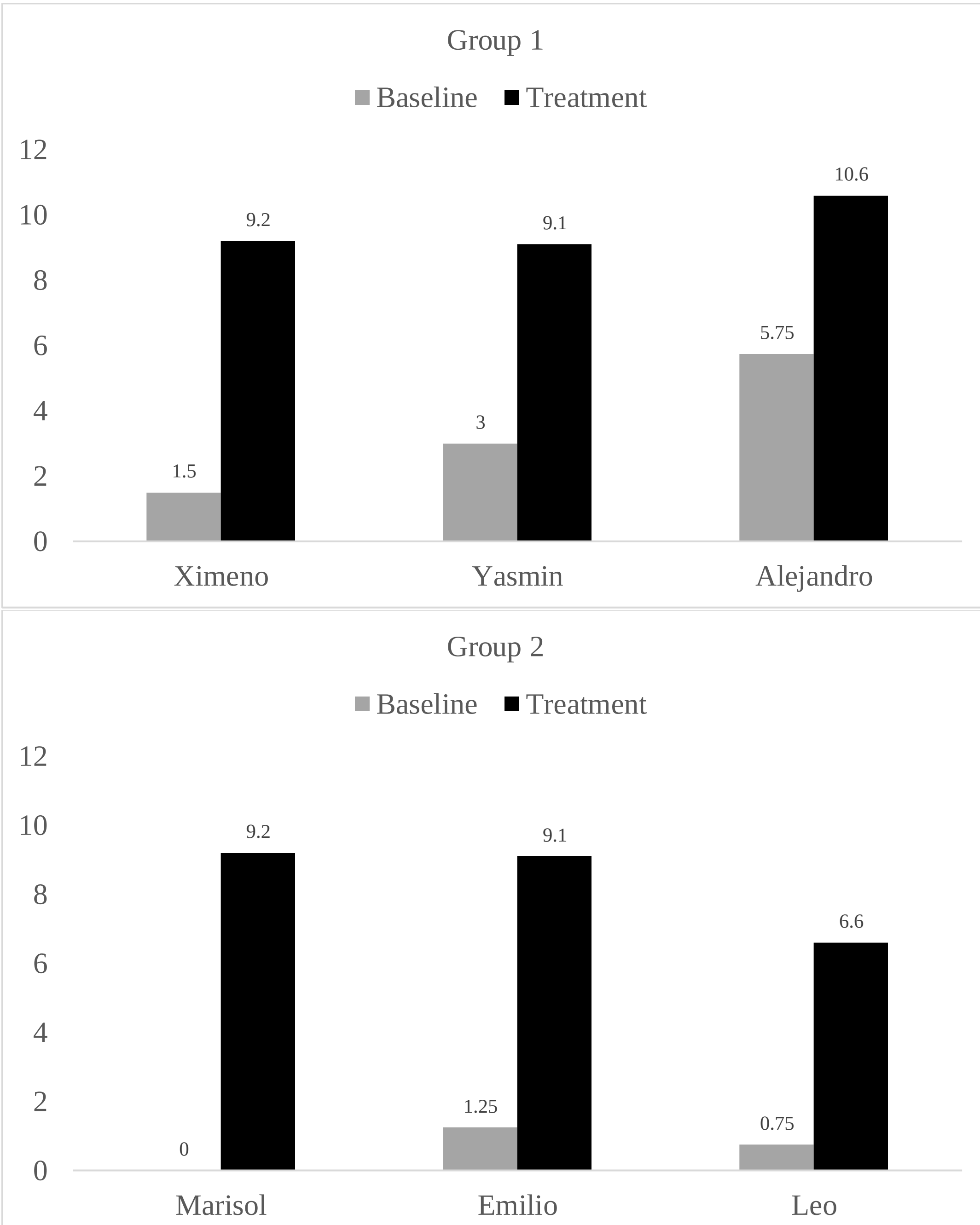
Summary of Descriptive S1tatistics of Task Performance

Group #	BL M	BL *SD*	BL *CV*	BL R	Trt M	Trt *SD*	Trt *CV*	Trt R
1	3.42	3.7	1.08	0-9	9.64	1.46	0.15	7-12
2	0.67	1.23	1.84	0-4	8.28	1.98	0.24	4-11

The comparison between the two groups' task performance in baseline and treatment phases is displayed in Bar Graph 1 and MB Graph 7. Bar Graph 1 explains how each student's mean score of performance on formative tasks increased from baseline to treatment. MB Graph 7 illustrates a comparison of task performance between two groups over 16 data points.

Bar Graph 1

The comparison between Task Performances of Group 1 and Group 2



MB Graph 7

The comparison between Task Performances of Group 1(left) and Group 2 (right)

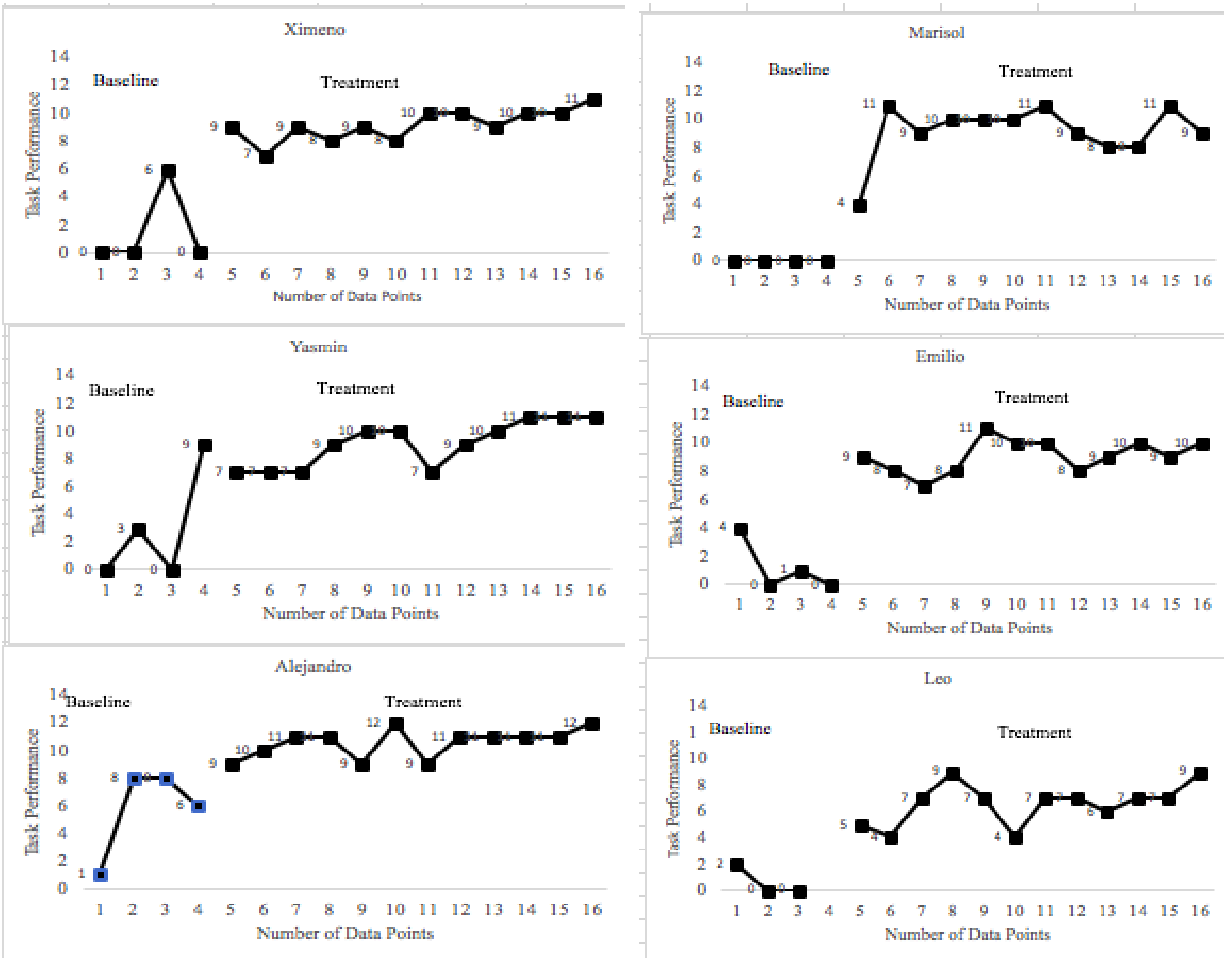
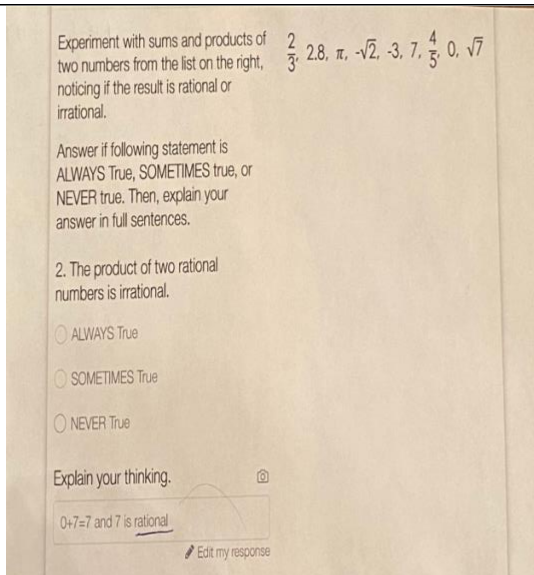
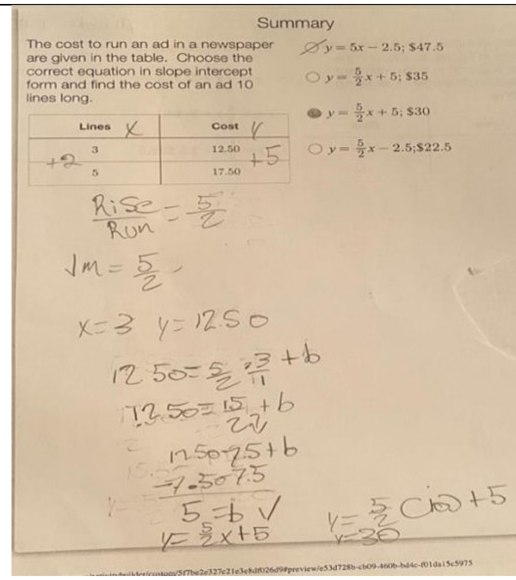


Table 7 displays Alejandro's (Group 1) and Emilio's (Group 2) work samples, and both students are F2F learners during the treatment. The student samples show how these participants produced more detailed problem-solving procedures during think-aloud than without think-aloud. Since the baseline phase occurred in the digital platform for all participants, the student work was typed, whereas the treatment phase happened in the concurrent model, which was written on the paper. These samples also show that the student work was incomplete without think-aloud and completed with detailed steps with think-aloud.

Table 7

Student Samples of F2F learners, Alejandro and Emilio

<table>
<tr><th>Group</th><th>Baseline</th><th>Treatment</th></tr>
<tr><td>1</td><td>
</td><td>
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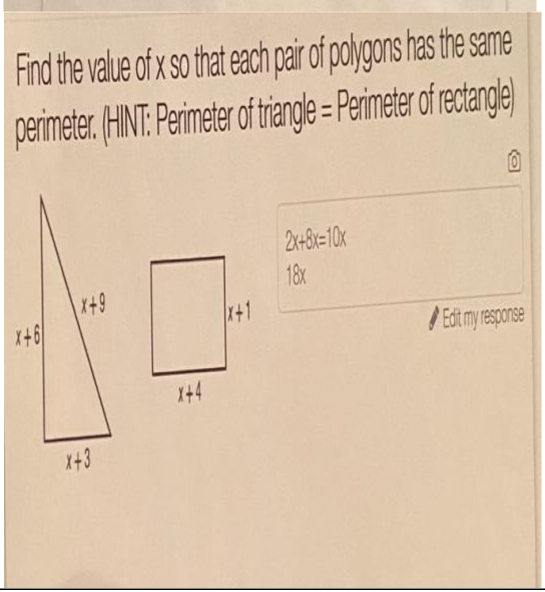
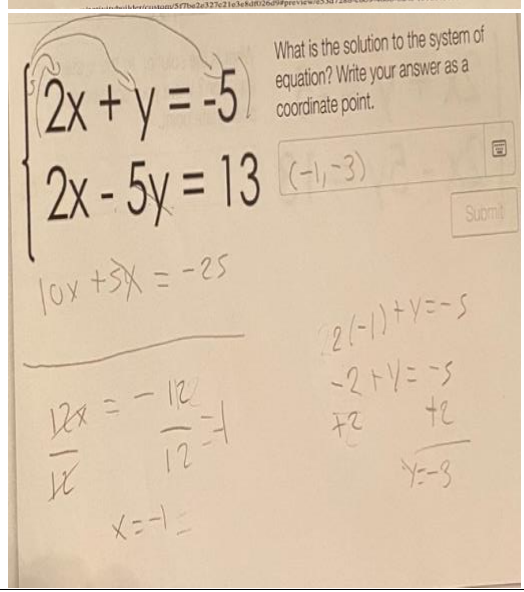
<tr><td>2</td><td>
</td><td>
</td></tr>
</table>

Evidence of Trend 2- Academic Language: Groups' academic language improved from baseline to treatment with think-aloud

For the number of academic language usage, Group 1 used an average of less than a word (M = 0.64; SD = 1, CV= 1.56; R: 0-3) in the baseline phase (BL) and an average of 12 words

(*M* = 12.06; *SD* = 5. 67, *CV* = 0.47; *R*: 2-24) in the treatment phase (Trt). The increase in the average score and the *CV*'s drop indicates improved language usage by Group 1 with the think-aloud treatment. Lastly, the average of academic vocabulary words used by Group 2 was less than a word (*M* = 0.58; *SD* = 0.996, *CV* = 1.72; *R*: 0-3) in the baseline and nine words (*M* = 8.86; *SD* = 4, *CV* = 0.45; *R*: 1-18) in the treatment phase. Again, the escalation in the average word usage and the value of the coefficient of variation specifies that the think-aloud improved Group 2's academic language acquisition. Table 8 displays the summary of descriptive statistics of academic language usage by participants in both groups.

Table 8

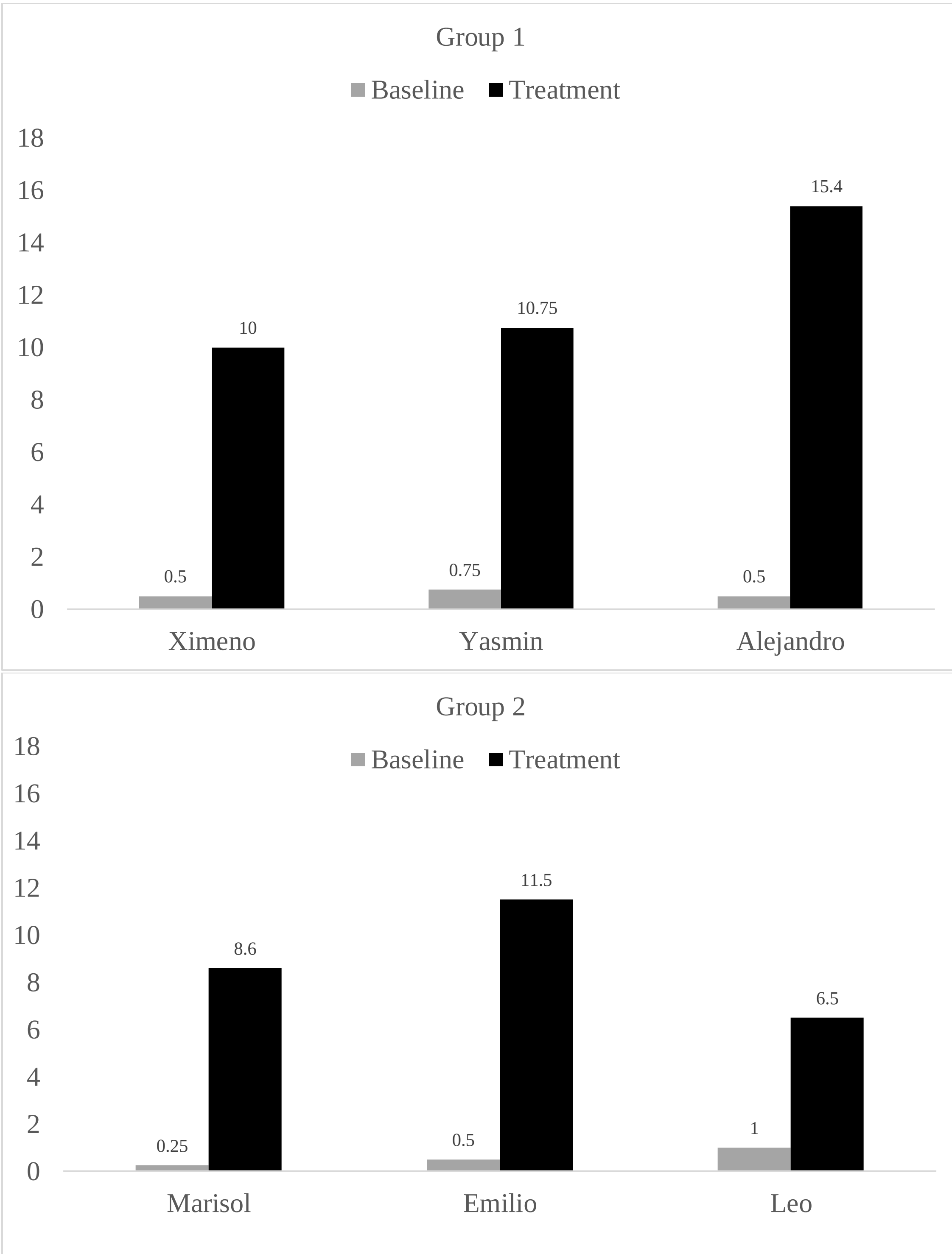
Summary of Descriptive statistics of Academic Language Usage

Group #	BL *M*	BL *SD*	BL *CV*	BL *R*	Trt *M*	Trt *SD*	Trt *CV*	Trt *R*
1	0.64	1	1.56	0-3	12	5.67	0.47	2-24
2	0.58	0.996	1.72	0-3	9	4	0.45	1-18

The comparison between the two groups' academic language usage in both baseline and treatment phases is explained in Bar Graph 2 and MB Graph 8. Bar Graph 2 displays how students improved their academic language usage from baseline to treatment with the think-aloud process. MB Graph 8 presents a comparison between two groups' academic language usage over 16 data points.

Bar Graph 2

The comparison between the number of Academic Language Used by Group 1 and Group 2



MB Graph 8

The comparison between the number of Academic Language Used

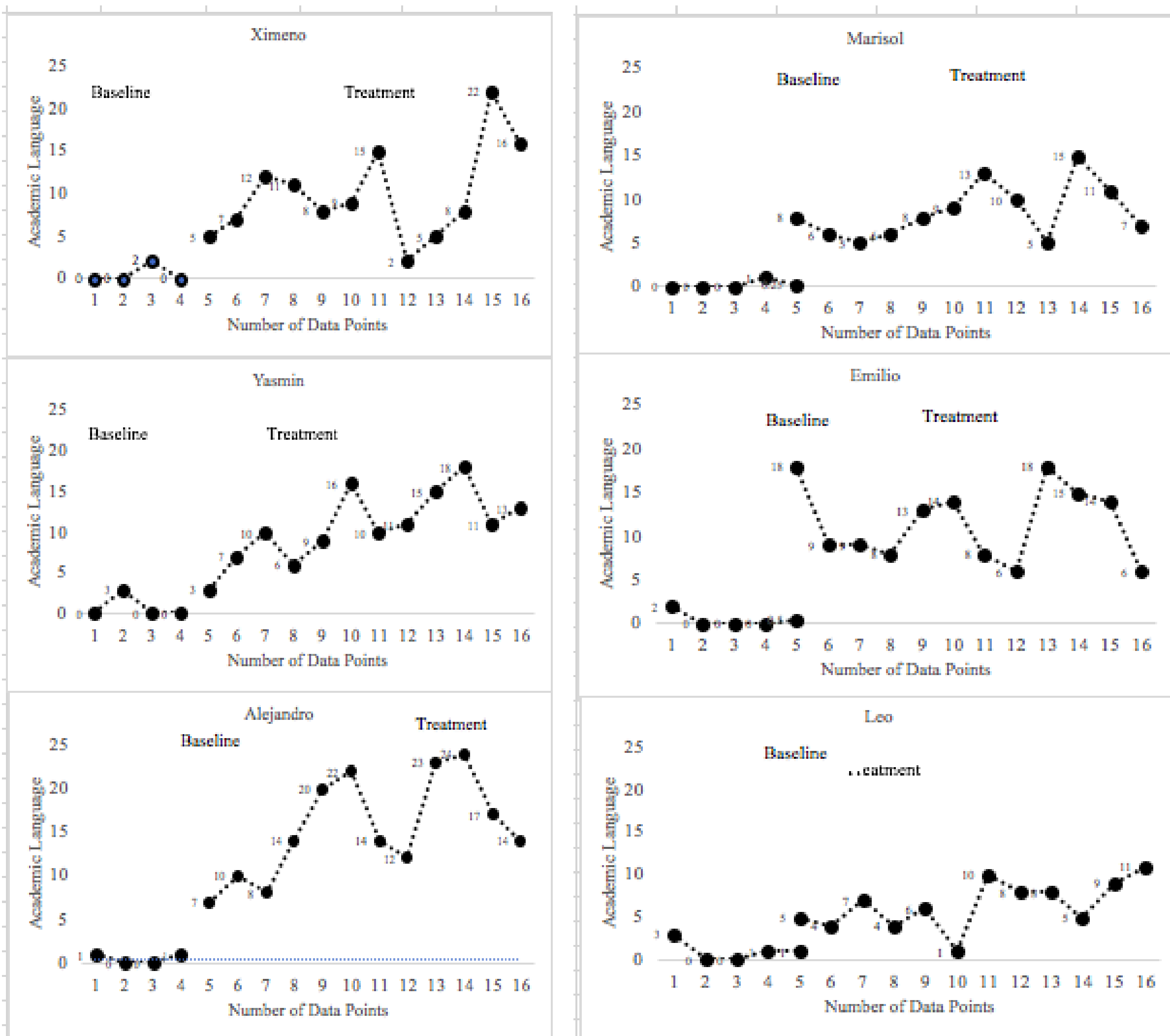
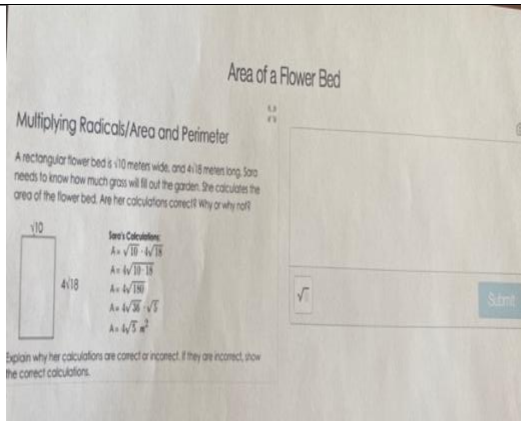
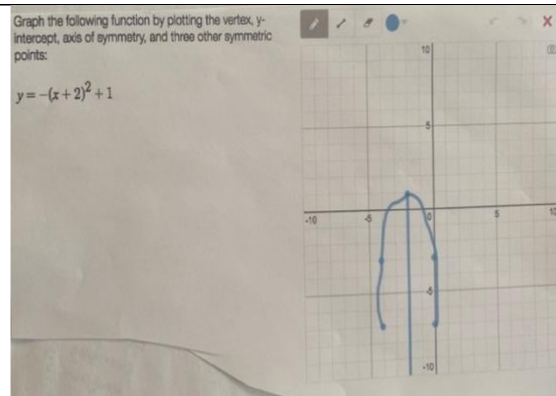
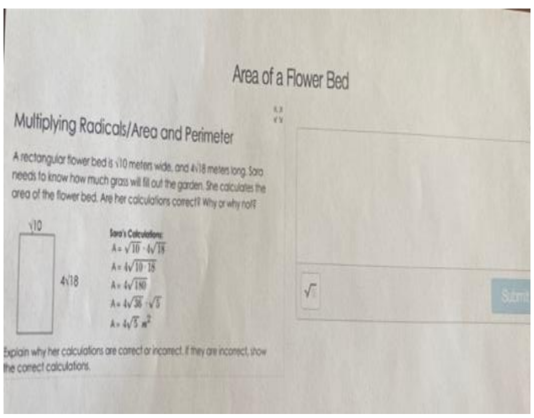
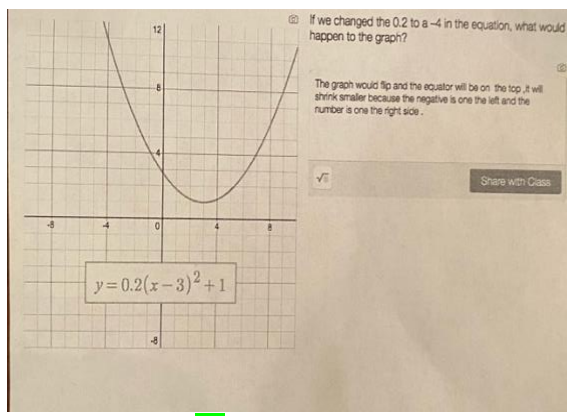


Table 9 demonstrates baseline student samples and the think-aloud transcripts of how ELLs improved their academic language over a specific time. Table 9 presents two digital students' work, Ximeno (Group 1) and Leo (Group 2). Both didn't attempt the formative tasks during the baseline phase but completed their work with the think-aloud.

Table 9

Student Samples of DLs, Ximeno (top) and Leo(bottom) from Baseline and Treatment Phases

Group #	Baseline	Treatment
1	 	 The Vertex is negative two and one. I got negative two because I figured out that... Okay. I did the vertex form and I can also see that this graph is a reflection because it has a negative sign in the front, at the start. I got negative two because my H value is positive two. But the H value always switches the signs to the opposite of that. So from positive it went to a negative. And then my K value is one. So that's how I got my vertex negative two, one. My Y intercept is neg zero, negative three. I got negative three because I replaced X with zero and then I solved it and I got zero... No. The equation that I used was zero plus two squared plus one. Zero plus two is nothing, just two. I split the signs because it's the H value which was negative four because I squared positive two, and then I just added the one and I got negative three. My axis of symmetry is negative two because that is the H value. And then for three other points, I got one which is zero, negative eight. I got this because I replaced X with one and then I... X equals one and then I just filled the blank, which was one plus two squared plus one. One plus two that's three. Flip the sign. That's a negative three, squared, that's nine, plus one equals negative eight. I plotted them. Total # of words: 22
2	 	 The graph is going to flip and the equate is going to be on the top. The graph shrank because the negative is on the left side and the number is on the right side. The numbers make smaller reflection. Total # of words: 9

Evidence of Trend 3- Performance Vs. Academic Language: The academic language usage was directly proportional to students' task performance score

A notable trend emerged from the data that it was likely that there is a proportional relationship between students' task performance score and the number of academic language used in solving it. In other words, in many instances, as participants' academic vocabulary word usage increased, their task performance score either improved or maintained consistency at the high end and vice versa. Specifically, compared to the other participants, Marisol had more incline and decline arrows, and Yasmin had more inclined arrows, which indicates that these female participants' performance improved when they utilized detailed think-aloud with more vocabulary words.

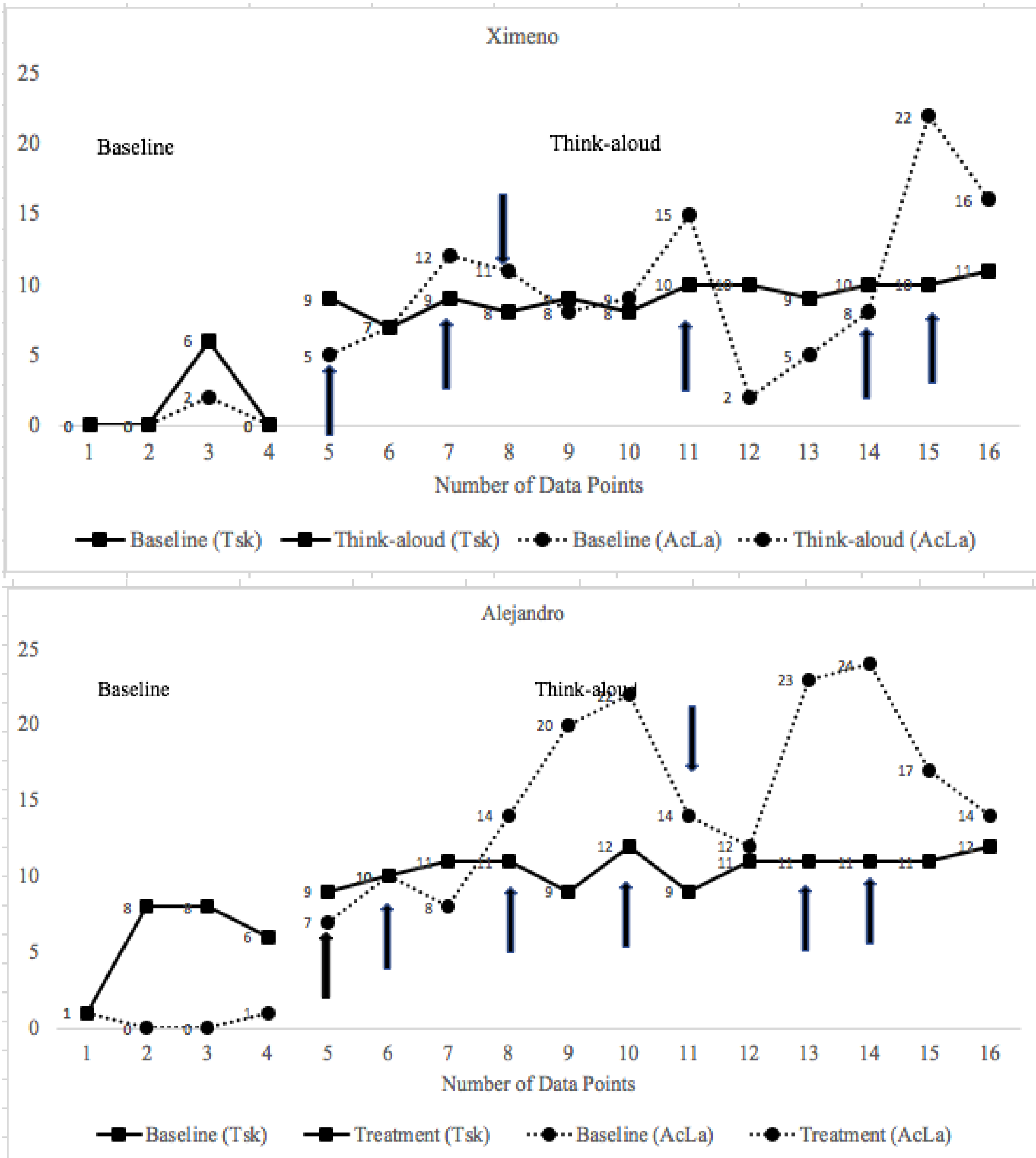
The task performance score includes four steps of problem-solving: defining the problem, developing a plan, collecting and analyzing the information, and solving the word problem presented in the rubric (Appendix A). Therefore, this trend could also indicate that if students used all four steps of the problem-solving process with detailed think-aloud, they could use more academic language, which ultimately helps them perform better on the task. The double MB graphs present these inclines and declines for each ELL. MB Graph 9 with up and down arrows illustrates the proportional relationship between task performance with a solid line and the number of the academic language used with a dotted line for each participant. Participants' six double MB graphs are divided into three groups based on the proportional relationships and patterns. The task score and language usage were less related for Ximeno and Alejandro from Group 1, but the solid line patterns (Tsk) and dotted line patterns (AcLa) were very similar.

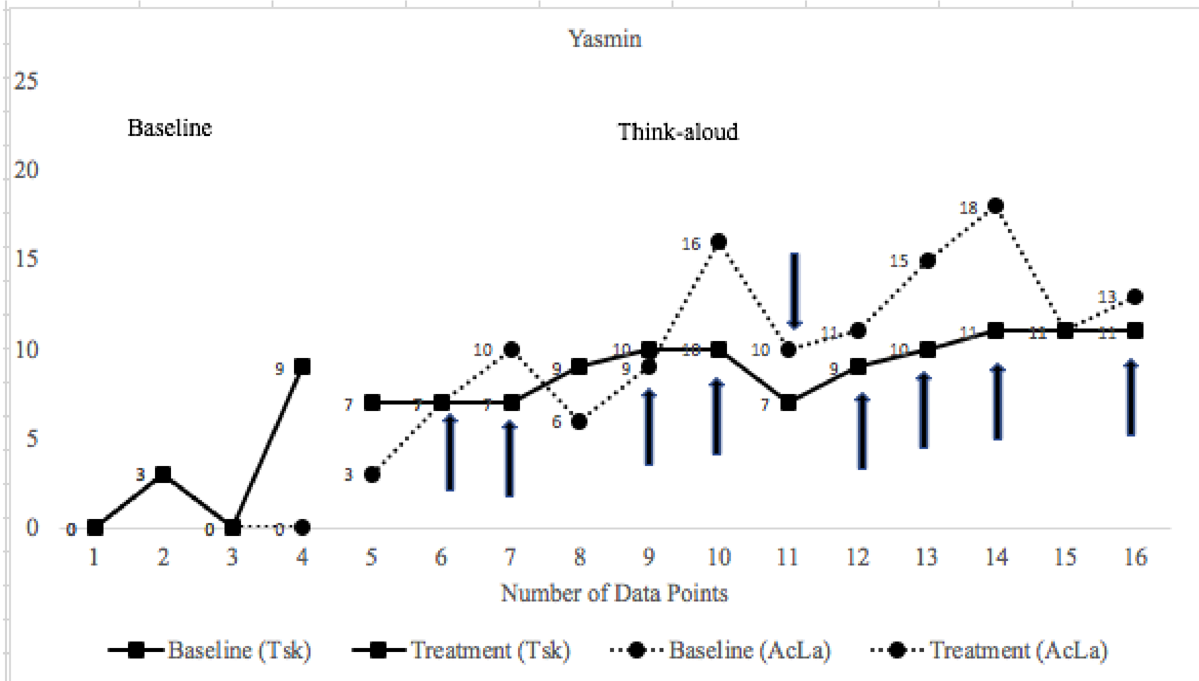
On the other hand, the proportional relationship between Tsk and AcLa was higher between Yasmin and Marisol though the dotted and solid lines' patterns didn't fully match.

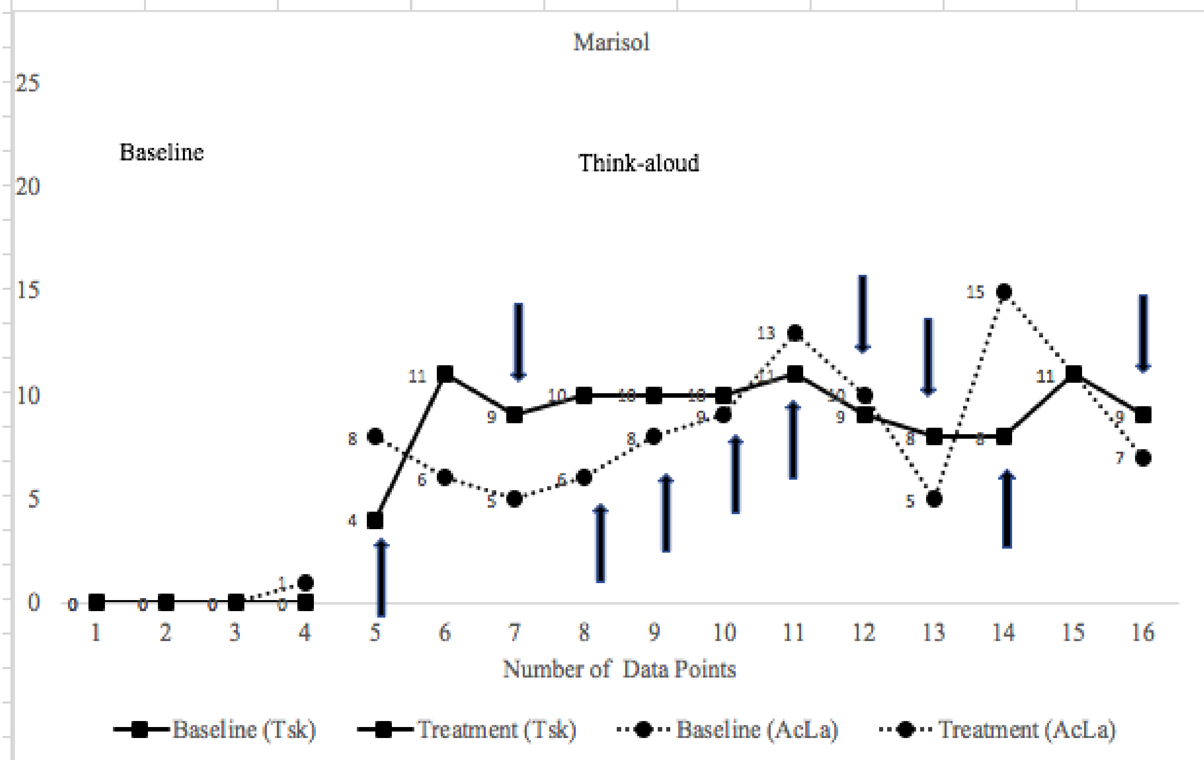
Similarly, Emilio and Leo from Group 2 were in the same Tsk and AcLa association, but there was no pattern in their dotted or solid lines. Figure 10 displays the work samples of Yasmin (Group 1) and Emilio (Group 2); when they used detailed think-aloud with more mathematical vocabulary words, they earned a high score on their task performance. Moreover, the samples and transcriptions show that these participants defined the problem, developed and executed the plan using the given information, and obtained the correct solution in a thorough think-aloud.

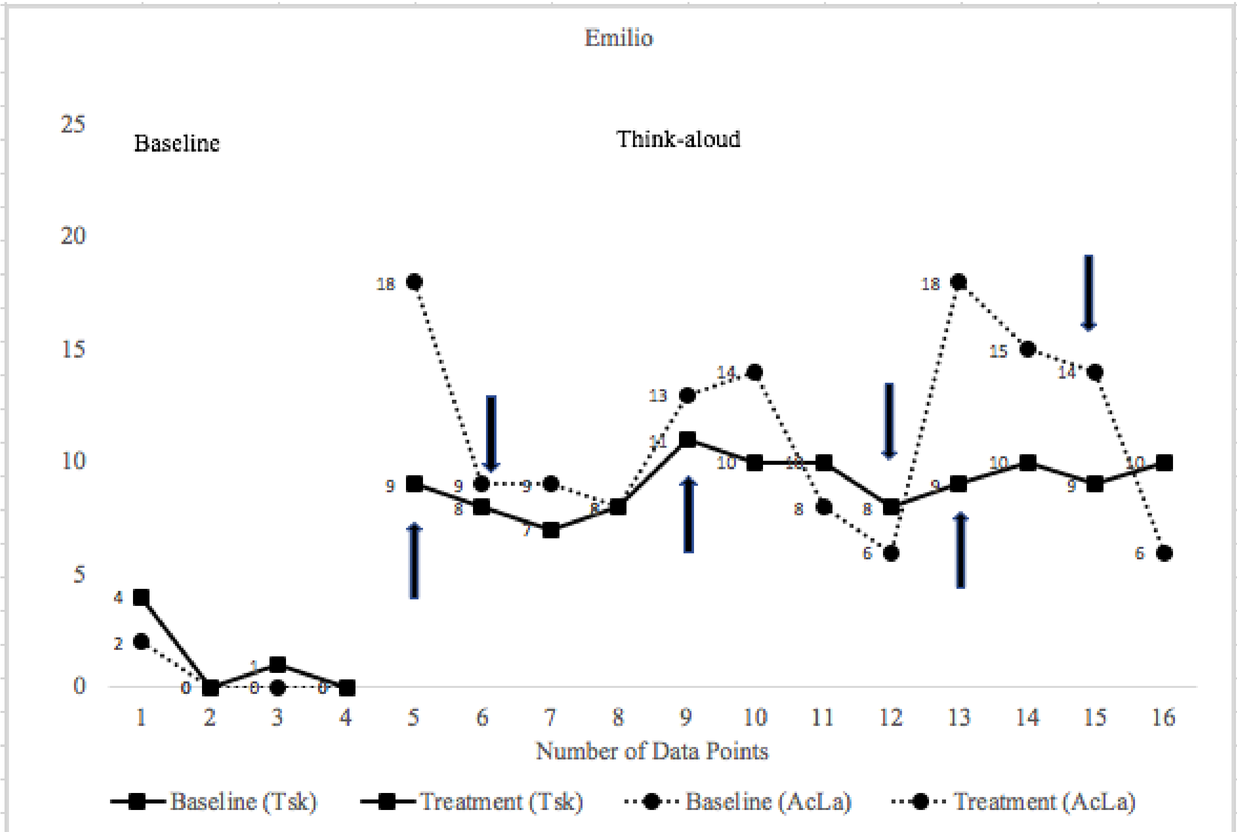
MB Graph 9

The Proportional Relationship between Task Performance Score and Academic Language Usage




Yasmin
Baseline
Think-aloud
Number of Data Points
Baseline (Tsk)
Treatment (Tsk)
Baseline (AcLa)
Treatment (AcLa)


Marisol
Baseline
Think-aloud
Number of Data Points
Baseline (Tsk)
Treatment (Tsk)
Baseline (AcLa)
Treatment (AcLa)


Emilio
Baseline
Think-aloud
Number of Data Points
Baseline (Tsk)
Treatment (Tsk)
Baseline (AcLa)
Treatment (AcLa)

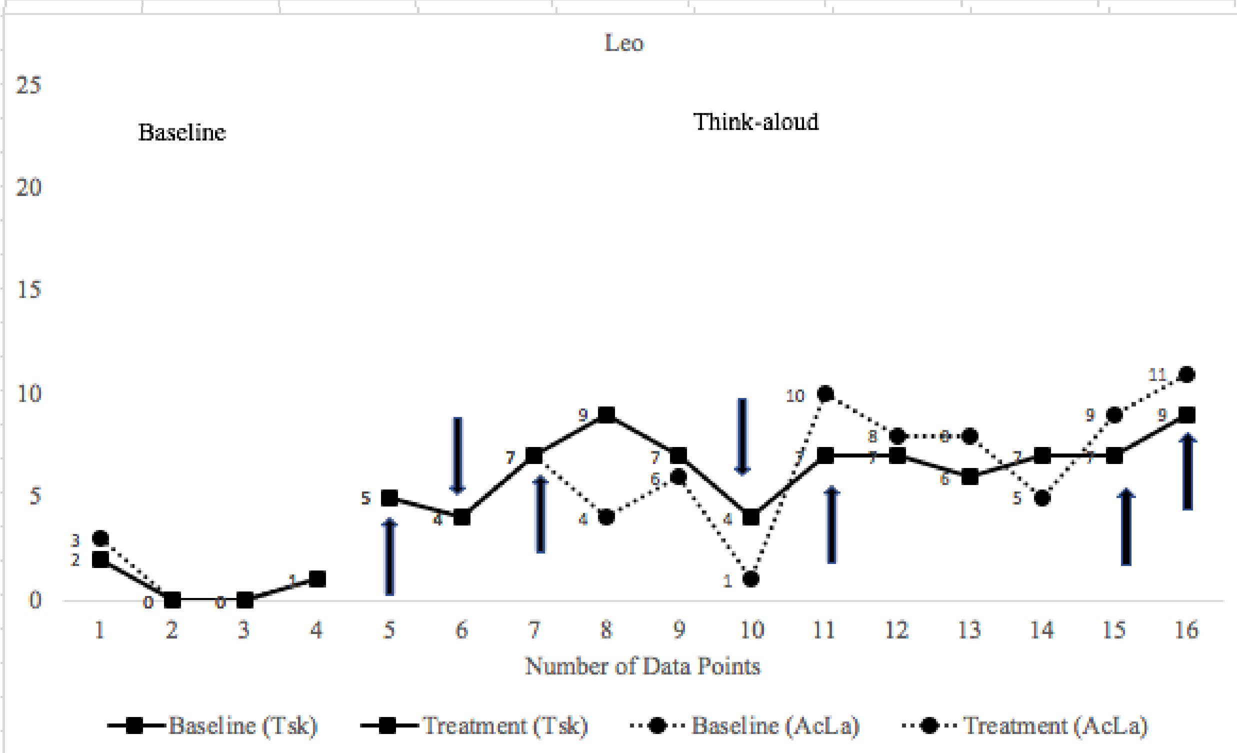
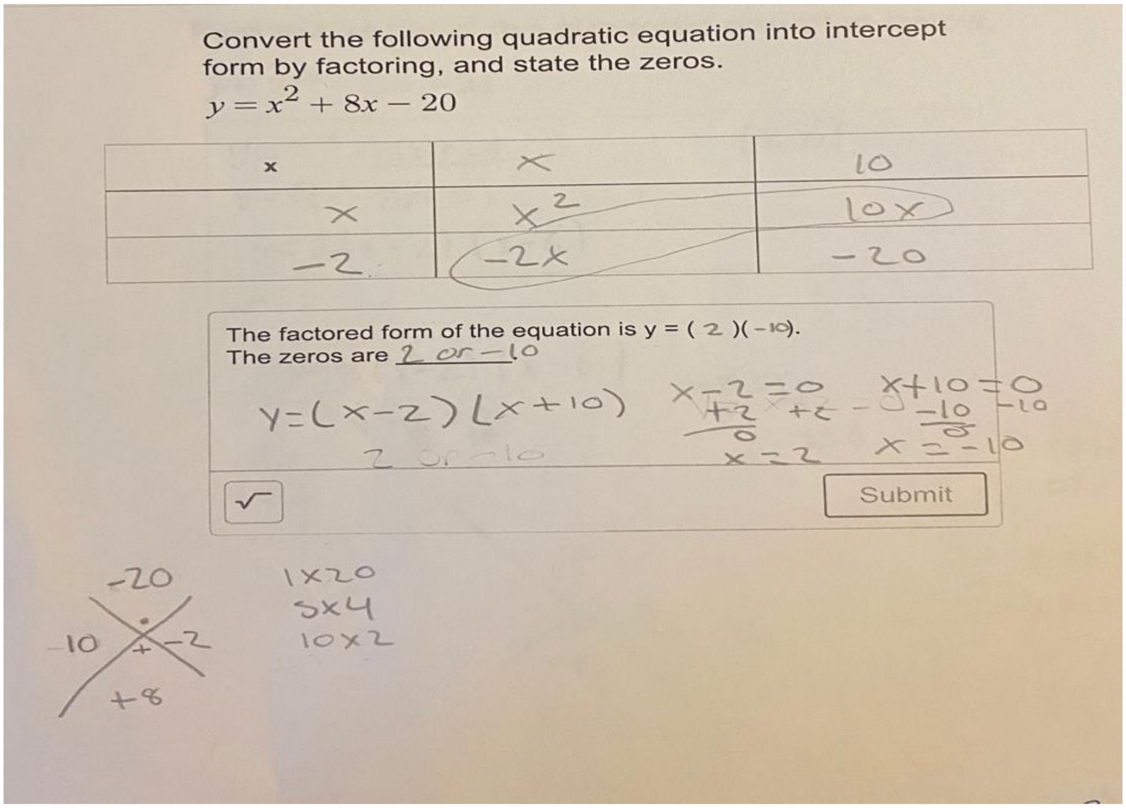

Leo
Baseline
Think-aloud
Number of Data Points
Baseline (Tsk)
Treatment (Tsk)
Baseline (AcLa)
Treatment (AcLa)

Figure 10

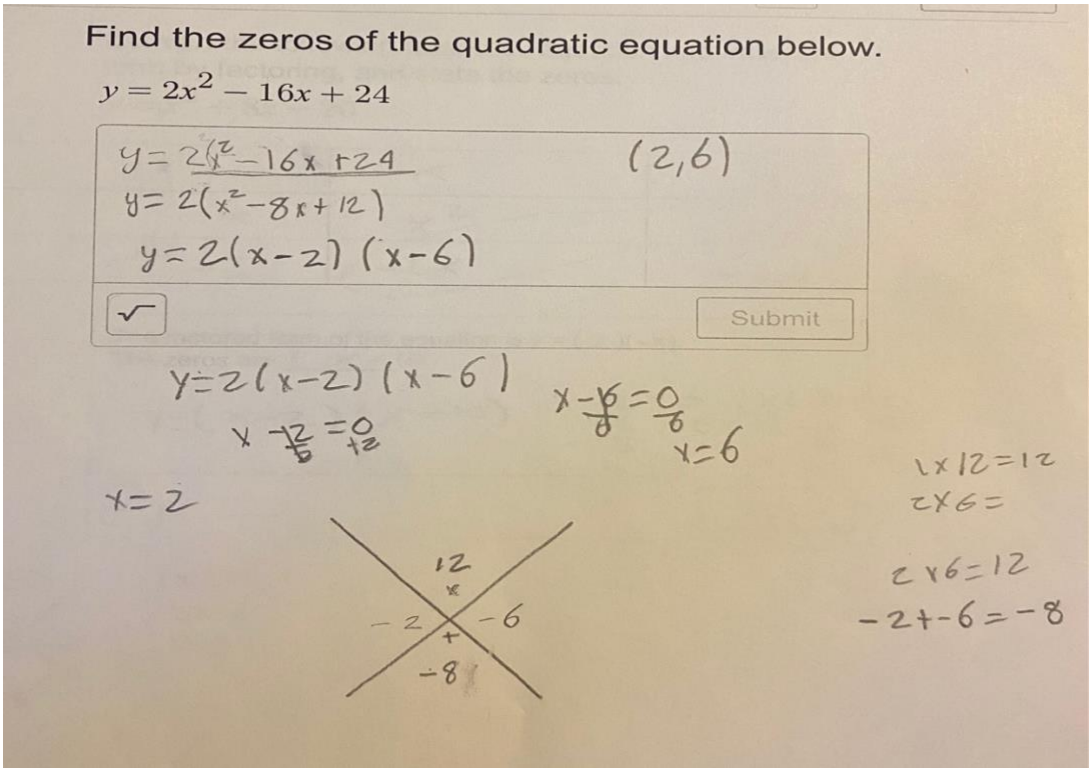
Student Samples of Yasmin and Emilio

Yasmin



First, I'm going to do the custom. So I have the X, and we're going to try to find... For 20, negative 20 and positive eight. Two factors that multiply to make negative 20, and two factors added to make positive eight. First we're going to find the factors of negative 20. Negative 20 is one times 20, five times four, and 10 times two. We could use 10 times two, and we have to figure out which one is negative because we have a negative 20. So the negative will be 10. Negative 10 times two. Okay. So it's not going to be negative 10 because we have a positive eight. If 10 minus two is eight and 10 times negative two is negative 20, that means the two will be negative. Now we're going to solve it. First we have X and X, which is going to give us X [inaudible 00:00:10] two. And then we've got our factors which is 10 and two, which is going to give us two X, 10X, and two times 20... Actually it's negative two. So it's going to give us negative 20, which this is going to be negative two X times X negative two X, 10X. Okay. In the area model puzzle, we have X and X, which is going to give us X square root of two, and then we've got X and 10, which is going to give us 10X. We got negative two, which is going to give us negative two X, and then we got negative two and 10, which is going to give us negative 20. Now, here's it says the factor form of the equation is Y equals [inaudible 00:03:22]. The zeros are... Now we're going to figure out the zeros. First, we've got the first equation, which is negative two X and positive 10X. Well, now we're going to do it. So Y equals X minus two, and then we have X plus positive 10. Now we're going to subtract that... No, we're going to convert it, which is going to give us Y equals X minus two equals zero. The factor form, we're going to take the parenthesis out and we're going to put X minus two equals zero, then we're going do the same to the 10 but first we're going to subtract this. It's negative two plus two will give us zero. And then zero plus two will give us X equals positive two. And then we've got X plus 10 equals zero. So we're going to find the zero pair of 10, which the zero pair is negative 10... So when we add negative 10 and positive 10 will give us zero. That is our zero pair. Then we're left with X, and then we're going to subtract negative 10 to zero. We get X equals negative 10. Our zeros are two or negative 10. So Y equals two and negative 10.

Emilio



So the first thing we're going to do is divide all the three numbers of the equation by two. And that's going to give us Y equals two minus eight. So, I'm going to rewrite or find the zeros of the quadratic equation below, Y equals two X squared minus 16 X plus 24. So, we're going to rewrite the equation. So, Y equals two X squared minus 16 X plus 24. Next, we're going to divide all the numbers in the equation by two, common factor. So, two divided by two or two... So, it's going to be Y equals two. Parentheses. Two, right
Two minus eight plus, no... Y equals two parentheses X squared minus eight X plus 12. And now, it's... Cross out, yeah. So, it's going to be Y equals... Cross out. Two, go. Okay. So the two numbers that add by 12 is... Oh, no. That's not it. Two plus... So... Okay, so the two factors that equal 12 is two times six and the factors that add that equal to negative eight is negative two plus negative six. So [inaudible 00:03:07].
Two times six equals 12 and negative two plus negative six equals negative eight. So it's two and six or negative two. Okay. So now... Oh yeah. And parentheses. This one, right? So, X minus two and then X minus six. So, Y equals two, parentheses, X minus two, parentheses, X minus six. And then... Okay. X minus two equals zero. Now we have to add on both sides and then that's a zero pair. And then, you add two on the zero and then X equals positive two, and then X minus six equals zero. You add six on both sides. That's a zero pair. Add six on the zero and then X equals a six. So the zero pairs of the quadratic equation are two comma six, right? Yeah.

Evidence of Trend 4- Gender Differences: Males used more vocabulary words than females in their think-aloud

In this study, female students used slightly less academic language in their think-aloud than male participants within the same group. Boys' think-aloud was more detailed and language-oriented than girls. Yasmin and Alejandro from group 1are F2F learners, and they both had similar listening and speaking ACCESS score ranges, which would infer that they have a similar amount of academic language usage. Alejandro used an average of 15 words with a maximum of 24 words, and Yasmin used ten words with a maximum of 18 words in the treatment phase. However, both of them used an average of one word in the baseline. The data also indicates that Alejandro's average task performance is 1.5 points higher than Yasmin's in the treatment. Even though Alejandro performed lower than Yasmin in 7th-grade mathematics DDA, his performance improved with solving word problems using the think-aloud approach. Bar Graph 3 shows that Yasmin and Alejandro completed five common tasks, and out of five, Alejandro used slightly more words than Yasmin on four tasks. Figure 11 displays their student samples of one of the common formatives.

Bar Graph 3

Summary of Academic Language Usage by Yasmin and Alejandro on their Common Formative Tasks

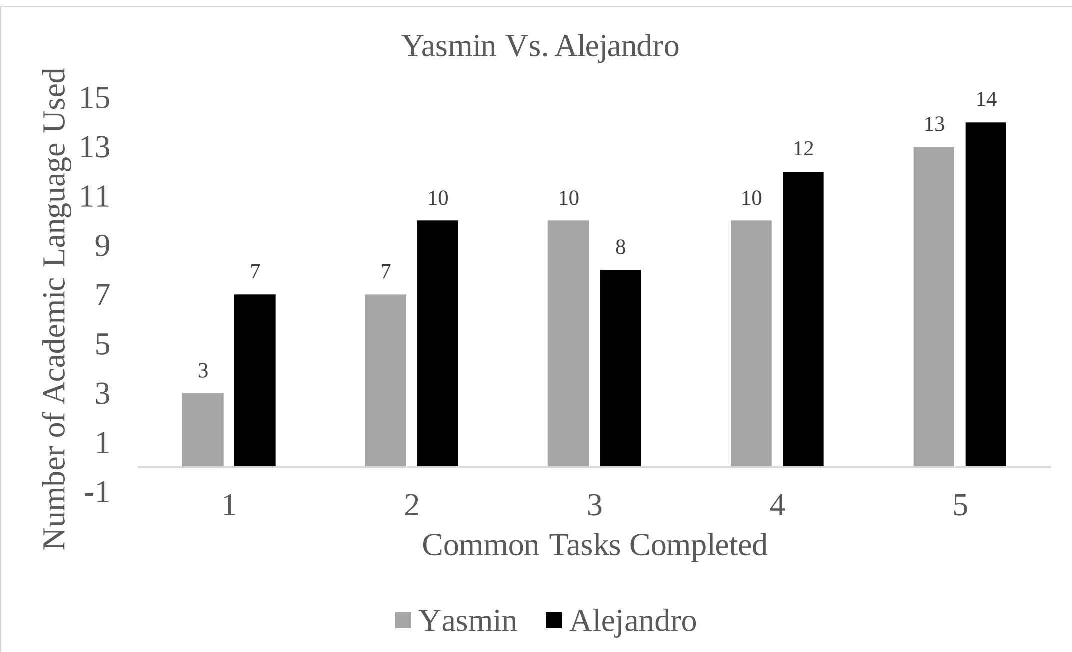
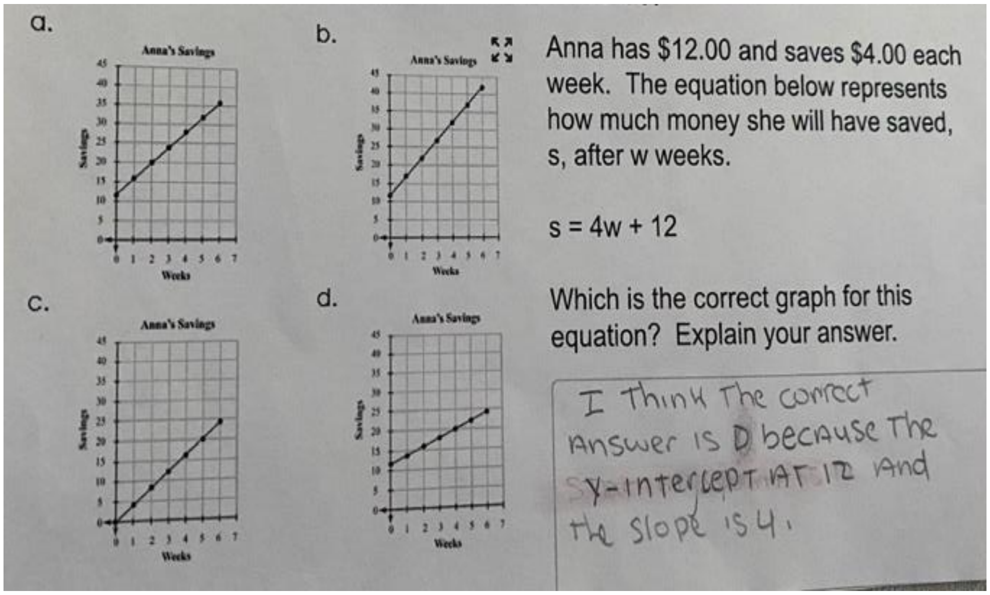


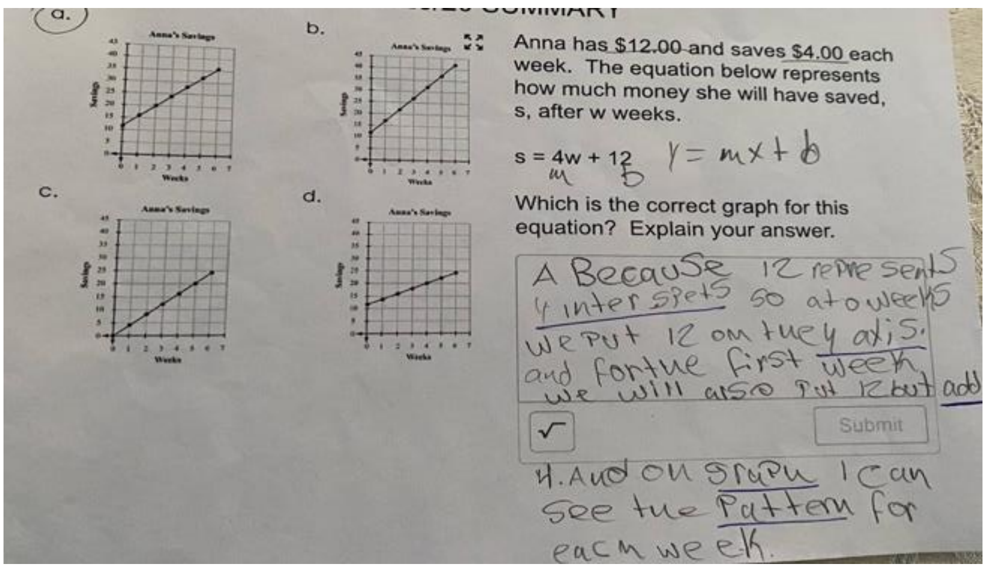
Figure 11

Student Samples of Yasmin (top) and Alejandro (bottom) from Group 1



They're saying which graph is showing the equation correctly. So I'm going to find...so the slope is four. So I'm going to find four. I'm going to pick a point... a starting point. Y intersects 12. A, B and D both show 12. And C doesn't so C is out. I'm going to find a point and divide it. 20 divided. So I did...I found a point and I divided 20 by two and It was 10 so I...A does not start with four. I just think Its B.

Total # of Words: 7



This means that it's going to be Y equals MX plus B, and we know that four equals M and 12 equals B. M is the slope and 12, which is B, is going to be Y intercepts. So it says, which is the correct graph for this equation?

I chose A, because 12 represents the Y intercept. So at zero weeks, we put 12 on the Y axis. And for the first week we put also 12 and four, since she saves $4 every week. And then I can see that on graph A, I see the pattern, that every time when the first week, it's 12, but they add four, which is corrected in week two. And when it was at 16, and then they add four, it will equal 20. So I think that A will be the correct answer.

Total # of Words: 10

The second set showing gender difference includes Group 2' F2F students, Marisol and Emilio. Table 2 and Table 4 shows that Marisol performed higher than Emilio in 7th-grade mathematics and for every ACCESS domain score range except Emilio's comprehension. However, her average academic language usage was two words fewer than Emilio's. Also, Emilio used an average of one word in the baseline phase, whereas Marisol used no vocabulary words. However, the task performance average was 9 for both of them. Overall, Emilio benefited slightly more than Marisol with the think-aloud treatment. The following Bar Graph 4 displays the summary of the language usage in their think-aloud on the seven common formative assessments they both completed. Out of seven tasks, Emilio used slightly more academic words on five tasks than Marisol. Figure 12 displays their work samples showing how each participant in a group solved the same problem with a different number of vocabulary words regardless of the right answer.

Bar Graph 4

Summary of Academic Language Usage by Marisol and Emilio on their Common Formative Tasks

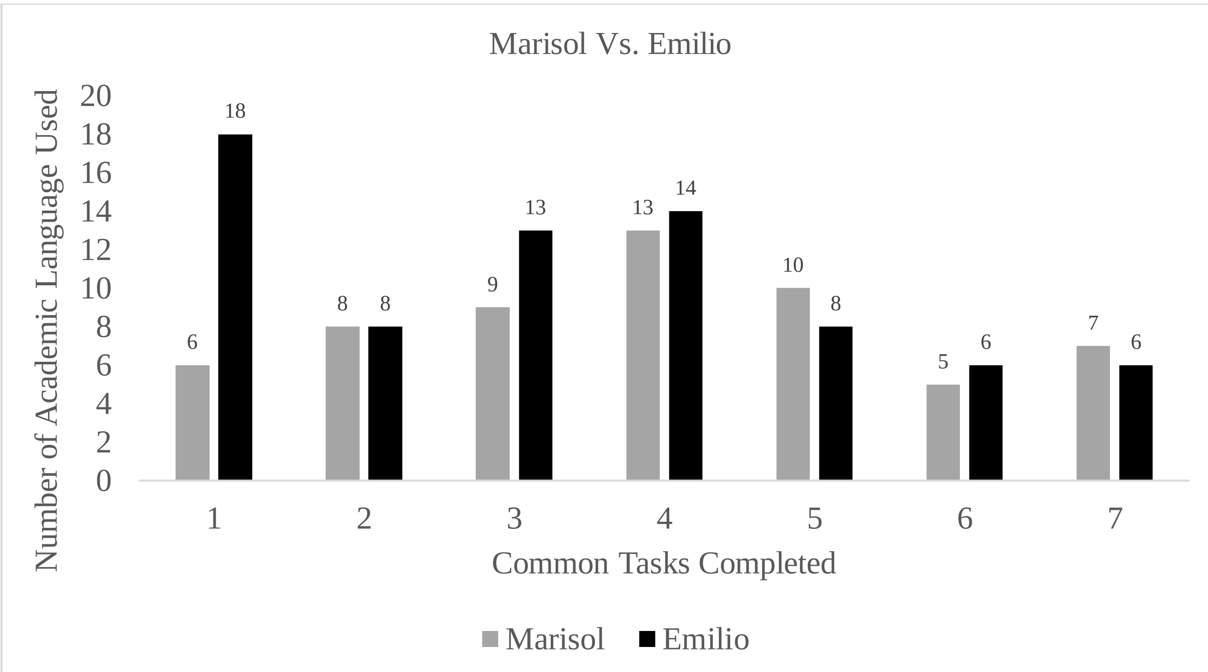
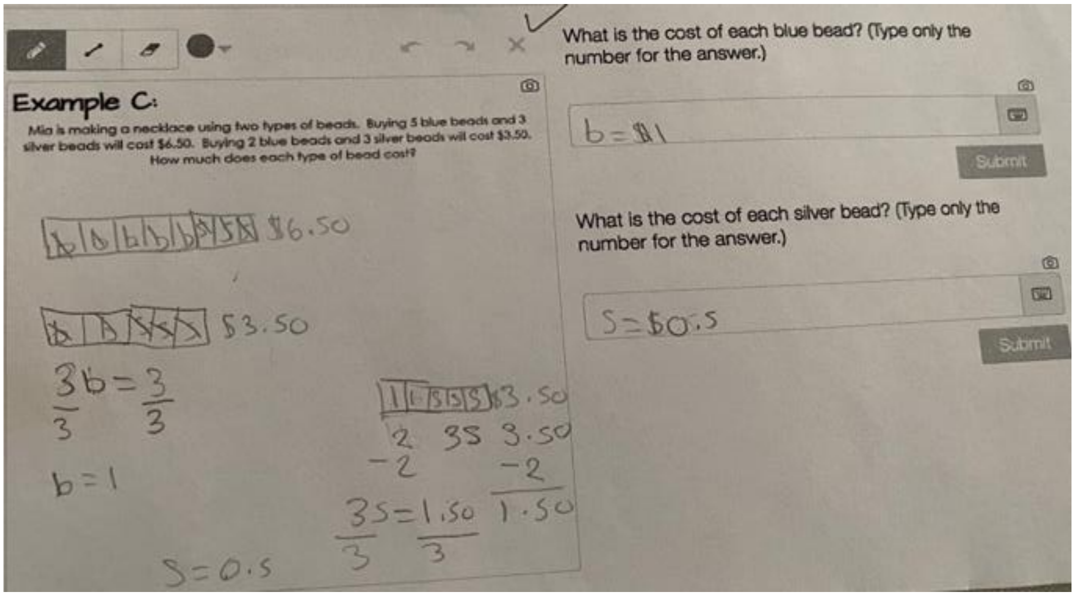


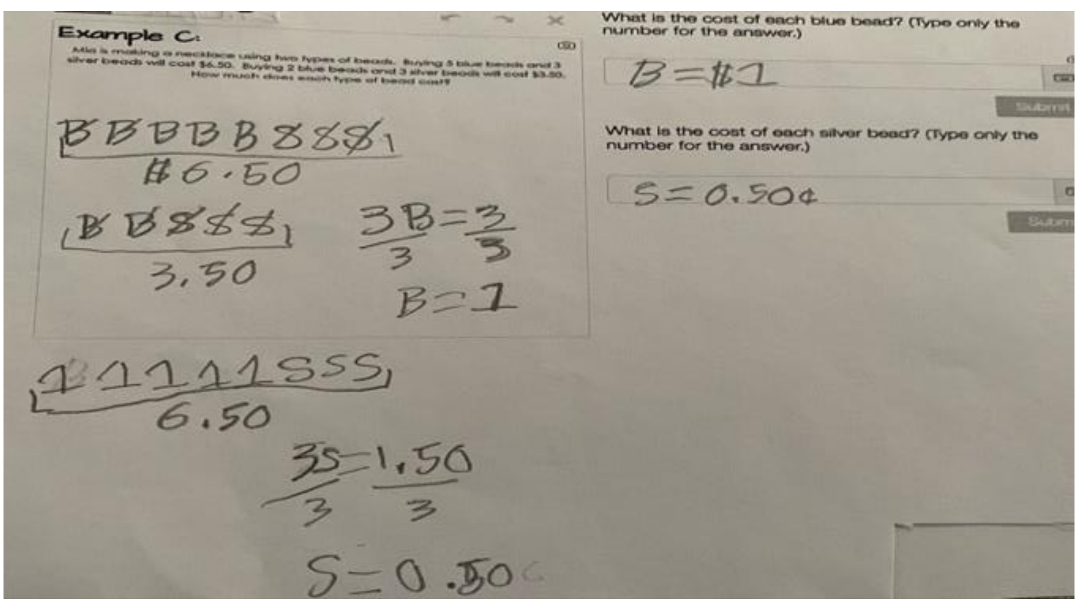
Figure 12

Student Samples of Marisol (Top) and Emilio (Bottom) from Group 2



So I'm going to make a table, a bar diagram, and put five B... B, B, B, B, and B. And then for three silver beads, I'm going to put S, S, and S equals $6.50. And then I'm going to make another bar diagram and for two blue beads, I'm going to put B, B. And then for the three silver beads, I'm going to put S, S, and S, equals $3.50. And then 2B equal... I'm going to cross out B, B, B, B, and then S, S, S, S, and S. So there is three B's left. So 3B equals... And then, I have to subtract $6.50 from $3.50, which is going to equal $3. So then divide three by three and then three by three. That's a zero pair. So B equals zero? No, three? So then B equals one. So then I'm going to grab the smaller bar diagram and do it again. So B, B, and then S, S, and then S equals $3.50. No, B is one. So one, one, S, S, S equals $3.50. So 1B, and then 3S, and then 2, and then 3S equals $3.50 minus 3... No minus 2, and then minus 2, and that equals...So then 3S equals $1.50 divided by 3, and divided by 3 equals 0.5. So S equals 0.5. So for what is the cost of each blue bead? The answer is B equals one. Then what is the cost of each silver bead, and S equals 0.5.

Total # of words: 9



So, for the first thing, I'm going to put five, B or five beads because it presents how many blue beads she's buying. Three, four, five, and I'm going to put three silver beads, three. So I'm going to put S three times that represents how many silver beads she bought, two, three. And at the

bottom, I'm going to put two blue. So two Bs, it's going to be $6,50. Two blue beads and three silver beads, so S,S,S,S and that cost at $3,50. Now I'm going to cross out. So that's one, two, three, so now we are left... So that's one, two and three. So here we cross out. So now we're left with three blue beads. So that's going to be three B that will equal, that'll be three B equals, that's $3.
By subtracting $6,50, minus $3,50. That's three and now we are going to divide by three. Which that equals... So it's going to be B equals $1, no, one B. So for the first problem it said, what is the cost of each blue bead? The answer is B equals $1. Now for the second problem. So it's going to be, so it's B, one B. So it's going to be one, one, one, one, one, one, one, and S,S,S. And that's $6,50. So now we're going to... So that's five equals, so it's three equals $6 minus... That's three S equals, that's a $1,50, equals a $1,50 cents. So now we have to divide again by three And Okay. So that's S equals 50 cents. So for the second part is telling us, what is the cost of each silver beet? And the answer is S equals zero point 50 cents. So it's 50 cents.

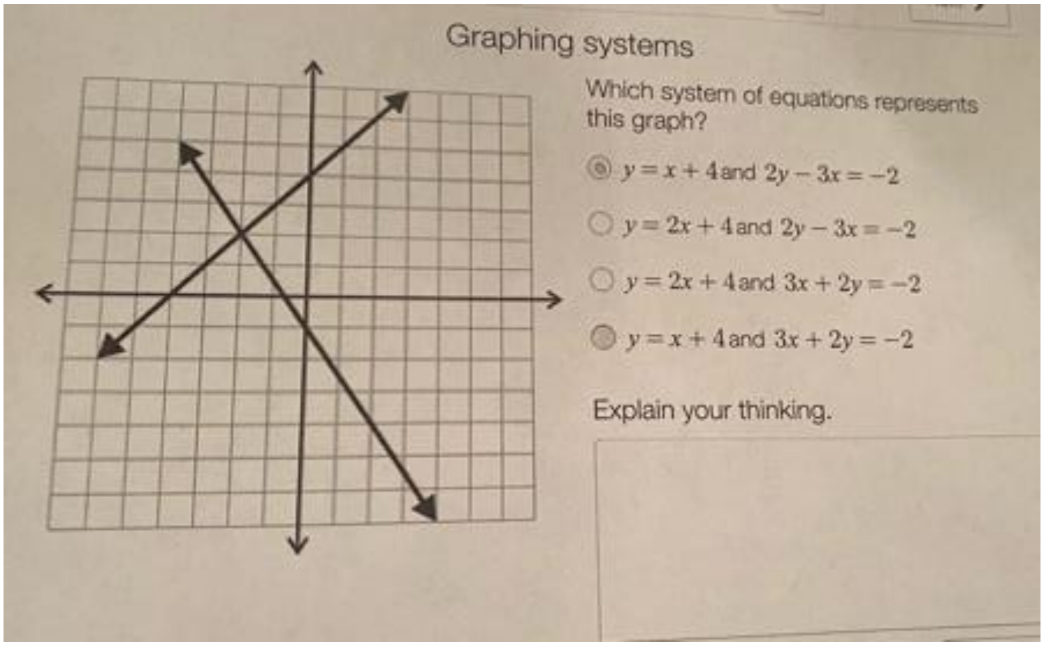
Total # of words: 13

Evidence of Trend 5- Speaking Vs. Writing: ELLs used more academic language in their speaking than writing when asked to explain their reasoning

The six participants produced less academic vocabulary in their writing than in their speaking. These students spoke several mathematical words in their think-aloud while solving a problem but failed to type or write in their explanation on their Desmos or worksheet. Although Yasmin, Alejandro, and Marisol wrote something on their worksheet, they produced more vocabulary in their think-aloud. The two digital students Ximeno and Leo, and the F2F student, Emilio, wrote from minimal language to no language in their explanation. According to Table 4, Ximeno's writing scores are almost in the same range as his speaking scores, and Emilio's and Leo's speaking scores were much lower than their writing. However, three of these participants produced more academic language in their speaking than in their writing. Although these students found the solution for each problem by thinking-aloud with several academic vocabulary words, they haven't produced any language in their writing except the answer in many instances. A sample of their work and the transcriptions are displayed in Figure 13.

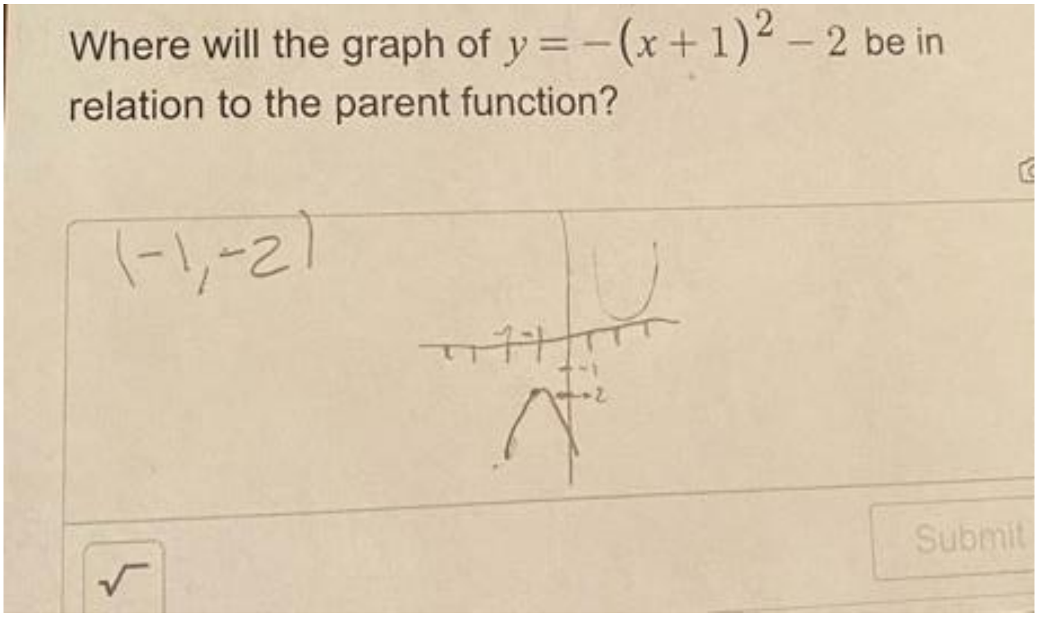
Figure 13

Student Samples of Ximeno (1st), Emilio (2nd), and Leo (3rd)



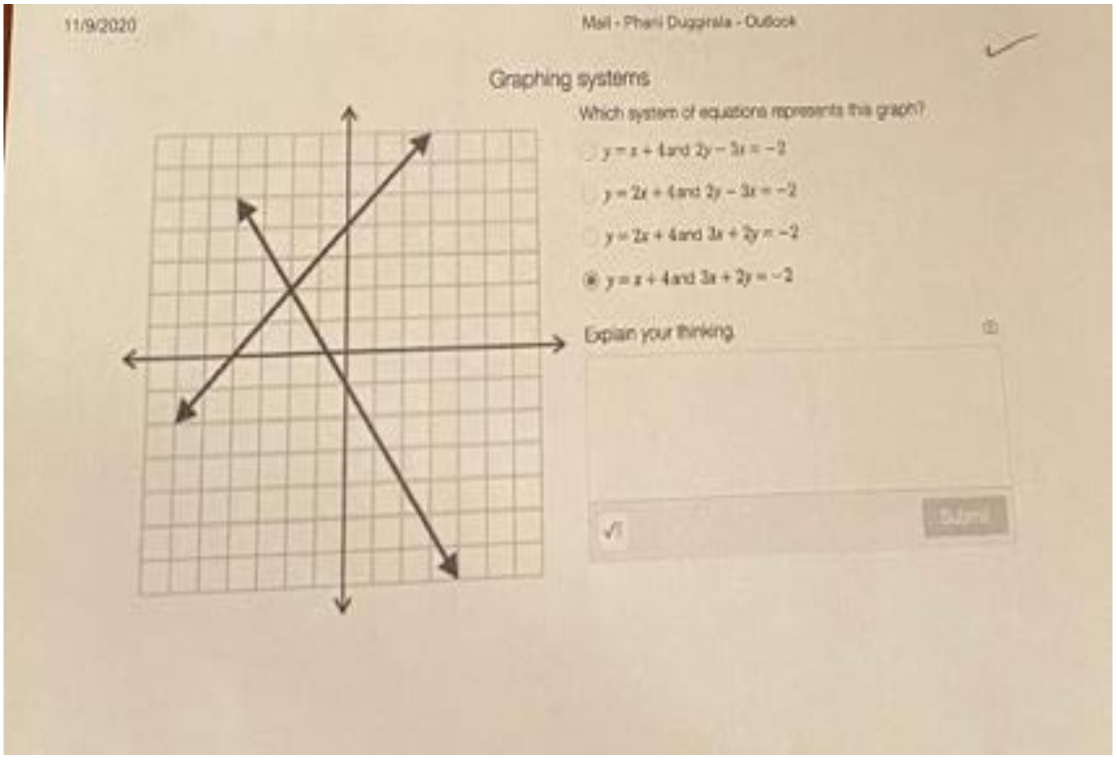
From the graph I can see that there is a one solution. Negative. Where they intercept the lines. Is that negative, negative two, and positive two. The first letter A says Y equals X plus four and two Y minus three X equals negative two. Answer B says Y equals two X plus four and two Y minus three X equals negative two. I think the answer is letter B. The reason I think it's B is because from how I see it is that they first are asking me for the Y and then they're asking for the X. So for the Y I can see that all of them have a positive and they're telling me to do what I did, okay. I got it now. Okay. I think it's letter A, because on X plus four, I put the numbers negative two for X plus four, and then I added and I got two positive. And then I put the Y, the two over the Y. So now it says two equals two. So that's correct. And then for the second part: two Y minus three X equals negative two. I plugged in two instead of, instead of Y and then I plugged negative two instead of X. And then for two times two, I got four and then for negative three, negative three plus, no, negative three times, negative two I got negative six equal. And then I subtracted negative six minus four, and I got negative two.

Total # of words: 12



First, I think we need to find the K and the H. The K is -1, so the vortex form in this equation is -1 and -2. Yes. -2. And since there is... Wait. -2, -1... And since there is a negative sign before the X, before the parenthesis. So it's going to flip and that's called reflection. So the... So the parabola will reflect on the graph. So, it's going to be like this. Right? [inaudible 00:01:34] That's -1, -2, -3. So it's going to go like... Okay. Since it's negative, it's going to be on the left side. So it's going to be -1. I'm putting the numbers on the X axis and the Y axis so there's going to be -1, -2, and this is going to be -1, -2. So it's going to... Go like... Okay so it's going to be -1 and -2 and since there's a negative sign, it's going to be... So it's going to go down. So, it's going to go like this. Like this. And then it's going to go like... Like this.

Total # of words: 14



My X, my X is going to be negative two and my Y going to be a positive two. Okay, because on the left side, it's always going to be a negative and the right side is always going to be a positive. Okay. And how I got, had the answers D because when, when I, when I was trying to, to find an answer and see two, two X plus four. Oh, I had to do the X plus four and then the ex parenthesis negative two, plus four. And when I did it, plus four is it's going to equal... Two. And then the three, the three X, three X plus Y two Y I meant. And when three, three X parentheses positive two, plus two Y, plus negative two, negative two, Parenthesis negative two. And then it's three X parentheses, two, negative two, negative two plus, plus now parentheses two and two Y is going to equals negative two. Okay. Okay. Two now? So the post tests are going to be [inaudible 00:03:31] to three X pleasantly parenthesis two plus, negative two plus two and two Y is going to equals negative two. And that's how I've come answer.

Total # of words: 7

Evidence of Trend 6- Complexity of Content: The academic language used depends on the complexity of the problem

Although a significant improvement in participants' academic language usage is visible in the treatment phase, the number of words they used varied based on the word problem's complexity. In other words, participants applied more vocabulary and longer think-aloud when the problem was difficult, whereas they used fewer academic words for solving easier tasks. As a result, a few declines occurred in the academic language usage for every participant's baseline and treatment data due to the content's complexity. For instance, a word problem that involves creating and solving a linear equation is less complicated and needs one-step problem-solving. In contrast, a word problem involving creating and solving systems of equations is more complex and requires a multi-step problem-solving procedure. Also, the think-aloud in solving a single-step equation involves less complicated language than the language used to solve multi-step systems of equations.

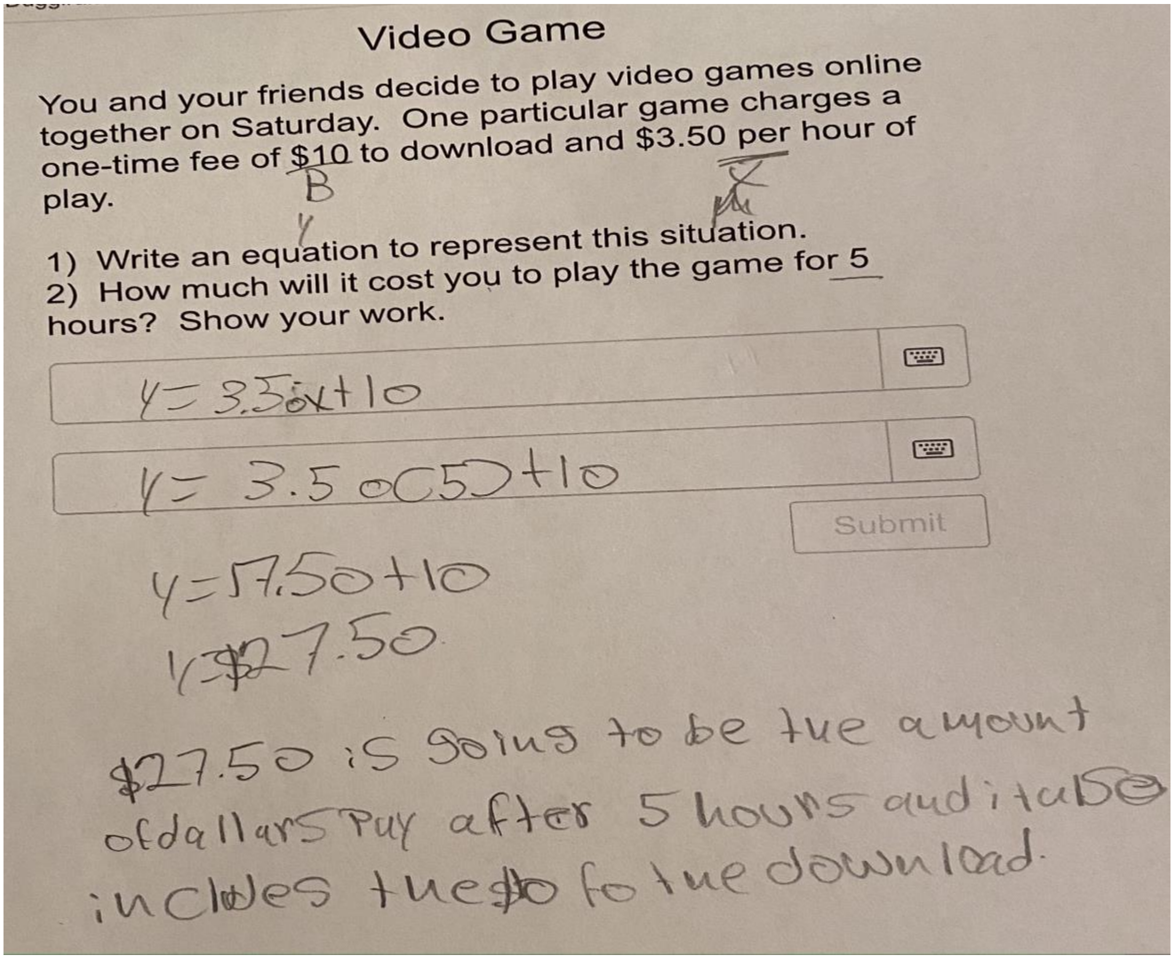
For example, Alejandro used the highest number of vocabulary words out of all participants with the treatment, an average of 15 words. Still, he had a few declines in language usage due to the problems' resulting complexity. Alejandro's following two student samples explain how the word problem's complexity is directly proportional to the number of academic words used. Figure 14 displays Alejandro's work samples on two different levels of word problems; one was creating and solving a linear equation, and one was creating and solving systems of equations. Sample 1 displays the less complicated word problem where the student was required to create a linear equation and solve for one variable (y) by substituting the value of x in the equation to find the answer. The think-aloud for this problem included only eight mathematics vocabulary words. Sample 2 displays the more complicated word problem in which the student needed to create two equations and solve for two variables (x, y) by using the elimination method. This think-aloud process contained 22 vocabulary words.

Moreover, as Sample 1 shows, the think-aloud for creating and solving a single step linear equation involved less complicated language such as equals, per hour, y-intercept, x value, cost, times, multiply, and add. In contrast, Sample 2 shows that the student used more complex language to create and solve systems of equations, including single pairs, elimination method, represent, original equation, positive, negative, and same amount.

Figure 14

Student Samples of Alejandro

Sample 1

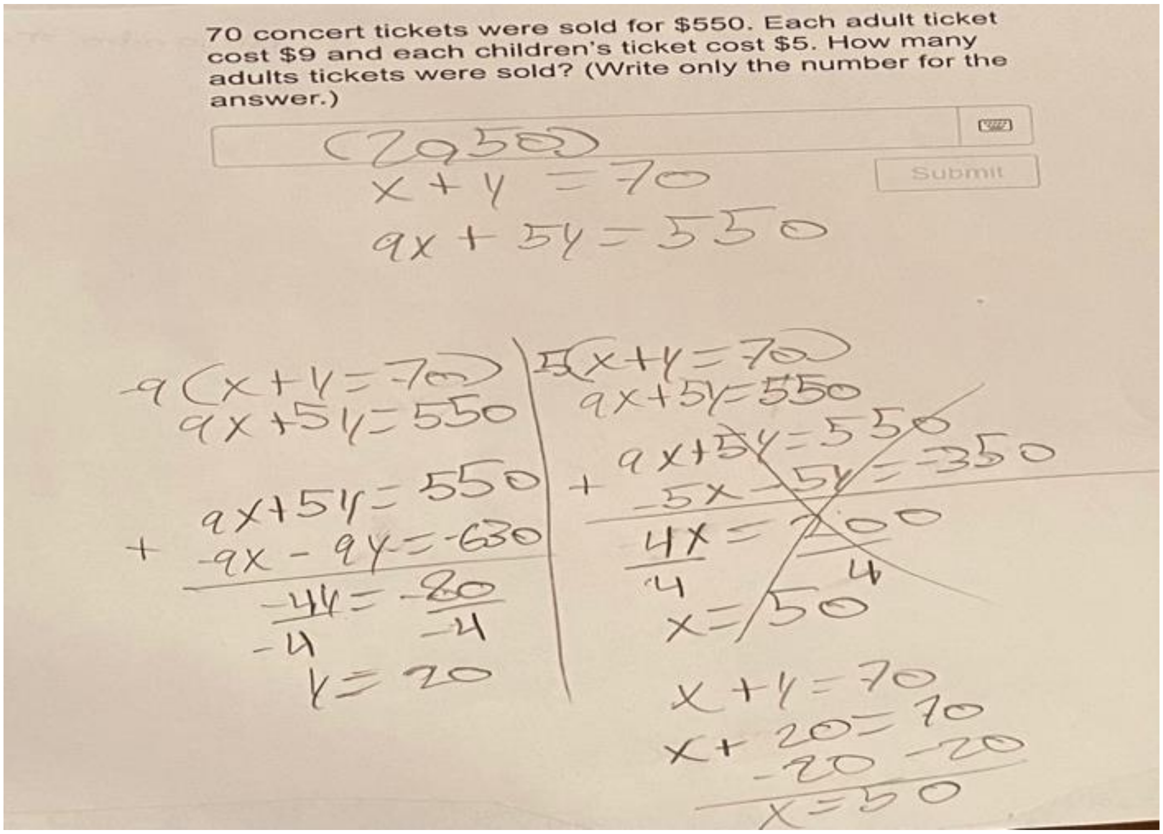


You and your friends decided to play video games online together on Saturday. One particular game charges one time fee of $10 to download and $3.50 per hour of play. Write an equation that represents this situation.

So, since we ... Where it says the 3.50, we see the word "per," which means that's going to be our X or our M for our- And also, the $10 is going to be our B value or Y value. So, for our equation we could write Y equals $3.50 X plus $10, which is our B. And it says for the second questions, "How much would it cost to play the-All right. So, for 3.50, three and 50 cents, no $3.50 per hour is going to be our X value or no our X, which is M and for the Y, and the 10 is going to be our B, which means the Y intercept. And for 3.5, 3.50 per hour, which is our M is going to be our X value. So, for that equation we're going to write Y equals $3.50 plus 10, which is our Y intercept value. And it says for the second question, "How much would it cost you to play a game for five hours?" And what we're going to do is for our X is we're going to multiply 3.50 times $5 and it says, "How much would it cost to play for five hours?" We don't know how much. We know that per one hour we pay $3.50. So, we're going to multiply $3.50 times five. And once we multiply that we equal. Y equals seven. That will equal 17. Wait. Wait. Yeah, that will equal $17. $17.50. So, now, since we got that and we also got our T, we add that, which is 10. So, we're going to add $17.50 plus 10, which is going to equal $27.50.

Total # of words: 8

Sample 2



First, we're going to look at the numbers we can see in our paper. We can highlight 70 tickets which sold so we know that's a total for the tickets that there were sold. And it said $450 were the cost of all the 70 tickets that they were sold. And it says each adult ticket cost $9 and each children cost $5. So for our equation, we can write X plus Y equals 70. Our X is going to represent our adult ticket and our Y is going to represent our children ticket and the 70 represents the 70 concert tickets that they were sold. And for our other equation, nine X plus five Y equals $450. It's going to be nine X because nine equals $9 for adult and we know that X is the value for the adult ticket and that Y is our children ticket, so you can see the children ticket equals $5 I'm going to prove five Y and equals $450 because 70 tickets will cost $450. So now when we're about to solve, when we write our equations, in order for us to do the elimination method we can see that they need to be opposite of each other and they need to be the same number. But, in this equation we can see that they are both positive. For us to do the single pairs problem, we first get our, turned into a negatives that are positive and our single pairs are now opposite from each other. So, we can just one number, we can do nine X or five Y. X was negative, X was nine too much to prove, so X plus Y equals 70. We're going to choose one of the equations to multiply. So X needs to be negative we can multiply by negative since it's positive. So we're going to multiply negative nine times X times Y and times 70. And our total is going to be nine X plus, yeah, negative nine X and negative nine Y equals negative $330. And we're going to bring down also the other equation which is our nine X plus five Y equals $450 and we add them. When we add them that's going to equal to negative four Y equals negative 80. Our nine Xs went away because they were both, they were single pairs and they had the same number, the same amount, but they were opposite of each other. So we eliminate those and we are left with negative Y equals negative 80 and for us to get our Y value we need to divide it by four so we're going to divide it by negative four Y equals negative 80 by four and our Y is equal to 20 because negative 80 divided by four is 20 because, I mean, negative divided by a negative is equals a positive. So now we know our Y value which is our children value is 20, so 20 tickets were sold for our children ticket. Now for the adult ticket we're going to find out, we're going to plug it in. So we can either choose one of the original equation of nine X, I mean, yeah, nine X plus five Y equals $450 so X plus Y equals 70. And we're going to pro-, we know, we know our value volume our Y volume, we're going to plug that in so we can prove nine X plus 20 equals 70. Now we're going to subtract 20 from each other and 20 from 70 and that's going to equal X equals 50.

Total # of words: 22

Moreover, Table 10 shows a couple of examples of how think-aloud contained fewer words and less complicated vocabulary words for less complicated tasks than for more complicated tasks. Marisol and Ximeno used less complicated language and a fewer number of vocabulary words for less complex word problems. In contrast, they both used more complicated language and a greater number of words for more complicated problems.

Table 10

Relation Between Complexity of Task and Complexity of Language

Less Complex	**More Complex**
Marisol Task # 3 Academic Language Used: equation, slope, y-intercept, per hour, every time Total # of words: 5	Marisol Task # 8 Academic Language Used: dotted line, solid line, point, shaded region, overlap, inequality, ordered pair, solution, negative, no solution Total # of words: 10
Ximeno Task # 1 Academic Language Used: slope, negative, y-intercept, two-thirds, nine-halves Total # of words: 5	Ximeno Task # 7 Academic Language Used: vertex, positive, negative, times, divided, simplified, replaced, equation, zero pair, y-value, factored, minus, formula, axis of symmetry, y-intercept Total # of words: 15

Table 11 and Table 12 display how each group of students used different numbers of vocabulary words for various degrees of complex problems. The treatment phase's 12 formative tasks were divided into two categories, less complex and more complex. Less complex tasks included solving one-step word problems, true/false questions, and multiple-choice questions with simple concepts. In contrast, more complex problems involved solving multi-step word problems, constructive response questions, and multi-step problems of quadratic factoring. Table 11 displays Group 1's academic language usage for less and more complex problems. The bar graphs for more complex problems are longer than the less complex problems, which shows that students had to produce lengthy think-aloud with more vocabulary words for more complicated tasks. Table 12 illustrates the academic language usage by Group 2. Although Group 2 used less language than Group 1, they utilized more vocabulary words for complicated problems compared to the less complicated tasks. Therefore, participants' vocabulary words and the complexity level of language depended on the complexity of the problem.

Table 11

Academic Language Usage by Group 1 on Less and More Complex Problems

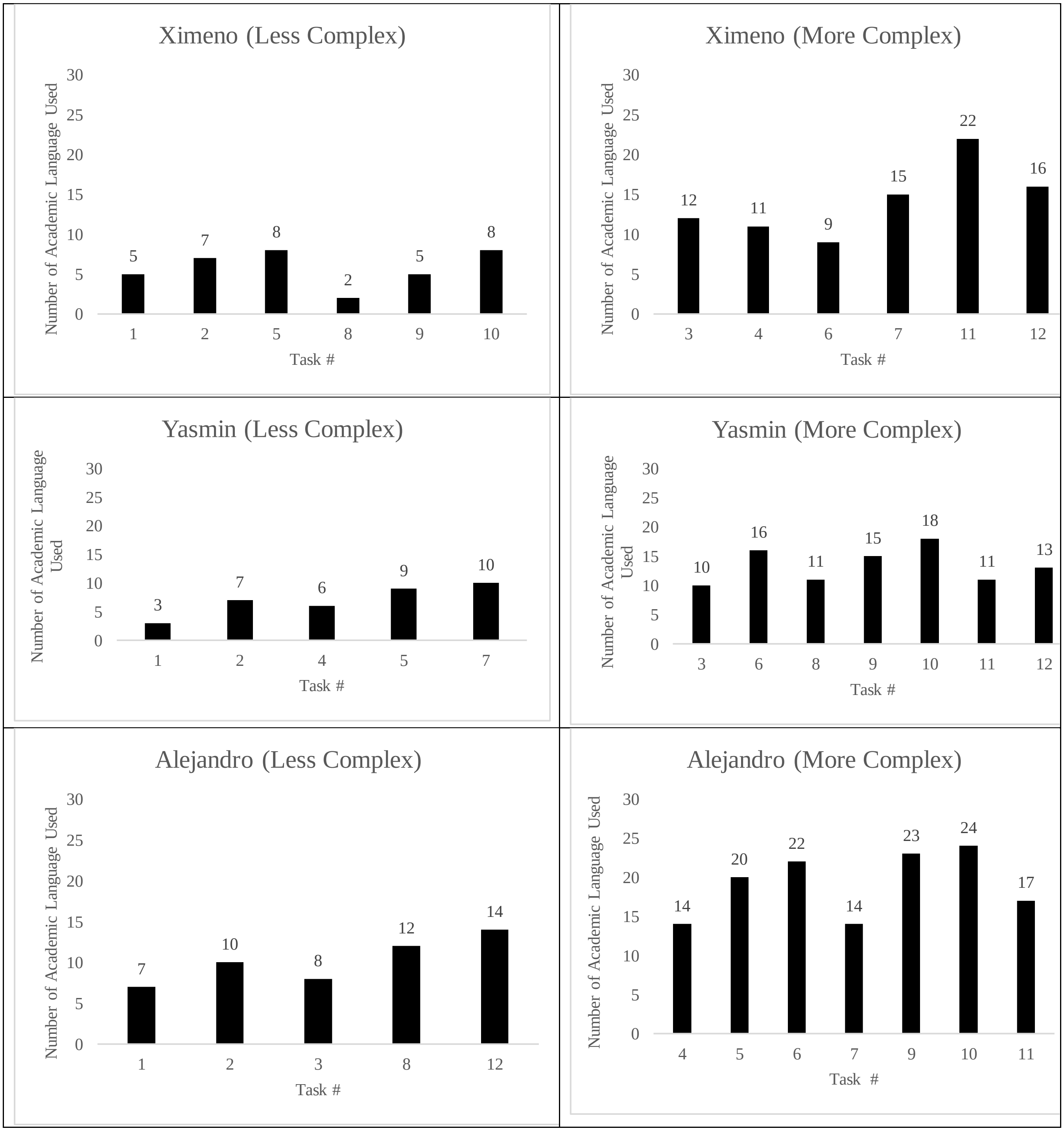
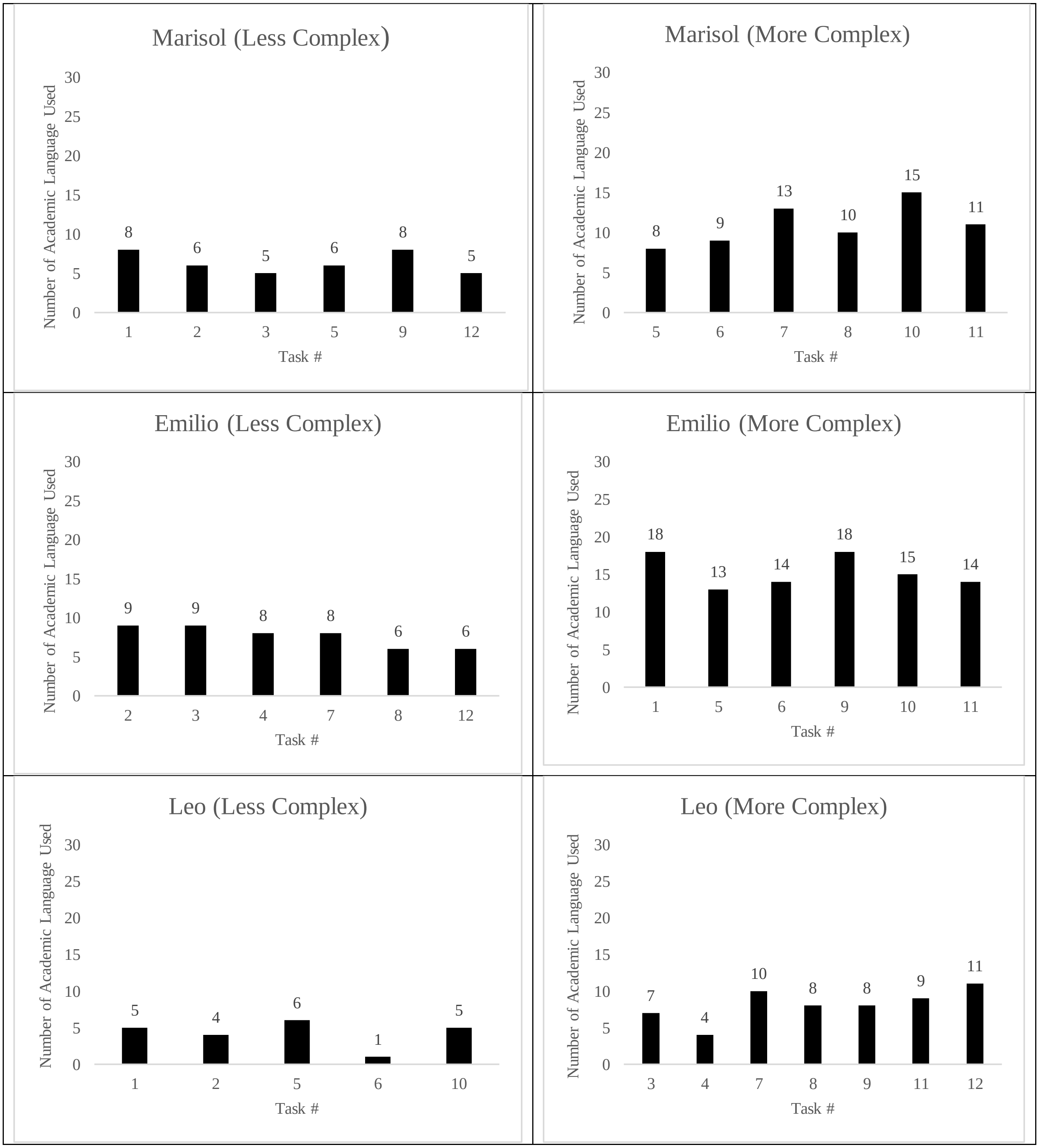


Table 12

Academic Language Usage by Group 2 on Less and More Complex Problems



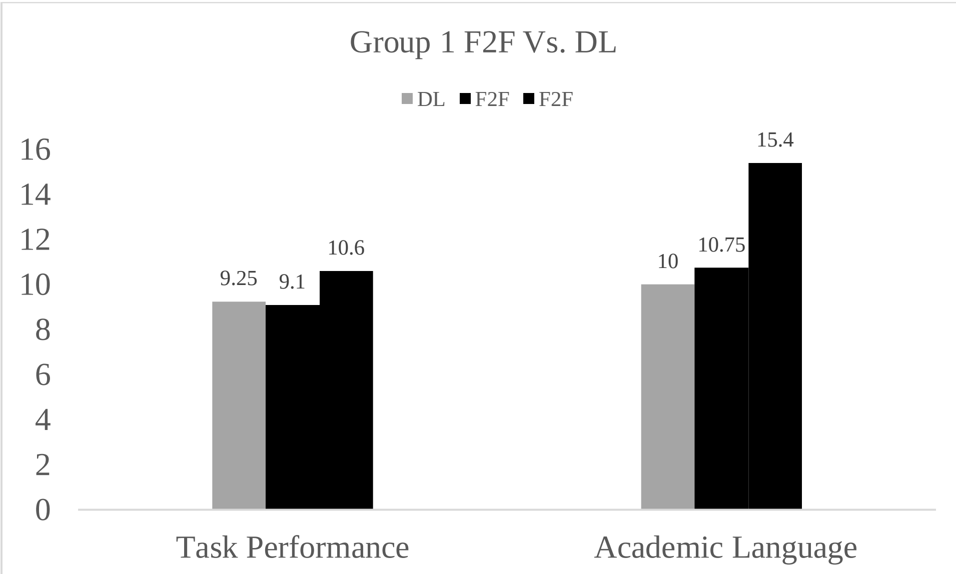
Evidence of Trend 7- Learning Model (Digital Vs. Face-to-Face) F2F Participants benefited from think-aloud more than DLs

Learning was primarily digital for all students in our district for the first five weeks of semester 1, when the baseline data collection occurred. Then, the teaching switched to a concurrent model. Out of the six participants for my study, four students were F2F (Yasmin, Alejandro, Marisol, and Emilio), and two were DLs (Ximeno and Leo). During the baseline phase, all six participants struggled to complete the formative tasks on Desmos and most of the time the tasks remained incomplete.

During treatment, all four F2F students completed their formative tasks by thinking aloud. However, both DLs also finished their formatives during the treatment, but in Group 2's participants, Leo's progress was lower than the other two F2F students in the same group. Although Ximeno's task performance was almost equal to Group 1's participants, his academic language was not as progressive as Alejandro's, though Alejandro's 7th-grade scores were much lower than Ximeno's. Bar Graph 5 displays the average performance of Group 1, and Bar Graph 6 demonstrates the average performance of Group 2 across 12 data points. However, some of the formative tasks are different from participant to participant in terms of complexity of the content. Overall, F2F participants' average scores are higher than DLs' average scores in the results.

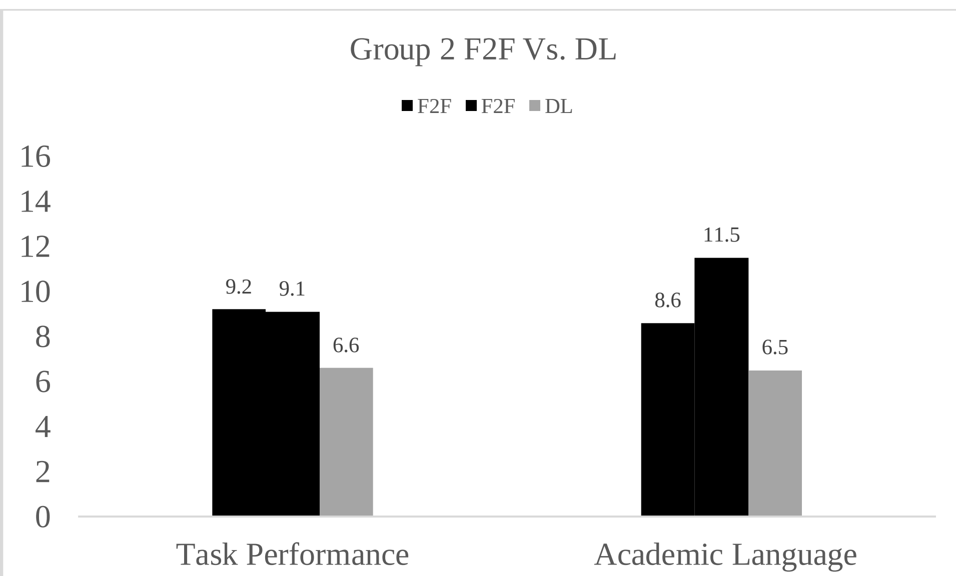
Bar Graph 5

Summary of Group 1's Task Performance and Academic Language Usage



Bar Graph 6

Summary of Group 2's Task Performance and Academic Language Usage



Based on these seven trends in student performance and academic language acquisition, Chapter 5 will present the positive effects of the think-aloud treatment and the adverse effects of the pandemic on ELLs performance in solving word problems using the think-aloud.

Chapter 4 Summary

Chapter 4 presented six ELLs' performance on formative assessment tasks in the baseline and treatment phases using the multiple baseline graphs with trend lines. This chapter also displayed seven trends and the evidence that emerged during the data analysis in numerous MB graphs, bar graphs, tables, and student work samples. The research on ELLs' learning theories and my personal experiences with teaching ELLs gave me a deep understanding of the importance of utilizing the think-aloud strategy to improve ELLs ability to solve word problems and to improve the academic language usage in middle school mathematics classrooms. The study's findings demonstrated teachers' need to teach ELLs using the think-aloud instructional strategy in their lesson delivery and to include this protocol in the students' problem-solving process. This study's findings result in four F2F students and two DLs in the treatment phase, and the learning was 100% digital for all ELLs during the baseline phase. Moreover, the findings provided the pandemic's impact on ELLs' education, especially with the concurrent learning model during the 12 days treatment period. Chapter 5 considers the study's results and its connections to the literature and suggestions for future research on the effect of the think-aloud instructional strategy on ELL students' performance.

CHAPTER 5 DISCUSSION

Overview of the Study

The main purpose of this investigation was to examine the effect of the think-aloud instructional strategy using academic language and problem-solving thought process on ELL student performance with solving word problems when teachers implement the protocol in middle school mathematics classrooms. This chapter highlights the summary of the study's findings and situates them within the reviewed literature. Also, this chapter discusses the implications and suggestions for future research and concludes with final thoughts.

The study was built on a conceptual framework of Vygotsky's social constructivism and sociocultural theory, and critical sociocultural theories. Since the study was conducted during the pandemic, ELL learning occurred through the learning theory of ZPD from teacher's guidance but not through sociocultural interactions between students. The research embedded a single case study with multiple baseline designs. The study took place in the fall semester of 2020 in a diversely populated Title I middle school. A sample of six Spanish-speaking ELLs from two 8th-grade Algebra 1 classes participated in the study. The research was guided by this question:

What is the effect of the think-aloud instructional strategy *using academic language and problem-solving thought process* on ELL student performance with solving word problems when teachers implement the protocol in middle school mathematics classrooms?

The results included multiple baseline graphs, various statistical measures, and bar graphs to analyze the data to examine the effect of the independent variable, think-aloud, on the dependent variable, ELL student performance. While examining the task performance and academic language usage with the multiple baseline method, seven trends emerged, and evidence was provided for each trend. The first two trends that appeared were directly related to the think-aloud strategy's impact on ELLs' performance and academic language. The third trend provided evidence that there was a proportional relationship between task performance and academic language usage. The three trends were 1) Groups' performance increased from baseline to treatment with the think-aloud; 2) Groups' academic language improved from baseline to treatment with the think-aloud; 3) Academic language usage is directly proportional to students' task performance score.

The other four trends emerged from various observations during data analysis were: 4) Gender Differences: Males used more academic language than females in their think-aloud; 5) Speaking Vs. Writing: ELLs used more academic language in their speaking than writing when asked to explain their reasoning; 6) Complexity of Content: The academic language usage depends on the complexity of the problem; 7) Learning Model: Digital Vs. Face-to-Face - F2F participants benefited from the think-aloud more than DLs.

The study used multiple statistical measures and representations to avoid internal validity threats (Kazdin,1982) and sustain statistical conclusion validity (Sealander, 2014). The findings section discussed the effect of the think-aloud strategy on individual and group performance, their academic language usage, and the proportional relationship between task performance and the academic language usage in addition to other four emerged observations in the data analysis.

Task Performance

When we compare individual performance growth, Bar Graph 1 comprehensibly displayed that each participant's average task performance increased significantly from baseline to the treatment. However, MB Graph 7 revealed that individuals from each group did not maintain their baseline performance. In contrast, participants' performance with the treatment significantly increased and remained steady throughout the 12 data points. Group 1 performed at an average score of 3.4/12 in the baseline, which increased to 9.6/12 with the treatment. Group 2 achieved an increase from an average score of 0.67/12 to 8.3/12 with the think-aloud. This improvement in the task performance scores and the declines in the values of *SD* and *CV* (Table 6) from baseline to treatment indicate that the think-aloud strategy seemed to help ELLs improve their problem-solving skills and maintain consistency throughout the treatment phase. Moreover, the trend lines with elevated slope and R^2 values indicate that the treatment phase's data values are reliable. The findings revealed that despite their low 7th-grade mathematics scores on district standardized tests, Group 2 performance improved with the treatment over time.

However, there were some variations in individuals' performance with the treatment. The literature review indicates that children's metacognition depends on their cognitive awareness and mathematical thinking (Hastuti et al., 2016; Purnomo et al., 2017; Wilson & Smetana, 2009). Although there was an improvement in individual student performance with the treatment, other factors seemed to cause the disparities in student performance in each group. As displayed in Table 4, Group 1's high 7th-grade ACCESS comprehension scores (5.5 to 6.0) tended to help them comprehend the word problem to plan how to solve it. Their proficient and developing levels of 7th-grade mathematics test scores as showed in Table 2 seemed to help them accomplish the task. Additionally, Alejandro's perfect attendance, self-motivation, and attentiveness in class benefitted him in achieving higher than his peers in Group 1. Despite his lower 7th-grade mathematics scores than his peers', his average task performance score was higher than the average scores of Ximeno and Yasmin. Alejandro's nature of attentiveness to his teacher's think-aloud, asking questions to clarify, and double-checking his work before submitting, tended to help him succeed in the overall task performance compared to his peers.

Similarly, Group 2 improved their task performance from the baseline to the treatment phase. Marisol and Emilio showed more and a similar amount of growth, respectively, than Leo. Although Marisol's 7th-grade mathematics test scores were slightly higher than her peers' in Group 2 as presented in Table 2, Emilio's higher comprehension 7th-grade ACCESS scores (5.0 to 5.5), perfect attendance, and self-motivation tended to help him accomplish his tasks by comprehending the problem and finding the right solution to improve his task performance that was similar to Marisol's.

Moreover, MB Graph 7 displays that students in Group 1 attempted most of the tasks and performed well on a few of them in the baseline, whereas Group 2 performed poorly in the baseline phase. Marisol from Group 2 didn't complete any tasks and earned zeros on every assignment. In contrast, Emilio and Leo attempted the problems. However, Group 2's task performance score improved rapidly from the baseline to the think-aloud treatment. Overall, the multiple baseline graphs showed that all six participants' performance changed dramatically based on their abilities and skills after the think-aloud was introduced, offering certainty and reliability in the treatment data (Sealander, 2014). Since students did not get opportunities to interact with their peers due to the pandemic, the six participants' performance growth solely resulted from listening to their teachers' think-aloud instruction and applying it in their own problem-solving.

Student samples in Table 7 and Table 9 illustrate that these participants had difficulty completing the baseline tasks, but they accomplished them with the think-aloud. It is possible that their baseline nonperformance was a result of issues with technology and disruptions in their home environments. This resulted in a lack of student accountability. Moreover, the complexity of the baseline problems might affect students' cognitive activity, causing them to withdraw

(Montague & Applegate, 1993). Altogether, the findings revealed that Group 1 and Group 2, despite their 7th-grade mathematics scores on district standardized tests, tended to improve their problem-solving performance with the treatment over time.

This study utilized the conceptual framework of Vygotsky's social constructivism, sociocultural, and critical sociocultural theories. However, the sociocultural component was overlooked due to the pandemic. Thus, ELL learning in this research merely depended on the learning theory of Vygotsky's ZPD. In conclusion, despite the pandemic restrictions, there was an improvement in ELL student performance in solving word problems with the think-aloud instructional strategy using the academic language and problem-solving thought process. In other words, it was evident from the findings that there was a positive effect of the think-aloud instructional strategy on ELL student performance with solving the word problems in middle school mathematics classrooms.

Academic Language

This study also examined individual's academic language usage during the think-aloud. Bar Graph 2 shows that individuals used more academic language in their think-aloud than in the baseline with minimal usage. It is also evident from the bar graph that individuals used the academic language at various degrees based on their literacy abilities and the task's complexity. As Table 11 and Table 12 illustrated, students used more language for complicated problems than less complicated tasks. Also, they used more complex academic language for more complicated algebra word problems, as shown in Table 10.

Overall, they seemed to improve their content vocabulary during the treatment phase. However, there were variations in all six participants' language improvement based on their mathematics abilities and academic skills. For instance, in Group 1, Alejandro improved his academic language usage than Yasmin and Ximeno. As presented in Table 2, despite his lower ACCESS test scores than his group members, Alejandro's attentiveness to their teacher's language usage and high ACCESS listening skills (5.5 to 6.0) seemed to help him learn the academic language better. Similarly, Group 2's participant Emilio improved his language usage than Marisol and Leo due to his attentiveness in class and high ACCESS listening scores (5.0 to 5.5). Emilio's hard work and self-motivation also tended to benefit him in being successful during the treatment phase.

Although there was an improvement in every participant's academic language usage, some participants developed their language more than others based on their intellectual abilities and mathematics skills. MB Graph 8 illustrates that despite the declines in language usage due to the complexity of the problem, the number of vocabulary words used by each participant improved over time with the treatment. Group 1's language usage increased from an average of one word in the baseline to 12 words with the treatment. Similarly, Group 2's language usage improved from an average of one word to an average of 9 words from baseline to treatment.

Furthermore, the decrease in *SD* and *CV* values from baseline to treatment distinctly indicates that students' academic language usage was consistent throughout the treatment phase. Also, the trendlines with slope (m) and R^2 values reveal that the participants' academic language data values were reliable. Alejandro and Emilio developed their academic language more than anyone else, and this improvement might be related to their perfect attendance and work habits throughout the study.

As displayed in Table 9, the student samples of the DLs, Ximeno (Group 1) and Leo (Group 2) explain how these ELLs accomplished their treatment tasks with the think-aloud by using the language to speak compared to their baseline work, where their attempt was nil. The treatment also helped Ximeno apply the specific academic language of the quadratic functions he learned from his teacher's think-aloud instruction. The transcription of Ximeno's think-aloud clearly reflects his language proficiency and mathematical thinking. Although Leo's think-aloud did not include content-heavy vocabulary, he solved the problem correctly. Leo could not explain his reasoning accurately because of his low speaking, writing, and comprehension skills (refer to Table 4). In short, the think-aloud helped these ELLs, including DLs, complete the task successfully and provide them opportunities to exhibit their academic language usage. However, these ELLs never participated in classroom conversations or small collaborative groups due to the pandemic. They practiced the think-aloud process only during the data collection. Though the pandemic restricted their learning strategies and resources, the six ELLs were motivated to participate in the study and executed good think-alouds.

Proportional Relationship between Task Performance and Academic Language

The next remarkable trend was a proportional relationship between task performance and academic language used to complete that task. Although this proportionality was not shown for every data point, various double MB charts in MB Graph 9 indicated different degrees of proportionality for different participants. When participants followed all four steps of the problem-solving thought process presented in the rubric, their task score and the number of vocabulary words increased and vice versa. The multiple charts with up and down arrows in MB Graph 9 illustrate the proportional relationship between the two dependent variables, student performance and academic language usage, due to the independent variable, the think-aloud.

Moreover, the student samples in Figure 10 show that Yasmin and Emilio used step-by-step problem-solving procedures and used content-specific vocabulary such as common factor, area model, factor form, zero pairs, factors in their think-aloud. Students were able to show their step-by-step work on the paper, in contrast to their baseline performance using the Desmos platform. Also, in the baseline phase, students were unaware of many of the problem-solving strategies introduced through the teacher's think-aloud and struggled to complete problems independently. In contrast, during the treatment phase, the think-aloud allowed them to present their thought process, which helped them perform the tasks. Therefore, an ELL who executes an effective think-aloud could produce more language and enhance their mathematics performance. In short, problem-solving steps and think-aloud strategy with academic language are beneficial for ELLs' academic success (Celedon-Pattichis, 1999). Moreover, Group 2 developed their academic language proficiency with the think-aloud approach, notwithstanding their low English language proficiency.

Additional Trends

There are other trends and observations found during the data collection and data analysis of the results. Most importantly, the COVID-19 pandemic has had an impact on ELLs' learning. Although participants performed well in the treatment phase, they had many incomplete assignments during the baseline. They were all digital learners, which could be a constraint on the baseline performance. They were also new to this Desmos platform and had a difficult time logging in, typing the equations, using the drawing tools, and submitting the work. In the treatment phase, the four F2F students preferred paper and pencil to complete their formative tasks during the data collection though they didn't have that choice in their classroom due to the pandemic restrictions. Moreover, the two DLs didn't produce much writing in their Desmos window, although they completed the assignments using the think-aloud in the treatment phase. Also, the inconsistency in their attendance and not being on time to class impacted their performance, especially for Leo, which could be a constraint for the valid results.

Secondly, gender differences were found in academic language usage, especially with F2F students. Males tended to use more academic language than females, and also, males' think-alouds were longer and more detailed. Bar Graphs 3 and 4 illustrate the variations in language usage by males and females on the common formative tasks completed by them. They were all F2F learners, and the comparison was made within the same group. Even though the difference in their vocabulary words was narrow on some tasks, overall, Alejandro and Emilio used more vocabulary words in their think-aloud than their female counterparts. This finding should lead to further research to examine gender differences in academic language acquisition.

The next trend was that the participants used more academic language while speaking than writing. Although most of the participants' writing ACCESS scores were higher than their speaking scores, they preferred to speak the language more than to write when explaining their reasoning. In many instances, students wrote the final answer after solving the problem after speaking their thought process, especially the DLs. This could be a result of their reluctance to use new words in writing due to lack of spelling or proper usage skills. Figure 13 displays how Ximeno, Emilio, and Leo executed good think-aloud but wrote minimal on their task. Also, the participants were nervous about thinking-aloud at the beginning. They used minimal words at first, and slowly they started feeling confident about it, which improved their performance and academic language. However, none of the participants ever used any Spanish words in their think-aloud, even though they were given that choice in the data collection. These participants didn't use their native language because it seemed that they didn't get opportunities to speak Spanish in the classroom during the task completion in the past. For instance, when I told one of the participants that he can speak both languages while thinking aloud, he said, "Can I speak in Spanish?" and he was very surprised because he never had this experience before in the classrooms. Hence, it is important for educators to provide these ELLs with opportunities to take advantage of their literacy skills of their first language.

The findings also indicate that the number of vocabulary words used depends on the complexity of the problem. In other words, students used more words for multi-step and challenging word problems than the less complex word problems. It was evident that complex mathematics problems require more detailed procedural steps to solve than easy questions with straightforward answers (Montague & Applegate, 1993). The scaffolding tool, the think-aloud, accommodates ELLs by breaking down the multi-step problem, therefore requiring more verbalization and academic language. Figure 14 illustrates Alejandro's two work samples with different difficulty levels and the number of vocabulary words used. He used only 8 academic words for solving a single-step word problem and 22 words in the multi-step word problem. Alejandro was always attentive to his teacher's modeling but never had any peer interactions, tended to learn problem-solving skills and essential content vocabulary more easily. He then worked in his proximal development zone to solve any level of complex problems successfully (Cardimona, 2018). Additionally, Table 10 shows that students used less complex vocabulary for less complicated problems and more complex words for more difficult problems. Therefore, the vocabulary words and the level of complexity of the language seemed to be proportional to the content's complexity.

The last trend in the findings was about which learning model was beneficial for ELLs during the pandemic. Although students worked independently throughout the semester due to the pandemic restrictions, F2F students were inclined to learn the content and language better than the DLs. As Bar Graph 5 shows, despite the higher ACCESS scores and 7^{th}-grade DDA scores, Ximeno's performance was slightly lower than Alejandro's. Also, Bar Graph 6 illustrates that Emilio performed much higher than Leo though they both were at the same level of academics in 7th-grade. Alejandro and Emilio are very studious and self-motivated students in addition to perfect attendance and good work ethic. They were attentive in class and focused on completing the tasks. In contrast, despite their abilities, Ximeno had family responsibilities that resulted in excessive absences, and Leo was always late to class and missed the first half of the instruction. These two DLs would have benefitted more with the F2F learning model.

In conclusion, the participants always attempted each formative task and produced their best think-aloud. All six participants mentioned that this research study motivated them to learn in class and perform better on their assignments. Therefore, the data demonstrated that the think-aloud protocol positively impacted ELLs' learning in this exploratory research study.

Connections to Literature

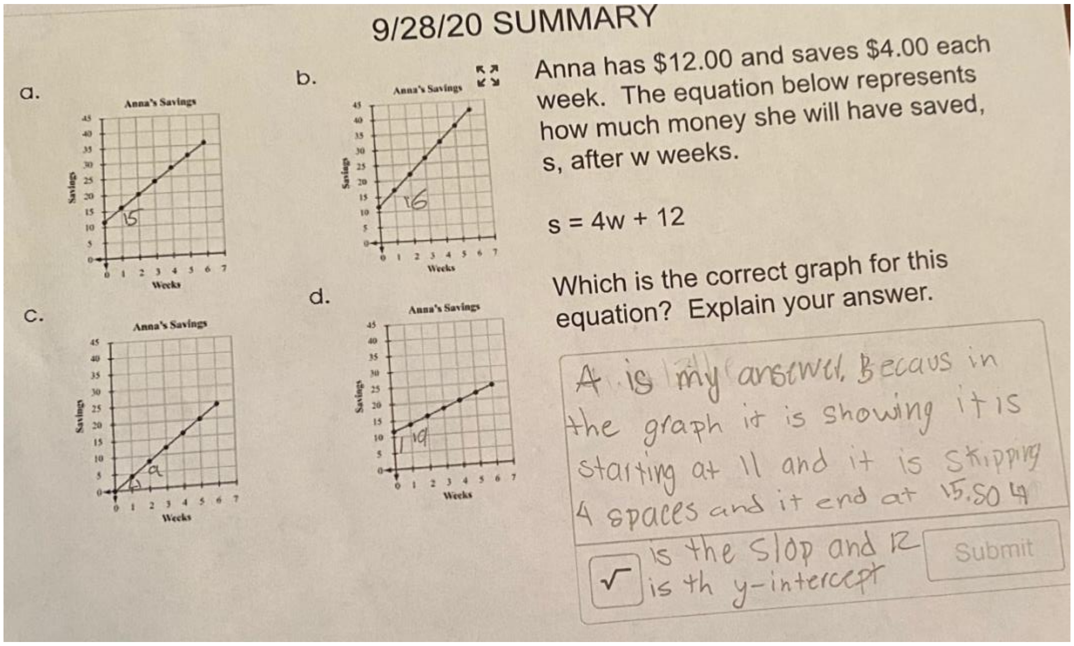
This study is aligned with the reviewed literature in chapter 2 in several ways. It is primarily based on Vygotsky's theory of ZPD, and this learning theory explains that teacher modeling helps children move to academic self-sufficiency in executing problem-solving (Bozkurt, 2017; Cardimona, 2018; Shabani et al., 2010; Sharkins et al., 2017). Chapter 2 literature review discussed that one of the essential components for ELLs' academic success in mathematics is providing necessary scaffolding (Vygotsky, 1978). Teacher modeling is one of the scaffolding strategies. The study's findings disclosed that the six participants learned the content and academic language from their teachers' problem-solving thought processes and executed their own think-aloud during the independent task completion. Although these ELLs could not have classroom interactions with their peers due to the pandemic, it was evident from the results that they improved mathematical thinking with the treatment to a certain degree. Therefore, teacher modeling is a critical component in engaging students in robust mathematical thinking and developing their metacognitive skills (Bernadowski, 2016; Nagy & Townsend, 2012).

Also, teacher expertise plays an important role in delivering powerful instruction for ELLs to succeed in the think-aloud process (Kurz et al., 2017; Nagy & Townsend, 2012). Teachers' expertise with think-aloud makes a tremendous difference in student learning. Although this study occurred in a pandemic, the two experienced teachers involved in this research delivered excellent think-alouds consistently in their daily instruction, reflected in the study results. Also, they taught ELLs and non-ELLs at the same rigorous level and did not make any modifications in their assignments. As studies reviewed, ELLs need to have access to high-quality education and the right opportunities they deserve regardless of their language proficiency (Kalinec-Craig, 2017; Martinez et al., 2010). Despite minimal interaction between students, teachers' consistency in modeling the think-aloud eventually helped students develop their metacognition and problem-solving skills (Purnomo et al., 2017; Wilson & Smetana, 2009). Therefore, these ELLs benefitted from their teachers' robust problem-solving thought processes and demonstrated an active thinking process in their independent practice during the data collection.

Moreover, in chapter 2, studies were reviewed (El Sayed, 2002; Schoenfeld, 2004; Tambychik & Meerah, 2010; Telli et al., 2018; Tinker Sachs, 1989) that student problem-solving performance is directly correlated with their language proficiency. If students can comprehend the word problem better, they can come up with a solution. The findings showed that participants' 7th-grade ACCESS comprehension scores are directly proportional to their academic language usage and task. Although participants' in this study held lower speaking and writing skills, their higher comprehension skills helped them improve their performance and vocabulary.

Moreover, the literature review from chapter 2 discussed that robust problem-solving requires procedural steps, which can be achieved by the thinking-aloud process (Fatqurhohman, 2016; Kurz et al., 2017; Montague & Applegate, 1993; Schoenfeld, 2004). The results and student samples revealed that the participants executed a step-by-step procedure while solving the problem using the think-aloud, which helped them develop their mathematical thinking over time. Lastly, the think-aloud strategy helped ELLs comprehend the word problems and monitor their own cognition in problem-solving (Bulut & Ertem, 2018; Tinker Sachs, 1989; Wilson & Smetana, 2009). In the study, there were several instances where students realized their own mistakes while thinking-aloud and fixed them using their conceptual understanding. Hence, the think-aloud approach helps to monitor one's thinking process and helps children become independent learners.

The following student sample with highlighted parts illustrates how Emilio monitored his own cognition and corrected his mistakes. The transcription of his think-aloud shows that Emilio first thought A was not the correct answer by looking at the slope and y-intercept. Later, he realized after looking at the other answer choices that the graph in answer choice A is skipping four units every time, so it is the right answer choice. Also, he got frustrated a little at the beginning by saying, "oh my God," because the graphs were hard to analyze for him to find the slope and y-intercept. However, his think-aloud assisted him in accomplishing the task and getting the right answer. In many instances, Group 2 participants felt overwhelmed and frustrated while problem-solving, but they completed the job with the think-aloud at their own pace.



Anna has $12 and saves four each week. The question below represents how much money she will save as after W weeks. What is the correct graph for this equation? Explain your answer. S equals four W plus 12. So we know that she saves four so the four W represents four dollars each week and the total represents how much she saves. And, okay. So, I'm going to write S plus four W. Okay. So I'm writing four W plus 12. And for graph A it shows that it is, graph A is representing. Oh my God. So, each week. So we know it's not A, because it's telling us that she saved $4 each week. And graph A is showing that she is saving about $11. Wait. (silence). Okay. So for graph A it is starting around 11 and then escaping so that... And then it's stopping. Wait. And it's stopping around 15. And B, it's starting at 11 and it's stopping at 16. All right. So it is around 15, and this is 16. Graph C is showing that it starts at zero and it's stopping around four. And after that it's going around nine. So this is four, nine. And graph D is starting around 11 and it's stopping around 19. So that is the nine. So for graph A, so it's not B because it starting at 11 and it's at the next point it starts stopping at 16. But it's showing that it's skipping four spaces each time and 11 plus four, or it's 15. So it's not B. It's not C because it's showing that it's starting at zero and it's going up four. That's correct. But it is skipping another four and it's stopping at around nine and it's supposed to be eight. And it's not D because the point of starting at it's 11 and the stopping. And the next point after that it's stopping at 19. And I think the answer for this question is A, because-... because 11 plus four is 15 and oh my God. So four W plus 12. The slope intersect is... Four is the slope and 12 is the Y intercept. Or, yeah.

Implications

The findings of the research study have practical implications for teaching and learning mathematics for ELLs. Also, this study has implications in the areas of research, practice, and methodology. This study offers mathematics educators a researched-based instructional strategy to improve ELLs' mathematical thinking and problem-solving performance. Teaching mathematical concepts and academic language to ELLs has been challenging for teachers in an integrated mathematics classroom in middle schools due in part to the lack of exposure to academic uses of English and the need for teachers' explicit teaching with modeling (Herges et al., 2017; Martinez et al., 2010; Verplaeste, 2008). Although ELLs have strong mathematical skills and may perform well in their first language, teachers need to prepare them for standardized testing here in the United States. Research shows that teachers spend more than one month per school year preparing students for mandated tests even though they believe in formative performance tasks (Garcia & Kleifgen, 2018). However, our goal is not just to help them pass the assessments but, to improve their problem-solving skills, mathematical thinking, and application in the real world. This study indicates that the think-aloud is one of the instructional strategies; mathematics teachers can use to teach mathematical reasoning and content vocabulary explicitly to help ELLs learn the problem-solving process and improve their performance (Özcan et al., 2017). This development of ELLs' problem-solving may ultimately lead to their academic achievement on assessments.

The study examined the impact of think-aloud instructional strategy on ELL student performance with formative assessments but not with summative unit tests or standardized tests. The study's findings also showed an improvement in their task performance and academic language usage in solving the formative tasks with the treatment. As Garcia & Kleifgen (2018) argue, there is no evidence that standardized testing improves emergent ELLs' education. Hence, it is recommended for mathematics teachers and school leaders to utilize more performance-based formative assessments, open-ended questions, discussion-based activities, close observations of students' conversations with mathematical thinking to measure ELLs' content learning and conceptual understanding (Garcia & Kleifgen, 2018; Verplaeste, 2008). Such alternative assessment practices help teachers assess what students learned and allow them to obtain valid and reliable information about ELLs' learning process, say Garcia & Kleifgen (2008).

Furthermore, the study's findings help teachers understand that the demonstration of the problem-solving thought process is a scaffolding tool that helps students learn the essential mathematics language and concepts simultaneously (Castellano et al., 2016; Pettit, 2011). Although this study did not involve any collaboration between students due to the pandemic, the findings indicate that ELLs engaged in discussing their thinking may enhance their mathematics performance and confidence. Also, collaboration with peers provides ELLs opportunities to connect mathematics problem-solving with their lives and experiences improving student engagement and achievement (Cummins, 2001; Garcia & Kleifgen, 2018; Verplaeste, 2008).

Thus, this study recommends mathematics educators implement more student-centered activities where ELLs receive abundant opportunities for interaction with the course content, with other students, and with their teachers (Verplaeste, 2008). Also, providing opportunities for ELLs to speak their home language and English in their learning process positively impacts their academic performance. As research shows, bilingual proficiency is positively related to academic achievement. Bilingual children also “possess more flexible perception and interpretations” (Garcia & Kleifgen, 2018, p. 51). Therefore, learning through interactions and giving ELLs opportunities to speak both languages in accomplishing the classroom tasks are crucial components for second language development and cognitive development, student motivation, and academic achievement (Garcia & Kleifgen, 2018; Verplaeste, 2008). Suppose ELLs never get opportunities to speak their first language in the classrooms, then the curriculum tends to neglect students’ culture and language from classroom contexts as a resource for learning. This disconnection of ELLs’ culture and lingo from classrooms is subtractive schooling and it is undemocratic, as Kalinec-Craig (2017) argues.

Furthermore, providing ELLs with opportunities to be paired up with a more competent ELL or a capable native-English speaker in collaborative learning is critical to boosting their problem-solving confidence. Student interactions with peers could create a physical space for them where they get more opportunities to think-aloud without hesitation and this helps them to produce language out loud to convey their thoughts and ideas, leading to personal and social development (Garcia & Kleifgen, 2018; Verplaeste, 2008).

The Algebra 1 course is a fast pacing class, and the complexity of content was a challenge for ELLs. As Robert and Schwarzenberger (2002) state, content's complexity "encountered by students sometimes causes them to lose all means of control over the material" (p. 131). Also, learning the difficult academic language and the concepts simultaneously might be overwhelming for these children, causing them to withdraw from the task completion. Despite these challenges, this study provided evidence that ELLs learned more complex language by listening to their teacher's think-aloud instruction and performed well on more challenging problems using the difficult language. As Verplaeste (2008) positions, teachers who provide explicit instruction for students by modeling the language usage and written samples could enhance ELLs' academic language communicative skills. Though students could not interact with their peers in this study, the opportunity they received to watch their teacher's problem-solving thought process and listen to their academic language usage seemed to help them grasp those skills. Additionally, the chance to think-aloud for the researcher during the treatment phase allowed them to express their mathematical thinking and utilize the academic language they learned to improve their mathematics performance and vocabulary.

In this study, ELLs could not complete the baseline tasks successfully, but in the treatment phase, they used the think-aloud as a strategy to accomplish the job in their zone of proximal development (Cardimona, 2018; Shabani et al., 2010; Zolkower & Shreyar, 2007). Therefore, it is evident from the study that students who cannot handle a problem alone may complete the task with the think-aloud strategy under adult supervision or with the teacher's guidance (Vygotsky, 1978). Mathematics teachers and school leaders can now adopt this instructional practice to help ELLs develop their mathematical competence and academic language proficiency.

The findings of the study have important implications for ELL learning in mathematics classrooms. As Celedon-Pattichis (1999) argues, teachers may not focus enough on content vocabulary and academic language when teaching ELLs. Hence, the instruction is not thorough enough to explain the essential mathematics concepts. The study's findings show that these ELLs acquired content-specific language from their teacher's detailed think-aloud. This vocabulary helped them comprehend the word problem, develop a plan, collect and analyze the given information, and find the solution. Teacher modeling collectively helped the six participants grasp the content vocabulary and metacognition process and apply it during their problem-solving task completion (Ness, 2016). Thus, teacher plays an important role in ELLs' learning process and teacher's expertise in explicit instruction and engaging ELLs in learner-centered activities help them develop cognitively and build positive literacy identities (Verplaeste, 2008).

Hence, this research study allows educators to understand that modeling their thought process is crucial for ELLs' learning and enhancement of their mathematical thinking. Moreover, the research findings demonstrate that when ELLs use the think-aloud approach, they produce step-by-step problem-solving procedures, which help them solve the problem correctly or correct their own mistakes. This step-by-step process also allows teachers to discover students' misconceptions and adjust their instruction accordingly.

These findings bridge the gaps in the literature on mathematical skills and abilities of ELLs in mathematics classrooms. When teachers provide them with explicit teaching about essential language, ELLs could exhibit their potential and perform at a high level regardless of their language proficiency. The results showed that despite the student-student interactions, the teacher's modeling plays a significant role in ELLs' academic performance and language acquisition. Therefore, this study urges mathematics educators to embrace the think-aloud instructional approach in their pedagogical practices to improve student achievement. Additionally, the study suggests educator leaders to implement this research-based strategy in their schools and provide novice teachers with adequate professional development on the think-aloud practice helping all students be successful in mathematics classrooms (Eun, 2011). Such experienced teachers in this study are also required to share their expertise with their colleague teachers, mathematics, and other content teachers to develop their knowledge of this powerful instructional tool.

Additionally, this study was conducted in two Algebra 1 teachers' classrooms, and these teachers have several years of experience teaching ELLs. Teacher expertise plays a crucial role in ELLs academic success. As Walqui (2008) argues, "the failure of schools to meet the needs of ELLs is directly linked to the degrees of teacher expertise" (p. 103), and it is necessary for teachers to receive appropriate professional development to provide quality education for ELLs to develop their potential. Effective professional development helps educators understand ELLs' academic strengths and limitations to provide proper scaffolding to extend their abilities with the help of their teachers and peers (Walqui, 2008). In summary, the study suggests that school leaders and teachers give ELLs multiple opportunities to extend their understanding and transfer their knowledge to a real-life application (Garcia & Kleifgen, 2018; Walqui, 2008).

Furthermore, this study fills the literature gap regarding ELLs from impoverished backgrounds and their mathematical strengths. In other words, ELLs can perform at a higher level regardless of their language proficiency and socioeconomic backgrounds when teachers explicitly teach them the necessary content and skills. The participants in this study are bilinguals, and their literacy skills in their home language could help them succeed in task completion and language usage. As Garcia & Kleifgen (2018) argue, bilinguals hold a greater learning mind as well as a problem-solving mind. As research shows, bilingualism is a critical factor in cognitive development, and bilinguals' constant use of two languages strengthens the brain's control mechanisms, which leads to academic proficiency. These bilinguals indeed have two separate languages that can support their learning with a cross-linguistic transfer, called translanguaging (Garcia & Kleifgen, 2018). In social interactions, bilingual speakers use both languages and become vibrantly linguistic. The translanguaging develops ELLs' second language and content understanding and creates a safe space for them to feel secured and connected, as Garcia and Kleifgen (2018) postulate. As a researcher and a bilingual teacher, I would tend to classify the ELLs as “Multi Lingual” (p. 63) Learners (MLLs) to increase the awareness of other cultures and promote these children's linguistic potentiality.

This study also indicated that ELLs are more motivated to speak than write. Hence, teachers need to provide more opportunities to collaborate for problem-solving, rather than independent practice. In this study, ELLs performed better by communicating their thought process, and thus, the think-aloud approach assists them in verbalizing their thinking through steps and monitoring their cognition (Barrera et al., 2006; Bernadowski, 2016; Ghaith & Obeid, 2004; Ness, 2016; Tinker Sachs, 1989). Thus, this study suggests that mathematics educators allow ELLs to interact more with teachers and peers through the whole group and small group discussions to gauge how ELLs' experiences and cultural backgrounds impact their academic achievement (Cummins, 2001; Verplaeste, 2008).

Lastly, the study used a single case design with multiple baseline methodology, and future studies can replicate this research design. The single-case design methodology helps evaluate the research question(s) with individuals or groups (Kazdin, 1982). Also, the results of this study highly recommend multiple baseline design to future studies involving examining the effectiveness of an independent variable, a treatment, on the dependent variable(s), individual's performance(s), or behavior(s). Moreover, the multiple baseline design's advantages are to analyze the impact of various treatments for one participant, one treatment for numerous participants, or a single participant in multiple settings (Sealander, 2014).

In conclusion, the findings revealed that the think-aloud strategy has positive effects on ELL student performance. Thus, this research suggests that mathematics teachers should adopt this approach in their daily instruction to develop their students’ problem-solving capacity.

Suggestions for Future Research

The COVID-19 pandemic impacted the data collection for this study. Despite the pandemic restrictions on teaching and learning, the think-aloud approach revealed many benefits on ELL student performance in the findings. Since this research occurred during the pandemic, there was minimal teacher-student and student-student interactions, especially for DLs. Thus, the DLs seem to have benefitted less from the think-aloud strategy than F2F learners. A suggestion for future research is to conduct the study during face-to-face instruction when the pandemic is over to obtain accurate results from the data collection and data analysis. Moreover, a future research is suggested to examine the impact of student-student interactions on ELLs’ academic language and cognitive development.

Unlike the present study of 8th-grade ELLs, it is recommended that future research be conducted with all three grade levels of the middle school, 6th, 7th, and 8th, to evaluate how ELLs respond to the think-aloud in lower grades. Also, the research can extend to higher grades beyond middle schools.

Additionally, this study had a sample size of six participants, which is not sufficient to generalize the results. These participants are all Spanish speakers. The findings showed that all six ELLs improved their problem-solving performance and academic language usage with the think-aloud. The future study may increase the sample size by extending the research to different language speakers from different cultural backgrounds to explore how culture influences academic performance with the treatment. This study can also be extended to students with disabilities and general education students to investigate how the impact of the think-aloud on their performance is similar or different from ELLs. Furthermore, educational researchers from other content areas can replicate this study to their subjects as well.

Moreover, as discussed in chapter 1, assessment achievement gaps exist for ELLs in diversely populated American schools (Polat et al., 2016; Willner et al., 2008). Since the findings showed an improvement in ELLs' performance with the think-aloud strategy, a further study is needed to investigate whether this treatment could boost their academic achievement on standardized testing. Therefore, future research is suggested to examine the pre-post-test growth before think-aloud and after think-aloud with an experiment and a control group with various students.

Lastly, in this study, a modified multiple-baseline design was used by keeping all six participants in the same baseline period for two weeks. A suggestion for the future is to follow the ideal MB design and keep the participants in each group more than the other students in the baseline period to investigate the intervention's impact on student performance.

Final Thoughts

Overall, my research study attempted to examine the effect of the think-aloud instructional strategy on ELLs' performance with problem-solving and their academic language usage when it is implemented in middle school mathematics classrooms. Based on the literature review and the study's findings, mathematics teachers can help ELLs improve their performance in solving word problems by modeling the problem-solving thought process with essential academic language. Teaching with think-alouds and encouraging ELLs to think-aloud in their individual and group activities could potentially enhance students' problem-solving performance.

Although ELLs with lower ACCESS speaking scores hesitate to think-aloud, they will become more comfortable as teachers consistently implement this strategy and provide guidance on the process. Regardless of their abilities in mathematics and ACCESS test scores, all six participants were nervous with the think-aloud process initially during the treatment phase. Eventually, they became comfortable with the process and started enjoying it. This research also motivated them and helped them improve their performance on other classroom assignments. However, the pandemic restricted their opportunities to use think-aloud daily in their small collaborative groups. Once the pandemic is over, mathematics teachers may need to integrate the think-aloud strategy into small-group activities to empower ELLs and improve their academic achievement in mathematics classrooms. The think-aloud instructional strategy has a tremendous impact in refining their conceptual understanding, polishing their problem-solving thought process, and building ELLs confidence in mathematics.

As the researcher, I recommend mathematics educators adopt the think-aloud practice as part of their daily instruction. Additionally, students should be provided with opportunities for thinking aloud frequently in classroom activities. The think-aloud protocol not only develops students' cognition but also encourages classroom interactions. These interactions build active student engagement and strengthen their conceptual understanding and language development (Bozkurt, 2017; Hanham & McCormick, 2018; Herges et al., 2017; Powell & Kalina, 2009; Sachs et al., 2003). Furthermore, the think-aloud strategy enhances ELLs' motivation, effort, and concentration during problem-solving. The think-aloud approach also creates a positive learning environment that can reinforce positive behaviors and self-esteem. As this study and the reviewed literature indicate, teacher modeling can ultimately result in students' cognitive development and performance growth even beyond the mathematics classrooms. In conclusion, helping the MLLs could provide them with a key to the world of mathematics!

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Appendices

Appendix A: Formative Assessment Rubric

Problem-Solving Skills Rubric

Name: ________________________ **Grade:** _________ **Date:** _______________

Performance Area	Rating = 3	Rating = 2	Rating = 1	Rating = 0	Score
Defining the Problem	Student states the problem clearly and identifies underlying issues.	Student adequately defines the problem.	Student fails to define the problem adequately.	Student does not identify the problem.	
Developing a Plan to Solve the Problem	Student develops a clear and concise plan to solve the problem, with alternative strategies, and follows the plan to conclusion.	Student develops an adequate plan and follows it to conclusion.	Student develops a marginal plan and does not follow it to conclusion.	Student does not develop a coherent plan to solve the problem.	
Collecting and Analyzing Information	Student collects information from multiple sources and analyzes the information in-depth.	Student collects adequate information and performs basic analyses.	Student collects inadequate information to perform meaningful analyses.	Student collects no viable information.	
Interpreting Findings and Solving the Problem	Student provides a logical interpretation of the findings and clearly solves the problem, offering alternative solutions.	Student provides an adequate interpretation of the findings and solves the problem but fails to provide alternatives.	Student provides an inadequate interpretation of the findings and does not derive a logical solution to the problem.	Student does not interpret the findings/reach a conclusion.	
				Total	
				Overall Score	**12**

Appendix B: Parental Consent Form

Georgia State University
Parental Permission Form

Title: Examining the Effect of the Think-Aloud Instructional Strategy on ELL Student Performance in Middle School Mathematics Classrooms

Principal Investigator: Dr. Pier Junor Clarke
Student Principal Investigator: Phani Duggirala

Introduction and Details

We are asking your child to take part in a research study. It is up to your child to decide if they would like to be in the study. The goal of this study is to see the result of the think-aloud strategy on ELL student work in math class. Your child will need to spend about 30 minutes a day for 16 days over 15 weeks. We will ask them to do a math task that their teacher makes. The study may either take place in a private room at the school OR on the zoom virtual platform if learning is digital during the pandemic. Being in this study will not create any more risks than your child would face in a day. This study will not help them. Overall, we hope to gain information about how the think-aloud strategy affects ELL success in math.

Purpose

The goal of the study is to see how the think-aloud strategy helps students do well in math class. We ask your child to be in this study because they are an ELL. We will ask a total of six ELLs to be in this study.

Procedures

If your child wants to take part, they will do a math task for 20 to 30 minutes a day for 16 days across 15 weeks. These are the rules and duties:

- Your child must be in a math classroom as an ELL
- You must give permission if your child is under the age of 18
- Your child must bring parental and student permission forms to the researcher before the deadline to join the study
- The study may either take place in a private room at the school OR on the zoom virtual platform if learning is digital during the pandemic
- The study will be during school hours
- Your child may leave the study at any time without notice
- Your child will finish a 20 to 30-minute math task per day for 16 days
- Your child's voice will be audio recorded while they complete the math task

Future Research

We will delete your child's name and may use their data for future study. If we do this, we will not ask for any more consent from them.

Risks
In this study, there will not be any more risks than in a normal day of life. Your child will not get hurt from this study, but if they think they got hurt, call the research team as soon as possible. Georgia State University and the research team will not pay for any injury.

Benefits
This study does not help your child. Overall, we hope to gain information about how the think-aloud strategy affects ELL student work.

Voluntary Participation and Withdrawal
Your child does not have to be in this study. If they decide to be in the study and change their mind, they have the right to leave at any time. Your child may stop doing the task at any time. They may refuse to be in the study or stop at any time. This will not affect their grade in any way.

Alternatives
The alternative to taking part in this study is to not take part in the study

Confidentiality
We will keep your child's records private to the extent allowed by law. The following people will have access to the details they provide:

- Phani Duggirala and Dr. Pier Junor Clarke
- GSU Institutional Review Board
- Office for Human Research Protection (OHRP)
- Transcription service "Rev"

We will use your child's numbers, not their name, on study records. We will keep the details they gave us including their audio voice recordings on password- and firewall-protected computers. We will keep the consent forms and study data separately. When we present or publish the results of this study, we will not use your child's name or other details that may identify them.

Contact Information

Contact Pier Junor Clarke at pjunor@gsu.edu or Phani Duggirala at pduggirala1@student.gsu.edu

- If you have questions about the study or your child's part in it
- If you have questions, concerns, or complaints about the study

The IRB at Georgia State University reviews all research that involves human participants. You can contact the IRB if you would like to speak to someone who is not involved directly with the study. You can contact the IRB for questions, concerns, problems, details, input, or questions about your child's rights as a research participant. Contact the IRB at 404-413-3500 or irb@gsu.edu.

Consent:
We will give you a copy of this parental permission form to keep. If you are willing to volunteer your child for this research, please sign below.
Participant/Child's Name: ________________________________

________________________________ ____________
Print Parent/ Legal Guardian's Name Date

____
Signature

________________________________ ____________
Principal Investigator or Researcher Obtaining Consent Date

Appendix C: Translated Parental Consent Form

Georgia State University (Universidad Estatal de Georgia)
Formato de Permiso de los Padres

Título: Evaluación de los efectos de la estrategia educativa de pensar en voz alta en el desempeño del estudiante de ELL*[*]*, en la clase de matemáticas del nivel secundaria.

[*] ELL – English Language Learner: Aprendiz del Idioma Inglés

Investigador Principal: Dr. Pier Junor Clarke
Estudiante Investigador Principal: Phani Duggirala

<u>Introducción y pormenores</u>
Estamos invitando a su hijo(a) a formar parte de un trabajo de investigación. Es decisión de su hijo(a) si le gustaría participar en este estudio. El objetivo del estudio es examinar los resultados de la estrategia de pensar en voz alta en el trabajo de un estudiante de ELL*[*]* en la clase de matemáticas. Su hijo(a) deberá dedicar alrededor de 30 minutos diarios, por 16 días en un periodo de 15 semanas. Se le pedirá a su hijo(a) que resuelva una tarea matemática que su maestra le indique. El estudio puede llevarse a cabo ya sea en un salón privado de la escuela, **<u>o</u>** a través de la plataforma virtual Zoom si la instrucción es digital durante la pandemia. Participar en este estudio no genera ningún riesgo más que el que su hijo(a) vive en un día normal. Este estudio no ayudará a su hijo(a); en general esperamos obtener información acerca de cómo la estrategia de pensar en voz alta afecta en el éxito de los estudiantes de ELL*[*]* en matemáticas.

<u>Propósito</u>
El objetivo del estudio es identificar cómo la estrategia de pensar en voz alta ayuda a los estudiantes a desempeñarse bien en la clase de matemáticas. Invitamos a su hijo(a) a participar en este estudio porque él es un estudiante de ELL*[*]*. Invitaremos a un total de seis estudiantes de ELL*[*]* a formar parte de este estudio.

<u>Procedimientos</u>
Si su hijo(a) quiere participar, él (ella) llevará a cabo una tarea matemática por 20 a 30 minutos al día, durante 16 días, en un periodo de 15 semanas. Estas son las reglas y las responsabilidades:

- Su hijo(a) debe ser parte de una clase de matemáticas como estudiante de ELL*[*]*
  [*]English Language Learner: Aprendíz del Idioma Inglés
- Si su hijo(a) es menor de 18 años, usted debe otorgar el permiso.
- Para participar en el estudio, su hijo(a) debe entregar al investigador los formularios de permiso de los padres y del estudiante, antes de la fecha límite.
- El estudio puede llevarse a cabo en un salón privado de la escuela **<u>o</u>** a través de la plataforma virtual Zoom si la instrucción es digital durante a la pandemia.
- El estudio se llevará a cabo durante las horas de escuela.
- Su hijo(a) puedes abandonar la investigación en cualquier momento, sin necesidad de aviso.
- Su hijo(a) deberá finalizar una tarea matemática de 20-30 minutos cada día, por 16 días.
- La voz de su hijo(a) será grabada mientras completa la tarea matemática.

Investigación futura
Suprimiremos el nombre de su hijo(a) y su información puede que sea utilizada en futuros estudios. Si hacemos esto, no solicitaremos ningún otro consentimiento de parte de su hijo(a).

Riesgos
En este estudio no habrá más riesgos que los de la vida cotidiana. Su hijo(a) no será lastimado(a) en este estudio; pero si su hijo(a) cree que fue lastimado(a), comuníquese con el equipo de investigación tan pronto como sea posible. La Universidad Estatal de Georgia y el equipo de investigación no pagará por ninguna lesión.

Beneficios
El estudio no está diseñado para ayudar a su hijo(a). En general, esperamos obtener información sobre cómo la estrategia de pensar en voz alta afecta el trabajo del estudiante de ELL*[*]*

Participación voluntaria y renuncia
Su hijo(a) no tienes que participar en este estudio. Si su hijo(a) decide participar en la investigación y cambia de opinión, el (ella) tiene el derecho de retirarse en cualquier momento. Su hijo(a) puede parar en cualquier momento al hacer la tarea matemática. Su hijo(a) puede rehusarse a participar en el estudio o detener su participación en cualquier momento. Esto no afectará sus calificaciones de ninguna manera.

Alternativas
La alternativa a participar en el estudio es no participar en él.

Confidencialidad
Mantendremos en privado los registros de su hijo(a) conforme lo requerido por ley. Las siguientes personas tendrán acceso a la información que su hijo(a) proporcione:

- Phani Duggirala y Dr. Pier Junor Clarke
- GSU Institutional Review Board [Consejo de Revisión Institucional de la Universidad Estatal de Georgia]
- Office for Human Research Protection (OHRP siglas en inglés) [Oficina para la Protección de Participantes en Investigaciones en Humanos]
- Servicios de transcripción “Rev”

En los registros del estudio utilizaremos el número de su hijo(a), no su nombre. Guardaremos la información que su hijo(a) nos proporcione, incluyendo las grabaciones de su voz, en computadoras protegidas a través de un servidor de seguridad y un código. Mantendremos por separado los formularios de consentimiento y los registros del estudio. Cuando presentemos o publiquemos los resultados de esta investigación no utilizaremos el nombre de su hijo(a) o ninguna otra información con la que pueda ser identificado.

Información de contacto

Contacte a Pier Junor Clarke a través de pjunor@gsu.edu o a Phani Duggirala a través de pduggiralal@student.gsu.edu

- Si tiene preguntas sobre la investigación o la participación de su hijo(a) en él.
- Si tiene preguntas, dudas o quejas sobre el estudio.

El Consejo de Revisión Institucional (IRB *siglas en inglés*) de la Universidad Estatal de Georgia revisa toda investigación que involucre participantes humanos. Usted puede contactar al IRB si desea hablar con alguien que no esté involucrado directamente en el estudio. Usted puede contactar al IRB si tiene preguntas, dudas, problemas, información o comentarios; o si tiene preguntas sobre los derechos de su hijo(a) como participante en la investigación. Contacte al IRB al teléfono 404-413-3500, o a través de irb@gsu.edu.

Consentimiento:
Le proporcionaremos una copia de este formulario de permiso de los padres para que lo tenga consigo. Si usted está dispuesto a que su hijo(a) sea voluntario(a) en esta investigación, por favor firme a continuación.

Nombre del menor que participa: ____

____ _______________
Nombre con letra imprenta del Padre (la Madre) / Tutor legal Fecha

____
Firma

____ _______________
Investigador principal que obtiene el consentimiento Fecha

Appendix D: Student Assent Form

Georgia State University
Student Informed Assent

Purpose
The goal of the study is to see how the think-aloud strategy helps students do well in math class.

Procedures
If you want to take part, you will do a math task for 20 to 30 minutes a day for 16 days across 15 weeks. These are the rules and duties:

- You must be in a math classroom as an ELL
- Your parents must give permission if you are under the age of 18
- You must bring parental and student permission forms to the researcher before the deadline to join the study
- The study may either take place in a private room at the school OR on the zoom virtual platform if learning is digital during the pandemic
- The study will be during school hours
- You may leave the study at any time without notice
- You will finish a 20 to 30-minute math task per day for 16 days
- Your voice will be audio recorded while you complete the math task

Risks
In this study, there will not be any more risks than in a normal day of life. You will not get hurt from this study, but if you think you got hurt, call the research team as soon as possible. Georgia State University and the research team will not pay for any injury.

Benefits
This study does not help you. Overall, we hope to gain information about how the think-aloud strategy affects ELL student work.

Voluntary Participation and Withdrawal
You don't have to be in this study, and your parent(s)/legal guardian(s) cannot make you be in it. Also, you can stop being in the study at any time and no one will be mad or upset with you if you decide not to be in the study.

Assent: If you are willing to volunteer for this research, please sign below.

_________________________________ _____________
Print Name Date

____
Signature

_________________________________ _____________
Principal Investigator or Researcher Obtaining Consent

Appendix E: Translated Student Assent Form

Georgia State University (Universidad Estatal de Georgia)
Consentimiento Informado del Estudiante

Propósito
El objetivo del estudio es identificar cómo la estrategia de pensar en voz alta ayuda a los estudiantes a desempeñarse bien en la clase de matemáticas.

Procedimientos
Si quieres formar parte de esta investigación, llevarás a cabo una tarea matemática por 20 a 30 minutos al día, durante 16 días, en un periodo de 15 semanas. Estas son las reglas y las responsabilidades:

- Debes ser parte de una clase de matemáticas como estudiante de ELL*[*]*
  [*]ELL-English Language Learner: Aprendíz del Idioma Inglés
- Si eres menor de 18 años, tus padres deben otorgar el permiso.
- Para ser parte de la investigación debes entregar al investigador los formularios de permiso de los padres y del estudiante, antes de la fecha límite.
- El estudio puede llevarse a cabo ya sea en un salón privado de la escuela **o** a través de la plataforma virtual Zoom, si la instrucción es digital durante a la pandemia.
- El estudio se llevará a cabo durante las horas de escuela.
- Puedes abandonar el estudio en cualquier momento, sin necesidad de aviso.
- Deberás finalizar una tarea matemática de 20-30 minutos cada día, por 16 días.
- Tu voz será grabada mientras completas la tarea matemática.

Riesgos
En este estudio no habrá más riesgos que los de la vida cotidiana. No serás lastimado en este estudio; pero si crees que fuiste lastimado, comunícate con el equipo de investigación tan pronto como sea posible. La Universidad Estatal de Georgia y el equipo de investigación no pagará por ninguna lesión.

Beneficios
El estudio no está diseñado para ayudarte. En general, esperamos obtener información sobre cómo la estrategia de pensar en voz alta afecta el trabajo del estudiante de ELL*[*].*
[*]ELL-English Language Learner: Aprendíz del Idioma Inglés

Participación Voluntaria y Rescisión
No tienes que participar en este estudio y tus padres o tutores legales no pueden hacerte participar en él. Puedes además renunciar a tu participación en cualquier momento y nadie se molestará o se enfadará contigo si decides no seguir en el estudio.

Consentimiento: Si estás dispuesto a ser un voluntario de esta investigación, por favor firma a continuación.

____ _______________
Nombre con letra imprenta Fecha

____
Firma

____ _______________
Investigador principal que obtiene el consentimiento Fecha

Appendix F: Recruitment Script for Parents

Hello [Name],

My name is Phani Duggirala, and I am the instructional coach at Hope Middle School. If you have a few minutes to spare, I would like to talk to you.

Thank you so much for your valuable time. I am a doctoral student at Georgia State University, and I am conducting a research study at Hope Middle School. My research is on examining the effect of the think-aloud instructional strategy on student performance of English language learners in mathematics classrooms. Your child is being asked to take part in this research study because he/she is an English language learner.

This study is anticipated to take no more than 30 minutes, once a week, occasionally twice a week for the 15 weeks of the fall semester. In this study, your child will need to complete a mathematics task created by their teacher by thinking aloud in a private setting in the building or on the zoom virtual platform if the learning is digital during the pandemic. Your child's voice will be audio recorded while completing the task. Our principal permitted me to do this research at school. Participation in this study is voluntary, and your child's identity as a participant will remain confidential during and after the study. This study neither benefits your child nor affects his/her grades. If you agree, your child is invited to participate.

Do you have any questions for me about this study? If you agree, I will mail the consent form to you and a pre-stamped envelope with the school address. You can drop the signed consent form at school, or you can mail it to school. If you have any questions at any time, feel free to call me at 678 895 4772. If you want your child to participate, you can either call me or I can call you back within two business days. Which one you prefer?

Once again, thank you so much for your time.
I am looking forward to working with your child. Have a great day!

Appendix G: Recruitment Script for Students

Dear [Name],

How are you doing? As you know, I work at this school as the mathematics instructional coach. I want to tell you that I am researching mathematics education, and we are recruiting six 8th-grade Algebra students. You are being asked to take part in this research study because you are an English language learner. We already contacted your parents, and they are willing for you to join this study. I would like to know whether you are also willing to participate.

Let me tell you the details. For this study, you will need to spend about 30 minutes, once a week, a couple of times twice a week for the 15 weeks of the fall semester. You will need to complete the math task that your teacher creates, in a private setting. In other words, after your teacher finish teaching, you will complete the classwork by sitting with me instead of sitting with your peers in the classroom for that day. Since schools are going online for the first few weeks, I will work with you on the zoom, the video call. During this process, only you and I will be present in the zoom breakout room and no other students or staff members will present in the breakout room. However, you might have your family members sitting in your study space at home. Please know that your work will not be graded. However, while completing the math task, you will need to be talking aloud how you solve the problem. While you are talking aloud, I will audio record your voice. Your audio recordings and your work will be confidential during and after the study. This study will not benefit you and will not affect your grades. But this research study may help mathematics teachers.

If you are willing to participate in this study, you will need to sign the assent form. Do you have any questions or concerns? Feel free to ask me, and our conversation will be very confidential. Are you willing to participate? You don't have to tell me right now if you need more time to think. I can get back to you in two days to hear your decision.

If you would like to participate, I would appreciate your participation. Thank you so much for spending your time with me and listening to me. I am looking forward to working with you. Hope you will have a great day!