Reading Fluency Development and Science in a Fourth Grade Dual Language Immersion Classroom

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Reading Fluency Development and Science in a Fourth Grade Dual Language Immersion Classroom

Talia A. Casares

A thesis submitted to the faculty of Brigham Young University in partial fulfillment of the requirements for the degree of Master of Arts

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ABSTRACT

Reading Fluency Development and Science in a Fourth Grade Dual Language Immersion Classroom

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Students from dual language immersion (DLI) classrooms are required to learn the language through content. However, some students have not yet developed these abilities by the time they start fourth grade. Thus, to fully comprehend content such as science, students need stronger reading and writing abilities in the second language (L2). To help stakeholders have a better understanding on how to effectively help students throughout this process, this action research studied the effectiveness of integrating literacy with science and mobile-assisted language learning (MALL). Findings showed that the integrations of literacy, science and MALL were effective with statistically significant results in science and reading. These findings also yielded pedagogical implications about the importance of considering students’ language background and gender, as well as the use of MALL when teaching and planning the curriculum for DLI classrooms.

Keywords: dual language immersion (DLI), science, literacy, mobile-assisted language learning (MALL), motivation, language background, gender, reading fluency, accuracy, retell, heritage learners, content-based instruction, TPACK
Acknowledgments

I would like to express my deepest gratitude to my committee members for their help and support throughout the study. I value their knowledge and advice. I would especially like to thank Dr. Cherice Montgomery, the chair of my committee for her time and expertise. Her example and the high expectations she set for me were valuable for the completion of this research. Lastly, I would like to thank my husband and parents for their support and encouragement, without them this research could have not been possible.
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Chapter 1: Introduction

Dual Language Immersion (DLI) programs have set goals for the development of academic content knowledge and language proficiency. That is why they provide a 50-50 program where half of the day students learn academic content in English and the other half of the day, they learn it in another language (Utah Dual Language Immersion, n.d.). Nevertheless, to be able to learn academic content from textbooks in school settings, students must become proficient readers to understand the content and build up their knowledge. In fact, it is important to remember that scientific communication has been done through print-based language for a long time (Yore et al., 1994). This means that scientists have used reading and writing as their medium of communication. Therefore, in order to acquire scientific knowledge in the way scientist do, students need to be able to understand and use printed texts such as articles and reports. For this reason, students need to improve literacy skills such as reading and writing. Likewise, students improve their reading by having science activities that influence their language development and motivate them to become good readers (Lee & Fradd, 1998). This means that by becoming good readers, students understand science better and become more proficient language learners.

Even though researchers have tried different strategies for improving reading comprehension and the enhancement of content learning such as science, there is still a lack of knowledge about how to effectively combine approaches to improve language learning in DLI classrooms. As a response, researchers have suggested that Mobile-Assisted Language Learning (MALL) is a promising tool that could help teachers and students in this process. In fact, this research has shown that the use of technology enhances learning and offers promising options for improving reading fluency (Luke & Britten, 2007). This means that the use of MALL is a
strategy that could help teachers improve their teaching. In fact, tool provides apps with audiobooks that have assisted-reading features such as audiobooks, text highlighting, audio recordings, and self-correction. In addition, audiobooks give students the opportunity to listen to the text read. Text highlighting allows students to see the text being read and audio recording allows students to record themselves as they read for further listening and self-correction experience (Yudhiantara & Nasir, 2017). In addition, MALL provides teachers and students with tools such as digital notebooks, interactives, and visual representations. All of these enhance interest and motivation in science learning (Edelson et al., 1999). All the findings of previous studies suggest that MALL may offer promising solutions to help students become proficient readers and interconnect different topics to develop reading and science skills.
Chapter 2: Review of Literature

Language education in the 21st century has evolved and changed over time and with experience. Specifically, three major changes have occurred in the last decade: the Common Core Standards were introduced, dual language immersion programs have grown, and technology has become an important part of classroom instruction.

Firstly, the United States of America launched new standards for education in 2009 designed to prepare students for college and future life opportunities (National Governors Association & Council of Chief State School Officers, 2010). The new system, called the Common Core State Standards Initiative, proposes that the purpose of education is to prepare learners to succeed in a global world (Zhao, 2010). In order to fulfill this purpose, students need to develop 21st century skills such as communication, collaboration, and technology skills (American Council on the Teaching of Foreign Languages [ACTFL], 2020). Because business is global and interdependent, one important 21st century skill is to communicate and collaborate with people from other cultures. This means students need to be able to function in other languages, not just by speaking the language, but by being able to function professionally among other cultures (Committee for Economic Development, 2006). Furthermore, the new system declares that language arts education should prepare students with critical-thinking skills and the ability to read in a way that will help students understand, examine, make connections, and improve communicative skills.

Secondly, students need to practice the language that is used in professional ways to become literate and succeed in a global world, making DLI one powerful model for integrating language and content. For instance, the state of Utah has approved and supported the International Education Initiative, Senate Bill 41, which allows schools to participate in a
program called Dual Language Immersion (DLI). In this program, students spend half of their school day learning English Common Core Standards whereas the other half of the day they continue learning the Common Core Standards, but in a different language (Utah Education Policy Center, n.d.). The implementation of this program has provided benefits to students that will allow them to succeed in a global community. For example, the Utah State Board of Education (2020) has said that when students take standardized tests, they usually score as well as or better than non-immersion students. By the same token, they develop cognitive skills that help them be proficient in both the target language and their own (Alanís & Rodríguez, 2008).

In addition, a third important change in education is technology. The regular use of technology on a daily basis is urging teachers to change their views and approaches towards technology in language classrooms (Kukulska, 2009). The opportunities and challenges that educators encounter as they teach are different from what they were before. As an example, some of the affordances of mobile devices are movability (students can use their devices at different places), social interactivity (facilitates communication with other people), connectivity (shared information), and individuality (individual learning based on their needs). All of these foster student’s engagement, collaboration, and self-learning. However, teachers may also encounter challenges related to technology, such as distraction, lack of availability, cost, and teacher development (Hashim et al., 2017; Klopfer et al., 2002; Kukulska et al., 2009). These challenges may require extra preparation and resources to which not all teachers have access. For example, when students use technology, they may be distracted exploring other apps or games on their mobile devices and teachers may need extra training to know how to handle and avoid these situations. Also, due to the cost of new technologies, teachers may not have access to devices such as tablets or phones, which may interfere with their desire to use them. Moreover, the fast
and growing innovation in technology is also changing the strategies and methodologies used by language teachers, and they need to be ready to help their students succeed in a rapidly emerging world (Garrison & Kanuka, 2004). An example of these changes is blended learning, in which students learn part of their curriculum online and part of it in person with a teacher (Clayton Christensen Institute, n.d.).

As part of blended learning, there are a few frameworks that teachers can use to improve instruction. One of these frameworks is called the SAMR (Substitution, Augmentation, Modification, Redefinition), which allows teachers and students to go above and beyond regular activities in the classroom by redefining and modifying instruction with tools such as augmented reality (Romrell et al. 2014). This means that technology is not just a substitution of activities done in a traditional classroom. On the contrary, SAMR provides an integration of transformed instruction in which students’ learning is enhanced.

Another example of a framework for blended learning is TPACK (Technological Pedagogical Content Knowledge), in which three primary forms of knowledge are used to plan instruction: technological knowledge, pedagogical knowledge, and content knowledge (Koehler & Mishra, 2009; Pamuk, 2012). These three types of knowledge are aligned to help teachers give a better instruction and empower students in their learning. In a DLI classroom, integrating the TPACK framework into instruction allows teachers to incorporate science and reading, technology and pedagogy to help students have a better learning experience in a second language. In fact, a review of literature suggested that using TPACK in language classrooms has helped students improve their communication skills (Debbagh & Jones, 2015). The literature review found that using technologies allows students to learn the culture and the language as they are used in real life settings. This helps language learners to be able to function in real life,
academic and professional settings and to actively participate in the community. As a result of these findings, the researchers suggested that in order for the TPACK framework to function successfully in language classrooms, several conditions must be met. First, the content component should include language and culture. Second, the pedagogical components should include second language acquisition strategies. Third, the technological components should include tools that are likely to help students learn both language and academic content. These tools might include tools for collaboration, tools for learning and exploring science content (such as simulations), and tools for learning both the culture of the language and the culture of the academic discipline (Keengwe & Kang, 2013). This means that the integration of content, pedagogy, and technology offers new opportunities for students. These opportunities go beyond their classrooms, giving them a better perspective on the world. However, these frameworks are still evolving, and due to the lack of research on the topic, it is still unknown how their integration would affect dual language immersion classrooms.

Finally, it is important to remember that to help students succeed in the 21st century, teachers need to equip them with the skills they need. Language and technology play an important role. However, research on technology implementation has, in general, focused mainly on attitude, motivation, and engagement of students. In addition, most of the research specific to language learning has been done in secondary and university English as a Second Language and world language classrooms. Therefore, more empirical evidence is needed to explore the impact of technology on the development of a second language, specifically on how the integration of science and reading fluency can be improved through technology in a DLI classroom.
Reading Proficiency

Although reading is an important part of the Common Core Standards for the 21st Century, reading continues to be a struggle for many students. Testing has shown that the majority of students' reading abilities in English are so far below grade level that more and better strategies need to be developed to help them become proficient readers (NAEP, 2019).

In the year 2019, the average scores on reading proficiency tests around the nation revealed that just 34% of 4th grade students scored at or above proficient. This means that more than 50% of the students lack the ability to read at their level, which may cause more difficulties in their academic development. For example, they may struggle to understand more complex concepts from other subjects such as science.

In addition, it is important to remember that the population of K-12 students in the United States of America is very diverse. Due to differences in students’ language proficiency levels and background knowledge, their learning experiences may vary among themselves, challenging teachers to provide adequate strategies to help them succeed (Baker et al., 2012). Consequently, there are students becoming literate in two languages, either because they are heritage students or second language learners. Additionally, due to the importance of language acquisition, many studies have shown that language ability and knowledge from students’ first language are likely to transfer to students’ second language. In other words, skills such as word accuracy and fluency are transferred between languages, as was suggested by a study done with 471 Spanish-speaking English learners in Grades 1 to 3 (Baker et al. 2012). In this study, pseudoword reading (non-words) and fluency were tested. These tests, intended to measure the accuracy and speed of learners’ reading skills, concluded that students’ reading fluency improved in both languages even when they were just taught in Spanish. This means that if students learn how to read in one
language, it is likely that they will be able to apply their knowledge to learning how to read in a second language.

In addition, a study of English-Spanish and English Chinese bilinguals (Pasquarella et al., 2015) examined cross-language transfer of word accuracy and fluency. In this study researchers gave each student a battery of tests at the beginning and at the end of the study. Such tests assessed students’ nonverbal reasoning, phonological awareness, word reading accuracy, and word reading fluency. Their findings suggest that there is a cross-linguistic transfer of reading skills in Spanish-English bilinguals, implying that accurate reading of words is necessary for word reading fluency. Therefore, having accurate reading of words is necessary for word reading fluency because it lowers students’ working memory load and it gives students automaticity. In sum, these findings show that interventions made in one language transfer to the other and help the diverse population to become biliterate as they apply their new reading skills in both languages.

**Elements of Reading Fluency**

Reading fluency impacts comprehension because it helps students practice and articulate their reading to build the skills they need to read and understand the words. There are three main factors that contribute to reading fluency: reading speed, working memory and their interaction with the text. Reading fluency has often been related to the amount of time a person takes to read a text accurately and with meaning (Berendes et al., 2019). Also, researchers have suggested that in order to read fluently, the reader has to learn accuracy, prosody, and automaticity (Dowd & Bartlett, 2019). In addition, researchers have suggested that reading fluency helps readers to have a better comprehension of the text, which is the ultimate goal for readers (Baker et al., 2012; Crosson & Lesaux, 2010; Iwahori, 2008; Pasquarella et al, 2015). By doing this, students have
more opportunities to focus on the meaning of the text rather than decoding it. However, reading is still one of the greatest struggles’ students from DLI classrooms encounter. Most of these struggles come from students having little or no motivation to learn how to read and write (McTigue et al., 2006).

The lack of motivation in reading and writing comes from the difficulties students encounter as they learn. For example, researchers have said that students experience high levels of stress and anxiety because learning a new language is related to their working memory (WM), which is a higher-level brain function in the prefrontal cortex (Kormos & Sáfár, 2008). This is related to temporary storage and manipulation of information; it also helps to interpret and store information for a period of time (Baddeley, 2003). Therefore, when students experience stress or anxiety, the resources available for WM are reduced. The reduction of working memory decreases the efficacy of language and reading comprehension, making the learning process more difficult for students (Rai et al., 2011).

Consequently, the lack of motivation is influenced by the stress and difficulty experienced by students while learning a different language. Thus, when students practice their reading fluency, they get familiar with words and by doing so they lower the load on their working memory and the stress and difficulty decreases (Taguchi et al., 2016). Also, researchers have related reading proficiency in another language with Working memory. In other words, by remembering what they have read, students have a better comprehension of the text. However, if the load of the working memory is too high, the process becomes more complicated because they have to concentrate on decoding the word and making phonological connections instead of focusing on the meaning of the word (Baddeley, 2003, 2010; Dowd & Bartlett, 2019; Pasquarella, 2015). Therefore, understanding how the working memory functions enables us to
understand that students need support and help to lower the load of the working memory. Consequently, to help dual immersion students to become good readers, they need to have extra support in the reading process, exposure to language, and repetition. (Cobb, et al., 2016; Lindholm & Hernández, 2011).

In addition, good readers also use multiple skills simultaneously to interact with the text. They do not read by just repeating words. In fact, they are accurate, they know how to manipulate sounds, they understand what they read, they make connections and find patterns (Boulware-Gooden et al., 2007). As a matter of fact, having a purpose and a deeper understanding of the words helps students become proficient readers (Roper, 2017). This suggests that students may benefit from instruction that builds their reading fluency through content. For example, when students practice reading fluency in preparation for a theater performance, or learning new content, their reading scores increase and they are more engaged and motivated (Garzón et al., 2008; Lee & Fradd, 1998).

Researchers have looked for different strategies to help students become fluent. The two most prevalent strategies used are Extended Reading and Repeated Reading. Extended Reading is when students read large amounts of text that they personally have chosen to read (LaBerge & Samuels, 1974). Hence, they improve their fluency based on the automaticity theory. This theory says that when a student gets used to seeing the same words multiple times, their vocabulary grows and their processes become automatic, so they are able to read the words with better comprehension (Iwahori, 2008; Taguchi et al. 2016). This means that as students read extensive texts, they are exposed to different vocabulary several times; and as they encounter the same words in different contexts, they learn new words and have a better comprehension of the texts. Therefore, automaticity comes from repetition and familiarity with words as a result of
reading fluency practice. In addition, because students get to choose the text they read, they tend to be more engaged with the texts they choose. This helps them to keep reading even when they encounter words they do not know.

Repeated reading is another strategy used by teachers to improve students’ reading fluency and comprehension. In this strategy students have to read the text several times until the level of fluency is achieved. This strategy is one of the most commonly used to help improve fluency in elementary classrooms. Therrien (2004) conducted a meta-analysis to confirm its effectiveness. As expected, the findings of the analysis confirmed those of many other studies suggesting that repeated reading helps improve reading fluency and comprehension. Some researchers hypothesize that one explanation for this might be the theory of automaticity. By helping students integrate text information progressively and in a more efficient way, they become better readers (Taguchi et al. 2016). Students learn vocabulary from content areas such as science, by becoming familiar with the words they are reading. Consequently, students’ comprehension increases resulting in better reading skills and understanding of the topic.

Moreover, to provide more support, exposure, and repetition, teachers have tried various strategies for improving reading fluency in struggling readers. These strategies include intervention groups and reading aloud (Bonfiglio et al., 2006; Manning et al., 1988; Ross, 1986). Intervention groups are done to help smaller groups of students with specific needs. These groups allow teachers to help students to develop the skills they are lacking based on their strengths and weaknesses. For instance, one study implemented phonological reading group interventions with 116 students from first through sixth grade (Rashotte et al. 2001). These interventions were done to help students from a low socioeconomic level with poor phonics skills. Such interventions were done outside of the classroom in groups of five to six students.
The main purpose of this was to strengthen students’ auditory skills and spelling to improve their reading fluency skills. The interventions integrated phonemic awareness, phonics, reading and writing to help students to read and write effectively. The results from this study suggest that the impact of having group interventions was highly positive in students’ overall reading with effect sizes across all languages ranging from 1.67-2.20 for phonetic decoding, 96-1.56 for phonological awareness, .54-.48 for reading comprehension and 2.65-3.64 for pseudo-spelling. This means that having phonological group interventions is a promising strategy that could be used in DLI classrooms to help readers improve, especially for poor readers.

Reading aloud is a strategy in which the teacher reads to the students, and they follow the reading in silence. One of the goals of this strategy is to exemplify the reading process by emphasizing intonation, punctuation, and exclamation. This strategy has been commonly explored by researchers who have concluded that reading aloud helps readers to have a better understanding of the text and a better attitude towards reading (Ross, 1986; Yaden et al., 1989). However, although this strategy has been used very successfully in regular elementary classrooms, this strategy has not been widely used or encouraged in language classrooms because language teachers feel it is inefficient. They think it is inefficient because students are not actively participating and some teacher may use it as a way of passing time (Amer, 1997; Dhaif, 1990). Despite the fact that this strategy has not been widely used in language classrooms, Lyster et al., (2009) have suggested that reading aloud projects promote comprehension because they are successful in initiating cross-linguistic connections of words and structure. This strategy could be promising in the development of language learners reading fluency.

In sum, although there is evidence to support that these strategies may improve learners' reading comprehension, few studies have been conducted in DLI classrooms. One exception was
a study done in a French immersion school in Canada that investigated students with reading difficulties (Archambault et. al, 2019). The main purpose of this study was to find out if the outcomes of reading fluency intervention transferred between languages. Some of the components of the interventions were modeled reading, repeated reading, phrase drills (Students read sentences that have a difficult word repeated three times). The study suggests that students became better fluent readers due to the effectiveness of their interventions. They were effective because students were exposed to the same text several times. These findings imply that interventions and repeated reading strategies may be beneficial to the development of reading fluency in DLI students. Therefore, to become proficient readers, students need to improve their fluency skills as many researchers have suggested (Baker et. al 2012; Iwahori, 2008).

Science

According to the U.S. Department of Education (2020), students need to be equipped with knowledge and skills that will allow them to solve problems, make sense of information and to be able to gather and evaluate evidence. Such skills are also known as STEM skills because they can be acquired through science, technology, engineering, and math (U.S. Department of Education, 2016). Therefore, teachers and administrators need to make sure children have access to good learning environments where they are engaged in science activities. Such activities need to promote the development of science knowledge. However, specific strategies need to be taken into account to know how to better help students learn science. Three promising strategies for teaching science are disaggregating instruction, inquiry-based learning, and project-based learning. For example, a study has suggested that disaggregating instruction promotes science learning and language (Brown et al., 2010). This means that the teacher first uses language familiar to students to explain science concepts, and then starts adding more academic language
to what students already know. In other words, the teacher uses the language and culture of minority students to help them make sense of science ideas and procedures. By drawing on daily experiences and activities of the students, the teacher helps them make connections between their own lives and the new science content they are learning. This scaffolds their knowledge and promotes conversations that enhance science learning.

Another promising strategy used to help students learn and improve their science content knowledge is the inquiry-based learning (Brown & Ryoo, 2008). This process is oftentimes interpreted as asking questions. However, the process involves more than questions. Inquiry-based learning is an approach where students learn based on their own discoveries. In this approach, students learn to observe the world around them and ask questions about the things they see. Students are supposed to find meaning in that and then apply it to other things. This fosters communication and develops cognitive and metacognitive skills. This approach is valuable because it helps students to understand more complicated concepts in science while also learning more science vocabulary and more academic language. Researchers have suggested that using an inquiry process and scaffolding (i.e., strategies to support the learning process) fosters students’ comprehension of the topic and increases their language abilities.

It is important to mention that inquiry-based instruction is oftentimes related to Project-based Learning (PBL). This is a student-centered strategy that promotes problem solving, interaction, and engagement in real-world activities (Larmer, 2020). In order to have successful projects, teachers need to consider having “significant content” (e.g., science), 21st century skills, “in-depth (or sustained) inquiry” (i.e., searching information to answer questions and provoking new questions), a “driving question” (i.e., initial open-ended questions that drive the inquiry process), a “need to know” (i.e., students feel the desire and interest to continue
learning), “student voice and choice,” “reflection and revision,” and a “public audience” (Key Elements of Project-Based Learning, n.d., p. 1). When students learn important science content through sustained inquiry using the processes and tools authentic to scientists, they are able to develop the content knowledge, disciplinary skills, and academic language they need to be successful in 21st century society. By having meaningful activities that imitate real world situations and it provokes students’ curiosity and interest. Hence, the use and application of different skills is needed to help students develop a deeper understanding of the content and make connections with other topics.

Also, it is important to mention that reading skills are essential to this process, and teachers need to make sure kids are equipped with the tools they need to perform well (Galaviz & Peralta, 2019). Considering that inquiry-based PBL science projects are oftentimes based on science investigations, teachers need to remember that reading is an essential skill needed to conduct such investigations. In fact, without reading, students cannot acquire new knowledge from books, articles, or any other written text. Moreover, teachers need to create opportunities for learning by supporting, encouraging, and assessing students’ learning. Technology plays a powerful role in enhancing students and teachers’ motivation to complete science projects (Blumenfeld et al., 1991).

However, there are different challenges involved in this process. For example, research indicates that teachers struggle in creating a collaborative classroom, adjusting to roles (teachers becoming facilitators), maintaining students’ engagement, integrating concepts, addressing misconceptions, and promoting reflective thinking (Ertmer & Simons, 2006). This means that PBL learning is still evolving and both teachers and students need to be trained to switch from traditional science instruction to PBL. Furthermore, it is important to note that asking questions
and scaffolding knowledge for students will enable them to overcome these challenges. For example, when using questions that are understandable and at the students’ language level, teachers enable them to develop cognitive and metacognitive skills. Therefore, as previously mentioned, when teachers use strategies to reduce the demand on working memory, the comprehension of language and reading becomes easier for students (Rai et al., 2011).

Finally, scientific knowledge emerges from different agencies, materials, instruments, people, etc. This means that this knowledge is not just a set of rules and information that can be transferred from one subject area to another. In fact, scientists use different technological tools and resources that are available to them in order to find meaning, negotiate, and rearrange knowledge (McGinn & Roth, 1999). Because of this approach, teachers need to provide students with both experiences and technological tools that will allow students to learn this scientific process. This means that in addition to being able to read and write (i.e., literacy) about science (content area literacy), students need to develop the knowledge, skills, and habits of mind that scientists use (disciplinary literacy).

Technology can help with inquiry-based learning, with science, and with literacy. For example, research proposes that technology benefits inquiry-based learning by giving the ability to store and manipulate information, present and permit interaction with information in a variety of formats, and support communication and expression (Edelson et al., 1999). Therefore, in order to help students learn the scientific process used by scientists, teachers need to incorporate technology into their instruction. Many of the technologies that scientists now use are located on mobile devices such as cell phones and iPads.
Mobile-Assisted Language Learning (MALL)

Mobile-Assisted Language Learning (MALL) is an approach to language learning in which mobile devices are used to enhance students’ learning. Such devices could be iPads, phones, or laptops. Burston (2014) reviewed the development of MALL over the past 20 years, and he concluded that even though this approach has progressed considerably, more developments in the learning theory and teaching methodologies needs to be done. Also, he suggested that some of the benefits of using MALL are the (1) accessibility in time and space, (2) communicative oriented features, (3) problem solving tasks, and (4) individualized learning. Another study mentioned that some of the main benefits of using MALL included motivation, collaboration, negotiation of meaning and feedback (Kukulska-Hulme & Viberg, 2018).

To have an effective MALL integration in a classroom, the TPACK frameworks must be considered. This framework stands for technological pedagogical content knowledge. In order to produce effective MALL lessons, teachers need to have three main types of teacher knowledge: Technological Knowledge, Pedagogical Knowledge and Content Knowledge. In addition, teachers must be able to interact between and among these bodies of knowledge (Koehler and Mishra, 2009).

Content Knowledge

This varies depending on the subject to be taught. For example, according to Overvliet (2018), integrating literacy and science content simplifies the development of academic science knowledge and language skills. For this study two fourth grade DLI classrooms participated in a curricular unit. The unit was based on literacy and Utah science core standards. In order to create this unit, Overvliet used scaffolding, argumentation, collaboration, metacognition, counterbalance and backward design strategies. The unit included the following activities:
• Narrative stories: These stories were chosen to cover science-based content.
• Narrative book club booklets: Students read with a partner while the teacher worked in small reading groups.
• Scientific texts: Students read a scientific text and completed different graphic organizers.
• Presentational writing: Students wrote a composition about the same scientific topic.
• Inquiry-based lessons: Interactive lessons were included with activities such as simulations, hands-on activities, inquiry-based activities, reading scientific texts, assessment, and role play.

Based on DIBELS and science benchmark scores, her students’ scores improved, including struggling learners who did better after the unit. In addition, her findings suggest that pre-reading activities increased comprehension and confidence while reading. Well-scaffolded, collaborative tasks open new possibilities to improve language and content; and having a variety of ways and flexibility to group students may improve students’ experiences. Based on these findings, Overvliet concluded that the integration of literacy and science positively impacts the development of immersion curriculum. However, not all the students liked the lesson because of the difficulty of some activities and personal disinterest in some of the activities (Overvliet, 2018). Nevertheless, Overvliet’s study suggests that technologies that provide MALL could help some students with difficulties, lack of motivation, and engagement.

**Technological Knowledge**

In our age students need to become proficient technological users to be competent in the professional world. Stakeholders need to understand that technological improvements have changed the way the world is understood, including the ways scientists look at different
phenomena. For example, a study by McGinn and Roth (1999) suggested that to help students be good science learners they need tools such as data recording devices, cameras, graphing calculators, computers, the world wide web, and other resources that would allow students to create, transform, and display visual representations. This means that in order to help students succeed in science, teachers need to help them acquire technological skills to understand the scientific world.

Moreover, the cognitive theory of multimedia learning states that “students learn more deeply from a multimedia explanation presented in words and pictures than in words alone” (Mayer, 2003, p.131). In this theory, words are represented by spoken or printed texts, whereas pictures are represented by graphs, diagrams, illustrations, photos, animations, and videos. Also, findings from a different study indicate that instruction integrated by multimedia with captions helps comprehension and promotes language learning (Gass et al., 2019). These findings suggest that having more than one source of input enables students to enhance their language skills. This is a consequence of the integration of multimedia learning with digital game-based learning which fosters the development of reading and writing skills (Erhel & Jamet, 2013; Neville et al., 2009). Using commercial online books provides students with the opportunity to interact with audiobooks, pictures, or even animations that enhance content learning, understanding, and motivation to learn (Lin, 2014; Winke et al., 2010). Consequently, when teachers include such materials in their lessons, students are empowered and motivated.

**Pedagogical Knowledge**

Pedagogy is the different methods and practices that are used by teachers to help students learn new academic subjects such as technological and content knowledge. In fact, pedagogy promotes learning and links curriculum and assessments (Koehler and Mishra, 2009). It is
essential that teachers implement pedagogy knowledge as they plan their technological instruction. For example, researchers have suggested that MALL can help diverse students by activating prior knowledge, providing immediate feedback, and giving opportunities for self-assessment (Kukulska-Hulme, 2009; Papastergiou, 2009). All of these are good pedagogical practices to help students succeed and teachers need to consider them as they plan their lessons. In addition, Mobile-Assisted Language Learning (MALL) provides educational content that enhances learning. Studies have shown that these resources are motivating, fun, and relaxing. (Hwang et al., 2016; Prensky, 2012). Using MALL helps students to relax and learn when learning difficult concepts and it provides insight about the benefits of using technology.

In sum, researchers have responded to educational concerns by experimenting with the TPACK framework. In this framework content, pedagogy and technological knowledge are interrelated to produce efficient mobile-assisted language learning (MALL). However, it is important to remember that in order to learn reading fluency and science, teachers need to use other strategies such as inquiry-based learning, PBL, and repeated reading. Evidence suggests that integrating literacy, science and technology may support students learning in a second language. These methodologies have the potential to improve 21st century skills and foster student success. However, much is still unknown about how these strategies work in a DLI classroom. For this reason, it is proposed to study the effects of the integration of reading, science, and technology in a DLI classroom.
Chapter 3: Study

Research Questions

The following research questions guided this study:

1) What is the relationship between students’ reading fluency in L1 and L2 as measured by DIBELS/IDEL, and does that relationship vary between the control and the experimental group?

2) What is the relationship between reading fluency scores of students who participated in MALL compared to students who did not use MALL?

3) What is the relationship between students’ pre- and post- Science RISE Benchmark Test scores and does that relationship vary between the control and experimental groups?

4) How effective is the purposeful integration of literacy and science content instruction in providing students with a positive dual immersion experience as measured by a questionnaire, classroom observations, video recording, and interviews?

Hypothesis

The integration of mobile-assisted language learning in a Dual Language Immersion classroom will enable students to work on improving science knowledge and reading fluency scores on post-tests compared to the pre-test scores.

Methodology

This mixed-methods study was carried out in two fourth-grade Spanish dual language immersion classes. The study was conducted in a rural area in Utah during students’ science instruction. It included two classes of 4th grade students already assigned to the researcher. Since it was the beginning of the year and the researcher did not know the students, one class was randomly chosen to be the experimental group and the other class was the control group.
study explored the use of an integrated literacy unit based on science core standards from the state of Utah. In addition, the study explored the effects of using MALL in an experimental group, while a control group learned the same strategies but without MALL. The study involved pre-tests, post-tests, surveys, videos, and interviews as sources of information. First, the learners’ reading fluency in English was assessed with the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) test (Deno & Mirkin, 1977). This test is already required for students by the state of Utah. In addition, students were assessed with the Indicadores Dinámicos del Exito en la Lectura (IDEL) test (Baker et al., 2012). The IDEL test was used to measure their reading skills in Spanish. The IDEL test is not required; however, it was added to the curriculum for this research. Moreover, students were assessed with the Readiness, Improvement, Success, Empowerment (RISE) science benchmark assessment, the science test required by the state of Utah to measure students’ science knowledge (Utah State Board of Education, 2022). After being pre-assessed, students participated in a treatment in which students had to read the same science text each day of the week. However, the experimental group used MALL and the control group did not use it. In addition, students participated in a science lesson based on inquiry-based instruction and PBL using MALL. Finally, students were post-assessed and interviewed at the end of the study (For more details on the process, read below).

Participants

The teacher for this research was Hispanic with 5 years of experience working in a Dual Language Immersion classroom. The teacher was also the researcher, and she observed the students as they participated in the appropriate interventions in both the experimental group and the control group.
A convenience sample was selected from a Tier 1 school in a rural area from Utah. The sample included two fourth grade classrooms attending an Elementary School. The classes included 36 students in total who spoke English as their first language, and Spanish heritage students. The Spanish heritage students are students that come from Hispanic families and have different English abilities due to different levels of English language exposure outside of the classroom. In addition, some students came from families with low socioeconomic status and some of them presented learning disabilities, such as hearing impairments, autism, short term memory problems, speech problems, and other learning disabilities. Also, a Spanish teacher with 28 years of experience and a Ph.D. in Curriculum, Teaching & Educational Policy with an emphasis in Learning, Technology and Culture was chosen to be the interviewer to avoid issues with validity and reliability.

**Procedures**

*Step 1: Consents*

Students’ parents were asked to grant permission for their students’ participation prior to the study. Participation was completely voluntary, and the researcher made it clear to parents and students that their participation in the study would not affect their academic grades. Parents were notified in advance so they could decide if their kids could participate or not. If parents chose not to participate, students were not included in the analysis of data, and they did not have to complete all the tests.

*Step 2: Background Survey*

Dual immersion classrooms have students from different cultural backgrounds, which may affect their reading performance. Therefore, a survey before the test was done to learn about the student's language background (Appendix C).
**Step 3: Administration of Pre-tests**

**DIBELS.** This test was initially created in the 1970s-1980s through the Institute for Research and Learning Disabilities at the University of Minnesota with ongoing research to document the reliability and validity of the test. The last study done at the University of Oregon reported that 17 states use this test with strong reliability and validity (Biancarosa et al., 2018). Also, other studies have found strong correlations with tests such as SAT which indicate a strong validity and reliability. For example, one study suggested that SAT scores and DIBELS scores had strong correlations ranging from $r= .37$ to $r=. 82$ depending on the year and grade level (Foslin, 2012). In another study, the researcher reported that reliability estimates were .80 or above and for inter-rater reliability were in the high .80s to .90s. Also, this research explained that the variance in scores was between 35%-40% with strong correlations (Elliott et al. 2001). This means that DIBELS is a valid and reliable test which in fact is the test that is required by the state of Utah. This program measures students' fluency progress in English. Students did a pre-test that measured their reading ability using three different stories for validity and reliability, but just the median score is assigned to students. Thus, the result from this test gave a good interpretation of students’ reading and language abilities. The test gives three different scores: fluency, accuracy, and retelling. The fluency is calculated by counting how many words students read per minute (WPM) and how accurately they did it. The accuracy measures the percentage of words read correctly, and the retelling measures the comprehension of the story by counting the number of words students say and the quality of information they give.

**IDEL.** This test is the Spanish version of DIBELS, and it was used to look at students’ reading progress in Spanish. Students had to do this test in addition to the required tests. Students did an IDEL pre-test that measured their reading fluency by counting how many words they read
per minute (WPM) at Level 3. The accuracy measures the percentage of words read correctly, and the retelling measures the comprehension of the story by counting the number of words students say and the quality of information they give, all of this at Level 3. As in DIBELS test students had to read three different stories to avoid validity and reliability issues. Although students participating in the study were in 4th grade, they completed Level 3 of the IDEL test because there was not a Level 4 test available.

**Step 4: Repeated Reading**

After the pre-tests, students were taught repeated reading strategies (See Appendix A). The control group and the experimental group learned the same reading strategies. However, the control group used printed text and the experimental group used mobile devices. The mobile devices allowed students to listen to the reading, follow the highlighted text, and record their voice as they read. Students read the same science text twice, five days per week. Each day they had a different purpose, they listened as the researcher read, they followed the reading along with the researcher, and they read out loud. In addition, by the end of the week, students recorded on a paper how many words they read per minute (WPM). After that they had to graph their progress. This metacognitive activity helped students make their own progress more visible to them and motivated them to continue improving. This process lasted four months of intervention after which students did a post-test measuring their reading fluency.

**Step 5: Science Instruction**

After the pre-tests, students participated in inquiry-based science instruction. Firstly, the researcher provided a picture or a video about a situation related to science that was familiar to the students. This situation was called a phenomenon and it was based on students’ interests and experiences. Secondly, the teacher started a conversation with the students about the topic with
familiar vocabulary. Finally, the researcher provided scaffolded activities, to scaffold these activates the researcher (1) introduce to the vocabulary they needed for the activity, (2) gave students little pieces of the activity at a time, and (3) depending on the activity the teacher provided extra support with comprehension. For example, the teacher did demonstrations, used gestures, realia, acted, and provided guided practice. These activities included an investigation of organisms functioning in their environment with experiments, simulations, games, projects, reading, writing and MALL to help students develop scientific vocabulary and knowledge.

**Step 6: Administration of Post-tests**

After the intervention of science and repeated reading using MALL, students took the DIBELS and IDEL post-tests in reading fluency, reading accuracy, and retelling to show the outcomes of the intervention on their English and Spanish reading fluency performance. In addition, students did Science RISE Benchmark Test post-tests. These tests measured their science knowledge.

**Step 7: Interviews**

An interview was administered after the post-tests to understand students' reactions and feelings about the study. Seventeen students assigned to the 4th grade classroom were chosen for the interviews, and 14 of them chose to speak English in the interview even though some of them speak Spanish at home. Students from both classes were classified in three groups based on their language use at home: 1) highly proficient in the Spanish language, 2) near proficient and 3) below proficient (see Table 4.1). From each of these three groups, the researcher randomly chose three students from each group to participate in the interviews. However, because of scheduling constraints the interviewer just interviewed 17 of the 18 students.
Data Sources and Analysis

The researcher collected data from the following data sources:

- Data Source 1: Survey
- Data Source 2: Pre-/Post-tests from DIBELS, IDEL, and Science RISE Benchmark Test.
- Data Source 3: Video observations
- Data Source 4: Interviews

The researcher recorded and analyzed students’ scores throughout the research. Each of these data sources and analysis procedures are described in more detail below. Also, a more detailed interpretation of these findings will be presented in Chapters 4 and 5.

Surveys

The survey (Appendix B) provided information about students' background knowledge of both languages and gave more detailed information about their past experiences with the language. The researcher analyzed this data by doing both quantitative and qualitative analyses in which the data from the surveys was analyzed to look for any relationship between the scores and their language. The researcher performed three different levels of analysis. First, I calculated gain scores, then performed ANCOVA tests and post hoc analyses. Based on the information students reported, they were categorized depending on their language background (see Table 3.1).

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Language Background</th>
<th>Criteria</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE</td>
<td>Native English</td>
<td>English speakers without Spanish</td>
<td>NEB-Boys</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NEG-Girls</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Note</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>HH</td>
<td>High Heritage learners</td>
<td>Students who speak more Spanish at home than English.</td>
<td></td>
</tr>
<tr>
<td>LH</td>
<td>Low Heritage learners</td>
<td>Students that come from Hispanic families but may or not speak Spanish at home.</td>
<td></td>
</tr>
<tr>
<td>NS</td>
<td>Native Spanish speakers</td>
<td>Students that just arrived to the U.S with very limited English knowledge.</td>
<td></td>
</tr>
</tbody>
</table>

**Pre- and Post-tests**

Three tests were used to measure reading proficiency: DIBELS, IDEL and RISE. DIBELS is a reading test used in Elementary schools to monitor students’ progress in English. This test provides information about students’ reading accuracy, fluency (WPM) and comprehension. IDEL is the Spanish version of DIBELS; because the Spanish test was only intended to test Grades K-3, and these students in this study are in 4th grade, that presents the problem that the test may not reflect the highest level of their performance.

However, national statistics have indicated that it is likely that the reading proficiency of at least 66% of the students is probably lower than grade level (NAEP, 2019). In addition, recent events with COVID-19 may have delayed students’ reading proficiency. As a result, I decided to use the test so that I could analyze and compare information between students’ performance in English and Spanish. Finally, students took the comprehensive RISE Science Benchmark Test to measure students' understanding in science. Consequently, by using multiple measures, it was expected to be able to identify a meaningful and accurate range of performance for students in English and in Spanish. First the gains scores of each pre and post-test were analyzed to see their
improvements. Based on that information an ANCOVA test was conducted by the researcher to analyze information and find statistically significant values. Once that information was obtained a post hoc analysis was done to have a better understanding of the effect size on the significant values. This was done for each of the students’ pre-test and post-test scores in DIBELS IDEL, and Science RISE Benchmark Test.

**Interviews**

Participants were interviewed (see the interview protocol in Appendix B) to learn more about their thoughts and perceptions of the experiences they had throughout the process. Participants were randomly chosen from three different groups of students for whom reading fluency scores were (1) below 64, (2) between 65-87, (3) above 85. The cutoff scores were based on the expectations provided by DIBELS & IDEL. Also, all interviews were audio-recorded and analyzed in more detail to look for patterns and trends. After qualitatively analyzing all the data, the researcher identified possibilities for generalizing the results. For this purpose, the interviews were transcribed and coded to find patterns in students' responses.

**Video Observations**

A video was recorded during the science lesson four different times in both the experimental group and the control group. The purpose of the videos was to observe students' reactions and behaviors during the science lesson, and their engagement and motivation using MALL. A section of the video was chosen based on students’ comments in the interviews and was selected to highlight interactions that exemplified some of the findings of the study. To code and analyze patterns based on different themes, the videos were transcribed. These patterns were compared with test scores and surveys. For this purpose, an observation form was used when analyzing the video (see Appendix G).
Chapter 4: Findings

Findings from this study will be discussed in three separate sections: (1) students’ progress in science, (2) students’ progress in reading, and (3) the impact of iPad use on students. In each of these sections, I will discuss quantitative data from students’ test scores, qualitative data from students’ comments during interviews, and observation data from recorded lessons.

Students’ Progress in Science

To measure students’ learning in science, the researcher calculated the difference between students' performance on the Science RISE Benchmark Test pre-test and their performance on the post-test. The results of this analysis are known as gain scores. The experimental group achieved a gain score of 1.20 points and the control group achieved a gain score of 0.57 points on average (See Table 4.1). These gain scores mean that the experimental group made 0.64 points more progress than the control group after the treatment.

Table 4.1

Gain scores from the Science RISE Benchmark Test
A closer look at the data revealed that most of the students improved in both groups. However, in the experimental group two students had negative gain scores which means that their post-test scores were lower than their pre-test scores. This was also true for four students in the control group (see Table 4.2).

Table 4.2

Individual Gain Scores for the Science RISE Benchmark Test

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Science RISE</td>
<td>Science RISE</td>
</tr>
<tr>
<td>Gain Scores</td>
<td>1.204578363</td>
<td>0.56827451</td>
</tr>
<tr>
<td>Average Gain Score</td>
<td>3.111111111</td>
<td>4.315798474</td>
</tr>
<tr>
<td></td>
<td>3.666666667</td>
<td>4.235294118</td>
</tr>
<tr>
<td>Goal: 6</td>
<td>Pre-test</td>
<td>Post-test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
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<tr>
<td>3</td>
<td>5</td>
<td>4</td>
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<tr>
<td>3</td>
<td>5</td>
<td>4</td>
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<tr>
<td>3</td>
<td>4</td>
<td>4</td>
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<tr>
<td>3</td>
<td>6</td>
<td>5</td>
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<tr>
<td>4</td>
<td>6</td>
<td>5</td>
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<tr>
<td>4</td>
<td>3</td>
<td>5</td>
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<td>4</td>
<td>3</td>
<td>6</td>
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<td>4</td>
<td>5</td>
<td>6</td>
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<td>4</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

To have a better understanding of the gain scores, we did ANCOVA analysis to see if students’ improvements were statistically significant. The analysis showed that the effect of gender reached statistical significance ($p=0.009$), meaning that gender was an important factor in determining students’ progress in science. In addition, the analysis revealed that there was also a highly statistically significant correlation between language background and gender ($p=0.002$), suggesting that students from certain language backgrounds benefitted more from the treatment.
than others. Finally, we also noticed that the interaction of language background, MALL and gender ($p=0.042$) reached significance. This means that students with certain language backgrounds and gender benefitted from using MALL (See Table 4.3).

Table 4.3

*ANCOVA - Gain Scores for Science on the Science RISE Benchmark Test*

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>RISE Pre-test</td>
<td>19.0720</td>
<td>1</td>
<td>19.0720</td>
<td>19.3841</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Lang.Back</td>
<td>0.0284</td>
<td>2</td>
<td>0.0142</td>
<td>0.0144</td>
<td>0.986</td>
</tr>
<tr>
<td>MALL=1</td>
<td>2.2073</td>
<td>1</td>
<td>2.2073</td>
<td>2.2434</td>
<td>0.150</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td><strong>8.3739</strong></td>
<td>1</td>
<td><strong>8.3739</strong></td>
<td><strong>8.5109</strong></td>
<td><em>0.009</em></td>
</tr>
<tr>
<td>Lang.Back ※ MALL=1</td>
<td>0.2179</td>
<td>2</td>
<td>0.1089</td>
<td>0.1107</td>
<td>0.896</td>
</tr>
<tr>
<td><strong>Lang.Back ※ Gender</strong></td>
<td><strong>17.5909</strong></td>
<td>2</td>
<td><strong>8.7954</strong></td>
<td><strong>8.9394</strong></td>
<td><em>0.002</em></td>
</tr>
<tr>
<td>MALL=1 ※ Gender</td>
<td>0.0567</td>
<td>1</td>
<td>0.0567</td>
<td>0.0576</td>
<td>0.813</td>
</tr>
<tr>
<td><strong>Lang.Back ※ MALL=1 ※ Gender</strong></td>
<td><strong>7.3387</strong></td>
<td>2</td>
<td><strong>3.6694</strong></td>
<td><strong>3.7294</strong></td>
<td><em>0.042</em></td>
</tr>
</tbody>
</table>

*Indicates significance at the .05 level

Based on these results, the researcher decided to do a post hoc analysis to determine the effect size of the data, or in other words, how strongly the treatment affected specific groups. The post hoc analysis showed that on average, boys did better than girls on the Science RISE Benchmark Test by a difference of 1.10 points. This is high considering that the highest score on the Science RISE Benchmark Test rating scale was 6 points. This strong effect size (Cohen’s $d=1.11$) means that gender is an important factor for science learning (See Table 4.4).
Table 4.4

*Post Hoc Comparisons for Gender*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Gender</th>
<th>Mean Difference</th>
<th>Ptukey</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Male</td>
<td>-1.10</td>
<td>*0.009</td>
<td>-1.11</td>
</tr>
</tbody>
</table>

*Indicates significance at the 0.05 level

Furthermore, after analyzing the results from the Science RISE Benchmark Test, the researcher noticed that with the interaction of language background, MALL and gender, boys tend to do better on the Science RISE Benchmark Test, especially among LH learners (see Table 4.5).

Table 4.5

*Post Hoc Comparison for Language Background, MALL, and Gender in the Science RISE Benchmark Test*

<table>
<thead>
<tr>
<th>Lang. Back</th>
<th>MALL</th>
<th>Gender</th>
<th>Lang Back</th>
<th>MALL</th>
<th>Gender</th>
<th>Mean Difference</th>
<th>Ptukey</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td>LH</td>
<td>1</td>
<td>Female</td>
<td>LH</td>
<td>1</td>
<td>Male</td>
<td>-3.6393</td>
<td>*0.055</td>
<td>-3.6689</td>
</tr>
<tr>
<td>LH</td>
<td>1</td>
<td>Male</td>
<td>NE</td>
<td>0</td>
<td>Female</td>
<td>3.5000</td>
<td>0.067</td>
<td>-3.5285</td>
</tr>
<tr>
<td>HH</td>
<td>0</td>
<td>Male</td>
<td>LH</td>
<td>1</td>
<td>Male</td>
<td>-3.221</td>
<td>0.146</td>
<td>-3.2477</td>
</tr>
<tr>
<td>LH</td>
<td>0</td>
<td>Male</td>
<td>LH</td>
<td>1</td>
<td>Female</td>
<td>2.6393</td>
<td>0.221</td>
<td>-2.6608</td>
</tr>
<tr>
<td>LH</td>
<td>0</td>
<td>Male</td>
<td>NE</td>
<td>0</td>
<td>Female</td>
<td>2.5000</td>
<td>0.267</td>
<td>-2.5204</td>
</tr>
<tr>
<td>LH</td>
<td>0</td>
<td>Female</td>
<td>LH</td>
<td>1</td>
<td>Male</td>
<td>-3.3607</td>
<td>0.273</td>
<td>-3.3881</td>
</tr>
<tr>
<td>LH</td>
<td>1</td>
<td>Female</td>
<td>NE</td>
<td>0</td>
<td>Male</td>
<td>-2.6119</td>
<td>0.273</td>
<td>-2.6332</td>
</tr>
<tr>
<td>NE</td>
<td>0</td>
<td>Female</td>
<td>NE</td>
<td>0</td>
<td>Male</td>
<td>-2.4726</td>
<td>0.295</td>
<td>-2.4928</td>
</tr>
</tbody>
</table>
The test results showed that the interaction between low heritage learners who used MALL nearly reached significance \((p=0.055)\), with strong effect size, Cohen’s \(d=3.66\). This means that when boys used MALL, they did better in Science RISE Benchmark Test than girls, with a difference of 3.63 points. Since there were only 6 points possible on the Science RISE Benchmark Test, an increase of 3.63 points means that learners made significant gains (See Table 4.5). Also, LH learners who used MALL nearly reached significance \((p=0.067)\), with strong effect size, Cohen’s \(d=3.52\). This means that LH learners who used MALL outperformed NE learners who did not use MALL by a difference of 3.50 points. Also, LHB that used MALL did better than LHB who did not use MALL. Finally, when comparing females from different language backgrounds, HH learners tend to do better in the Science RISE Benchmark Test and with a strong effect size. Although a significant value was not found among other comparisons, the researcher noticed that there is a positive impact on the use of MALL and gender among different groups with a strong effect size Cohen’s \(d=<1\) (See Table 4.6). For example, NE students who used MALL did better than NE students who did not use MALL. LHB who used MALL did better than HHG who did not use it, and HHB who used MALL did better than NEG who did not use MALL.
Moreover, when the researcher compared the students who used MALL with the interaction of language background, MALL, and gender it was learned that high heritage boys (HHB) had the strongest effect size Cohen’s $d =< 1$ (See Table 4.7).

Table 4.7

*Post Hoc Comparison of Language Background MALL and Gender with a Strong Effect Size when Using MALL*
In general, these results suggest that students who used MALL did as well or better than students who did not use MALL. However, language background may be considered, too. For example, HHB had the strongest effect size compared to low heritage girls (LHG). Also, LHB benefited the most from using MALL compared to NE and HH. Consequently, language background and gender had a strong effect on Science RISE Benchmark Test scores.

Based on these results students gave three different reasons to explain these improvements in their learning: (1) specific facts and details, (2) scientific investigations, and (3) collaborating with games and simulations.

**Specific Facts and Details**

First, students made only general comments about their learning. However, some students mentioned the specific content they had learned, but only when they were prompted by the interviewer. For example:

Interviewer: Um, so let's talk about science for a minute. Do you think you understand more about science now that you're in fourth grade?

LHB Student: Oh yeah, yeah.

Interviewer: Yeah? What makes you think so?

LHB Student: Because a lot of times, I don't know about fossils, like in third grade I didn't really know about fossils. I didn't know how they worked, what they did, and I didn't even know what they used to be until I went into fourth grade. Then I knew how dinosaurs looked a little bit, how they aged, how they climbed, how they got into a museum, and how they lived a little bit.

Interviewer: You learned a lot of stuff!

Student: Yeah!
As this example shows, the student recalls some of the details he learned in class and acknowledges how much he learned. Moreover, the student measures his progress in learning a new topic by the new information he is acquiring. This is exemplified by the number of concrete details he is giving about the things he learned. From this response, we may infer that boys may base their progress on the amount of new facts and details they learn.

Responses from other boys confirmed this inference. They also mentioned that one of the main reasons why they felt they had learned science is because they were able to tell specific facts or details learned in science. For example, one of the students said: “Well, I didn't know before that elephants could sense when there's going to be an earthquake. So, like, there are some things that we are just learning, that are kind of small details that I didn't know.” In this example, the NEB student is recalling small sections from the first part of the unit when the class learned about animal adaptations from their reading. Another student said: “Antes no sabía, por ejemplo, que el cuerpo humano tenía 210 huesos, pero ahora lo sé.” [Before I did not know, for example, that the human body had 210 bones, but now I know]. In this example, the NSB student mentions a small detail learned from the unit called internal structures of a system and was read in one of the books. These examples show how students measured their learning by looking at the new and small details learned during their science class that they didn’t know before as evidence that they had learned something.

Also, these details came from the scientific texts that students had to read for their science investigations. The same thing happened to some of the other details students gave related to science learning in which they read the content in the scientific texts they read. In fact, a student said:

Interviewer: Um, how about science? Have you learned more science in fourth grade?
HHB: Yeah, a lot more.

Interviewer: A lot more? What makes you think so?

HHB: Because we get—every time we read one, we get different kinds of them.

Interviewer: Every time you want to get different kinds of them?

HHB: Yeah, cuz when we finished them, we get even more books of different stuff.

Interviewer: Oh, so when you finish a book, you get to read new books that have different information in them?

HHB: Yeah.

On the contrary, when the girls were interviewed, the responses most of them gave were a little more simple and vague in general. For example:

Interviewer: Do you think you understand more about science?

NEG: I can understand most of it. Just some of the words on the paper, like, are kind of confusing, but I'm—the teacher said I can do this, and so I do and I kind of worked my way through it. And that's it.

Interviewer: Well, let me ask you this. Are there specific activities that help you get better at science?

NEG: Um, yeah, we do. So, just a couple of weeks ago, we did like, “What are we?” because we was working on birds and you try to guess what birds you are and that helps me understand more of what we were doing. And when we do, that helps me cooperate with the other kids that know Spanish more and helps me learn the word, words they're learning, and that's it.

This example shows that the female student did not give specific details or information. In fact, she was a little hesitant about her response. Instead, she was worried about understanding
the language and processing the information. Similar things happened with other girls as well, as in the following example:

Interviewer: Yeah. Um, let's talk about science for a minute. Do you think you understand anything else? Anything new about science from fourth grade?
LHG: Just a little bit.

Interviewer: What makes you think so?
LGH: Long pause.

Interviewer: Do you understand what I mean when I'm asking that question?
LHG: No.

Interviewer: No? So how can you tell if you're getting better at science this year?

LHG: If I can understand stuff? And if I can learn more.

In the first example, the boy perceived his learning only when he noticed specific details and facts, while the girl in this example perceives her learning by how well she understands the information. It is also important to mention that the girl did not give details until she was prompted to do it. Also, in the following example a HHG gave a general answer without too many details.

Interviewer: Ok, ¿Crees que entiendes más sobre las ciencias? [Ok, do you think you understand more about science?]
HHG Student: Sí. [Yes.]

Interviewer: Y ¿que te hace pensar eso? [And what makes you think that?]

HHG Student: Porque cada vez aprendemos nuevas actividades, a veces aprendo cosas que no sabía antes. [Because each time we learn new activities, sometimes I learn things that I didn’t know before.]
Interviewer: Aaa aprendes de las actividades cosas nuevas. [Ahhh, you learn new things from the activities.]

HHG: Sí.

In this example, the student did not give any specific answer or detail related to science, and her response was very general. Therefore, girls' responses were more general and sometimes that meant that they were focused on the language and understanding more than the content. In fact, it is interesting that even though there were a couple of girls with answers that were specific, they provided those answers only when prompted to do it. Also, it seems like the girls who had a lower language level were more worried about the language and understanding than girls with a higher language level. Interestingly, one of the girls who gave a more detailed answer with a low language level said a lot of things that seemed to have used her own background knowledge.

On the opposite side, most of the boys gave a lot of details of their learning even though they were at different levels. The only two boys that gave general answers had learning disabilities. One of them answered most of the questions with a ‘yes’ or ‘no’ and the other student seemed to misunderstand most of the questions in the interview. Also, both students had a low language level. Therefore, students' answers to interview questions confirmed the post hoc analysis, showing that gender is an important factor in science learning and that the learning process for boys and girls may be different (See Table 4.4).

**Scientific Investigations**

The scientific investigations were activities completed in each class which included reading, writing, talking about the phenomenon, and participating in activities such as simulations, games, and experiments. Also, as part of the students’ investigations in science, they
had to create an explanation at the end of the class based on the things they had observed, investigated, and learned in class. In fact, the scientific investigations were one of the reasons why students felt they had learned science. And in their comments, students connected their reading of scientific texts with the activities made in class. For example:

Interviewer: Are there any things that you do in your classes that help you to learn?
NEB: Um yes, when we study animals or fossils, I learn more words so I can, if I see them in a book, I can I know what they are.

Interviewer: Interesting. So, are you saying that like when you're learning your science lessons that the words that you learn in your science lessons help you read other things?
NEB: Yeah.

Interviewer: And what does your teacher do that helps you learn those words in science?
NEB: I don't know.

Interviewer: You don't know? Well now can you think of any, like any activities or assignments that she gave you that you're like ‘wow – this is really helpful!’ or ‘this is really fun!’ or ‘this really helps me learn!’?
NEB: Yeah, it's we're doing piñatas right now, we just finished so that's an activity that we did.

Interviewer: Yeah, and does that help you learn science or help you learn to read at all?
NEB: Um, it kind of helped me how to do a little bit, um, I don't, I don't know what it's called—like showing how to put things together. So if we were trying to put a fossil together, like pieces of pieces, it could be kind of easy because I've done it with something else.
Interviewer: That is a brilliant explanation. So, you're saying that the things that you are learning like when you make a piñata, you're learning how to follow the instructions and put things together, and so then you can do it better in your science class.

NEB: Uh huh.

In another example one of the students said, “It was mainly reading a bunch of books, and then doing a, filling a bunch of papers and looking at some real copies of—looking at copies of fossils, and they helped me learn that they were modified.” In this example, the NEG student felt. She had learned science by completing the assigned investigations of the class where she had to read about fossils; observe real samples of fossils; and write her observations and explanations in her journal.

In these two examples, students are connecting their reading with the hands-on activities to explain how they have learned. In addition, other students mentioned some of the details that students recall were part of the texts they had to read for their investigations. This means that students access information in the target language through reading scientific texts because of the investigations they made. Moreover, it was interesting to see that the investigations met students’ need differently. For example, one student said, “reading helps you do science because it helps you learn more.” In this example the student is acknowledging that the reading they did to complete their investigations helped her learn science, while another student said, “because she [the teacher] lets us like dig around with the actual fossil and look at it and stuff.” In the last example, the students learned science because of the hands-on activities. This is evidence that the integration of science and reading had a positive effect on kids.
Collaborating with Games and Simulations

Another important factor that students perceived as one of the reasons they had learned science was collaboration. In fact, a few students mentioned that collaboration and doing projects and games was the reason why they had learned science. For example, one student said “Personally, it's probably the science texts that we read. That helps me most. Yeah, it's also just when we're talking with their partner about what something was about.” In this example the student is talking about the reading and collaborating with other students. In the following example, it is noticeable that some students get help from others to be able to complete the assignments “It helps me because I know what to do and people like helped me know like what I’m supposed to do and they're supposed to do what the other people are doing but they're supposed to, they're, they can do their own thing if they don't want to copy other people.” In addition, another student said:

Interviewer: Let's talk a little bit about science. Do you think you understand more things about science now that you're in fourth grade?

NE: Yes.

Interviewer: What makes you think that? Why do you think you're getting better at science?

NE: Because it's easy and fun.

Interviewer: It's fun. What's fun about it?

NE: You get to do all kinds of stuff. Like make it

Interviewer: like you make things in science.

NE: Yeah.
In this example, the student is talking about the hands-on activities they did in class in which they had to create something or represent it. For example, at the beginning of the study students had to create a plant with their structures and functions. Also, they did a diorama with ecosystems and for each of these activities they had to collaborate with other students.

Finally, another example shows that collaboration with other students is an important part of their learning process as well as having meaningful and engaging activities:

Interviewer: Hey, how about science? Do you think you understand more about science in fourth grade?
BNE Student: Yep.
Interviewer: And what helps you learn science in Spanish?
BNE Student: Because she [the teacher] lets us, like, dig around with the actual fossil and look at it and stuff.
Interviewer: How does that help you learn?
BNE Student: Like she [the teacher] said, to write it down what you think about it.
Interviewer: And so, because you're like doing the stuff and then writing it down, that makes it easier to understand?
BNE Student: Yeah, pretty much.

In this case the student is talking about the activities the teacher asks them to do in science such as: observing fossils and making investigations where they had to write their questions; look for information; and give a written explanation of their understanding. This means that when students are engaged in activities that require them to make or create something their learning is foster because the activity is more meaningful to them. In sum, these examples
show that students perceive collaboration and engagement as an important part of their learning process and provides opportunities for meaningful learning.

**Video Recordings in Science Classes**

Video recordings of a science lesson about animal adaptations confirmed findings from the interviews. Students did some simulations and games to activate their prior knowledge. An example of these simulations or games was when students learned about animals' senses. First, they watched a video about elephants, then they were instructed about senses. After that they were assigned an animal and asked to stand up in their chairs with their eyes closed. As they stood there, the teacher made different noises, sprayed different odors, and moved their chairs depending on the animal and their adaptation. After that they discussed the different senses, they had to use, making emphasis on the movement of the chair to relate it to the elephant’s adaptation with their feet to sense earthquakes. For example,

Teacher: ¿Por qué sintieron que los movía? [Why did you feel that it moved you?]

LH B Student 1: Porque me mataste. [Because you killed me.]

Teacher: No, no te maté pero ¿qué es lo que va a pasar? [No, I didn’t kill you but what is it that is going to happen?]

HH B Student 2: Cuando así (and the kid shakes his body). [When this way.]

Teacher: ¿Qué es lo que pasa cuando todo se mueve así? [What is happening when everything moves in this way?]

NE G Student 3: Terremoto [Earthquake]

Teacher: Todos diciendo <<terremoto.>>. [Everyone saying “earthquake”]

ALL Students: Terremoto. [Earthquake]

Teacher: Ahora todos moviéndose así. [Now everyone moving like this.]
[To learn the word, all students move their bodies and repeat the word out loud. They practice this a few times with the teacher.]

Teacher: Entonces, el fenómeno de esta semana es que el elefante siente un terremoto antes de que pase un terremoto. [So, the phenomenon for this week is that the elephant feels an earthquake before an earthquake happens.]

LHB Student 1: ¿Sí? (The student’s answer was with surprise). [Really?!!]

[Experimental group, Video 37, 21:47-30:15]

In addition, when the video recordings were observed, it was noticed that the integration of reading activities and science content was motivating and engaging for students. For example, in one of the videos students were reading and one of them stood up from her seat and went to tell the teacher about something she was learning in the text related to the phenomenon and the class discussion presented before the reading of the text.

HHG Student: Los elefantes pueden escuchar, este, a dos millas. [Elephants can hear, like, two miles.]

Teacher: Aaahh, ¿entonces qué sentido usaron? [Ah, then what sense did they use?]

HHG Student: Escuchan. [They listen.]

[Experimental group, Video 37, 58:52 minute-mark]

This example shows the connections she is making from the reading to the phenomenon and activities related to the science that was presented before that. Also, she has a feeling of accomplishment when she returns to her desk because of her facial expressions and body language.
Students’ Progress in Reading

To measure students’ learning in reading, the researcher looked at students’ DIBELS and IDEL scores in three areas: (1) reading fluency, (2) reading accuracy, and (3) retelling a text.

Fluency

As in science, the researcher also calculated students’ gain scores in reading. The first ability that was measured was students’ reading fluency. Students in the experimental group received a lower gain score on the English DIBELS test (22.89) than the control group, who scored 29 points (see Table 4.8).

Table 4.8

Gain Scores for DIBELS & IDEL in Fluency

By contrast, the reverse was true on the IDEL test, where the experimental group earned a gain score of 40.57 points and the control group received a gain score of 37.17 points (see Table 4.9).
Table 4.9

*Individual Gain Scores in Fluency for the DIBELS and IDEL Test*

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More detailed data analysis confirmed that even though both groups improved, the experimental group showed a greater improvement on the IDEL test than on DIBELS. Additionally, the English reading fluency score of one student in the experimental group decreased by 18 points, and the English reading fluency score of one student in the control group decreased by 14 points. Most students made gains of more than 20 points from the pre- to the post-test on both IDEL and DIBELS. Consequently, the researcher performed both ANCOVA and post hoc analyses to determine if these gains were statistically significant. However, no statistically significant differences were found in English or Spanish fluency. Also, because of the low number of students, it was harder to recognize the effect of the treatment and make conclusions.

Interestingly, NE students who read more than 100 words in Spanish read at least 140 words per minute in English. However, not all the NE students who read more than 100 words per minute in English were able to read as many words in Spanish. The same relationship...
between English and Spanish scores was also true for most heritage students—if they had high reading fluency in English, they also demonstrated a high level of reading fluency in Spanish. The only exception was one high heritage girl (HHG) who scored better in Spanish (115 wpm) than in English (78 wpm). In fact, although this student’s score in Spanish improved from 54 wpm to 115 wpm, it declined by fourteen words in English (from 92 wpm to 78 wpm). Also, the only native Spanish (NS) student did better in Spanish (139 wpm) than in English (62 wpm). In addition, students who had the lowest scores in one language had them in the other no matter their language background.

**Accuracy**

The second ability that was measured to understand students’ reading progress was accuracy and the classes' test scores indicated that students made strong progress in reading accuracy on both the DIBELS and IDEL tests (see Table 4.10).

**Table 4.10**

*Gain Scores for DIBELS & IDEL in Accuracy*

In fact, out of 100 percent, the experimental group received a gain score of 0.57% percent and the control group received a gain score of 4.47% on the DIBELS test. On the IDEL Test, the
experimental group received a gain score of 22.21% out of 100% and the control group received a gain score of 21.17%. On the IDEL Test students from both groups made large gains in the scores they received, but with only a slight difference between the two groups (See Table 4.11).

Table 4.11

**Individual Gain Scores in Accuracy for the DIBELS and IDEL Test**

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A deeper analysis of the gain scores suggested that some values reached statistical significance: (1) gender, (2) language background, and (3) the interaction between language background and MALL (see Table 4.12).
### Table 4.12

**ANCOVA Test for Accuracy on IDEL Tests**

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<td>4.639</td>
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<td>0.1501</td>
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</tbody>
</table>

*Indicates significance at the .05 level

Also, a post hoc analysis was done to have a better understanding of the significant difference and the results show that the effect of language background on changes in accuracy reached significance ($p=.005$), with very strong effect size (Cohen’s $d=1.69$) (see Table 4.13).

### Table 4.13

**Post Hoc Comparison for Language Background on the IDEL Reading Accuracy Test**

<table>
<thead>
<tr>
<th>Gain Score</th>
<th>Mean Difference</th>
<th>Ptukey</th>
<th>Cohen’s $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LH NE</td>
<td>-4.49</td>
<td>*0.005</td>
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<tr>
<td>HH LH</td>
<td>3.48</td>
<td>*0.026</td>
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<tr>
<td>HH NE</td>
<td>-1.01</td>
<td>0.624</td>
<td>-0.380</td>
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</tbody>
</table>
NS

Did not show up at the table because there was just one student.

*Indicates significance at the .05 level

This means that NE learners improved more than LH learners with an average difference of 4.49 points, which as mentioned before, is high for the accuracy range scale. Also, the results showed that HH learners compared to LH learners reached significance ($p=.026$) with a very strong effect size, (Cohen’s $d=1.31$). This means that HH learners did better than LH learners by an average difference of 3.48 points.

The post hoc test for gender showed that boys on average improve more than girls on the IDEL reading accuracy sub-test with an average difference of 2.09 points. This difference is high for the accuracy range scale because students move from one proficiency level to another in intervals of one to two percentage points with a medium to strong effect (see Table 4.14).

**Table 4.14**

*Post Hoc Comparison Test for Gender on the IDEL Reading Accuracy Test*

| Gain Score for IDEL Reading Accuracy Test (Post Hoc Comparisons for Gender) |
|-----------------------------|------------------|----------------|------------------|
| Gender | Gender | Mean Difference | Ptukey | Cohen’s $d$ |
| Female | Male | -2.09 | 0.044 | -0.786 |

Even though the experimental group started with better accuracy scores in DIBELS, they improved less than the control group. Also, DIBELS results based on gender nearly reached significance ($p=.072$) (see Table 4.15). This means that boys improved more than girls by a difference of 1.97, which is high considering that accuracy proficiency levels changed by 1 or 2 percentage points, with a medium to strong effect size.
Table 4.15

*Post Hoc Comparison for Gender on the DIBELS Reading Accuracy Test*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Gender</th>
<th>Mean Difference</th>
<th>Ptukey</th>
<th>Cohen’s $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Male</td>
<td>-1.97</td>
<td>0.072</td>
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In addition, the results from the analysis of language background and MALL interaction show that the gain scores in DIBELS were less than 5 points and the gain scores on the IDEL test were more than 20 points. In fact, the experimental group had a slightly higher improvement of 22.21 points on the IDEL test, and the control group had an improvement of 21.17 points. The interaction between MALL and language background on the IDEL reading accuracy test reached significance ($p=0.006$) with very strong effect size (Cohen’s $d=2.913$) (see Table 4.16).

So, after analyzing all the interactions, the researcher concluded that the use of MALL makes a strong difference on students’ IDEL reading accuracy test scores, depending on the language background of the student. The analyses showed that there was a stronger effect size (Cohen’s $d=<1$) with a mean difference of 7.737 for NE. However, NE did not seem to have such a strong effect when using MALL as much as the other groups did for reading accuracy. Also, among the LH students, those using MALL did better than those in the control group. Moreover, HH learners did better than LH students whether or not they used MALL.
Table 4.16

Post Hoc Comparison for MALL and Language Background on the IDEL Reading Accuracy Test

Gain Scores for IDEL Reading Accuracy Test (Post Hoc Comparisons for MALL=1 *Lang. Back)

<table>
<thead>
<tr>
<th>MALL=1</th>
<th>Lang. Back</th>
<th>MALL=1</th>
<th>Lang Back</th>
<th>Mean Difference</th>
<th>Ptukey</th>
<th>Cohen’s d</th>
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*Indicates significance at the .05 level

Retelling

To have a better understanding of students’ comprehension, we looked at both the DIBELS and IDEL Retelling sub-test scores. Interestingly, the results from DIBELS showed that the experimental group had an average gain score of 2.63 points and the control group received a gain score of 3.70 on the retell score. This means that the control group outperformed the experimental group by more than 1 point. For the IDEL retell scores the experimental group had a gain score of 19.68 words and the control group received a gain score of 27.1 (see Table 4.17).
Table 4.17

*Gain Scores for DIBELS & IDEL in Retelling*

However, there was no statistical significance related to the Spanish retell and even though there were some gains in the scores, the growth for some students was minimal. Interestingly, on the DIBELS Retelling Test, the scores of six students in the experimental group and seven students in the control group decreased. On the contrary, on the IDEL Retelling Test, most of the students showed improvement and just two of them stayed the same (see Table 4.18).
Table 4.18

Individual Gain Scores in Retelling for the DIBELS and IDEL Test

<table>
<thead>
<tr>
<th>Goal 23</th>
<th>Pre-test</th>
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<th>Goal 30</th>
<th>Pre-test</th>
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</table>

Video Recordings in Reading

Students’ Experiences with Reading.

To understand students’ perceptions and interests about the different reading activities, during the interviews, the researcher asked them to choose a number from one to five to determine how much they like to read. Interestingly, most of the students who were interviewed expressed that they like to read: from the control group six students chose number 5, two students chose number 3 and one said most of the time. From the experimental group one student chose number 5, five students chose number 4, one student chose number 3, and one student chose number 2. Therefore, more than half of them enjoyed reading. For example:

Interviewer: Um, so the first question is super easy: You're going to tell me how much you like to read on a scale of one to five, with one being not very much and five being a lot.

BLH Student: Seven?
Interviewer: A seven? You like to read that much!? That's amazing! Um, are there parts of reading in Spanish that are easy for you?

BLH Student: Uh huh.

Interviewer: What are those parts?

BLH Student: Parts like mini paragraphs. I can't read Spanish that well and I don’t really know big words.

Interviewer: But what parts of reading in Spanish are easy for you? You told me the hard parts. Now what are the easy parts?

BLH Student: Lectors.

Interviewer: The *lecturas* [readings]? Okay and what is easy about the *lecturas* [readings]?

BLH Student: They don't have that many big words and like I don't get as nervous to read them.

Interviewer: And why don't you get as nervous?

BLH Student: Because I know I don't have big words and like I know I just have confidence in myself.

Interviewer: Oh, and where does the confidence come from?

BLH Student: Probably from the feelings that I am getting.

Interviewer: Like you're getting that you're understanding what you're reading?

BLH Student: Yeah.
Easy Things for Students When Reading

Things that Helped Students Improve Their Reading

Students thought that practicing their reading was the number one reason why they improved their reading. However, it is important to mention that students had different preferences on how to practice. Whereas some students prefer to practice with a partner in class to improve their reading, others prefer reading at home at night; reading different books; or reading as much as possible. The second reason why they thought they improved their reading is because of the help they received at home from family members. For example, one HHG student said, “Porque mi familia habla en español y ahí aprendo más cosas.” In this example, the student is expressing how family members helped her learn more. Another example is: HHB “Because whenever I say a word wrong at my home, they tell me how to say it…good.” These two examples show how important it is to receive corrective feedback, not just from teachers, but also from family members at home. In addition, students mentioned that science lessons helped them improve their reading. One of the students said:

NEB Student: When we study animals or fossils, I learn more words so I can, if I see them in a book… I know what they are.

Interviewer: Interesting, so are you saying that like when you are learning your science lessons, that the words that you learn in your science lessons help you read other things?

NEB Student: Yeah.

Students from these examples not only learned facts and details about science, but they also recognized that they learned new words and improved their reading. This indicates that students recognize that the knowledge and skills they are acquiring in class is transferring into
other subject areas. Finally, one student mentioned that the quizzes after the readings help him have a better understanding and read better:

BLH Student: Sometimes when I start reading, I have to read it twice and if we read it twice, we have a quiz.

Interviewer: And does that help you? The quiz?

BLH Student: Yes.

Interviewer: Well, how does it help?

BLH Student: Because if you read and then you like try figuring out the quiz and you don't know the quiz like you can ask like a teacher for help or not, or like a student in your class.

Interviewer: So, the quiz helps you know if you're getting it or not?

BLH Student: [Nodded yes.]

Also, students mentioned different strategies they use to understand the text. The number one strategy they used was asking the teacher or another student for help.

Interviewer: Umm on a scale of one to five, how much do you like to read? One is not very much, and five is all a lot.

GNE Student: Um, I like to read most of the time, it just helps me get better.

Interviewer: Is there anything that you would change about the reading activities that you do in your class?

GNE Student: Um, no, I kinda like how they are because sometimes you can do it with partners, and it helps the other kids that don't know how to read, and because it helps you. It helps them and you tell them the word if they don't know it.
Similarly, students used other metacognitive skills to understand the text such as thinking about the word first and trying to figure out the meaning or pronunciation of the word in their minds before saying it, spelling the word, reading it twice, or sounding it out. However, some students chose to change their reading strategies and pick a different word, page, or even book. For example, one student said, “When you get to like, get a harder word you don't know, so I just skip them if I don't know them.” Another student said that she would pick or do something different.

Interviewer: So, the first question is really easy. How much do you like to read on a scale of one to five? If one is not very much, and five is a lot? How much do you like to read?
GLH Student: Five.

Interviewer: Five? Oh, my goodness! So, what part of reading in Spanish is easy for you?
GLH Student: Probably the language.

Interviewer: The language – what part of the language? Like what about reading in Spanish is easy?
GLH Student: Umm reading in Spanish.

Interviewer: Just the reading?
GLH Student: Uh huh.

Interviewer: Okay. Um, is there anything about reading in Spanish that's hard for you?
GLH Student: Just when I don't understand some words. And like a book I don't understand.

Interviewer: And what do you do when you don't understand something?
GLH Student: Um, I tell the teacher, or I pick, or I do a different thing.

Lastly, another LHB student said:
Sometimes I just stop and think about the word in Spanish. I say in my head in English first. And then I say, what does it mean? How does he explain this? How's the explanation? And then if I still don't know, I still, I tell Mrs. Casares. But if I start to know it, then I just go back, I just sit in my seat and do my work.

**Hard Things for Students When Reading.**

**Spanish Improvement Based on Reading**

After the intervention students felt that they had improved their Spanish abilities. In fact, fourteen students said that their improvement was directly related to their reading. The first reason why they thought they had improved was because of the books they read in class and the new words they had learned while reading the books. For example, a LHG student said, “Because I've learned a lot of new words, reading books in Spanish and talking a lot in Spanish.” Also, a NEG student said, “Yeah, I got a lot better Spanish than in third grade, it was really hard for me to read in Spanish.” Moreover, they acknowledge that practicing and reading different books was part of the reason they got better at Spanish. Another NEB student said, “Ummm we read, we read tons and tons of books in Spanish.” Also, a LHG Student said, “If I keep practicing Spanish words. I like reading books in Spanish.” In this case, practicing Spanish words was the reason she felt she could get better at Spanish. Students mentioned that learning new words and practicing while reading was one of the main reasons why they had improved their Spanish. The fact that students felt they had improved their language and the amount of practice they had may be the reason why their accuracy improved in Spanish.

In addition, students suggested that the small books or the pass-off books helped them improve their reading because they started with an easy book and moved up to a higher level to improve their pronunciation, fluency, and understanding. The second reason why students felt
they were getting better at Spanish was because of the science lessons and the writing. For example, a NEB student said, “Personally, it's probably the, the science texts that we read. That helps me most. Yeah, it's also just when we're like talking with their partner about what something was about.” Another student said:

NEB Student 5: Um, mostly the writing and the science.

Interviewer: How does writing and the science help you get better at Spanish?

NEB Student 5: Make you better at Spanish? Like, writing Spanish words actually helps because you're actually learning more words.

Interviewer: Can you say a little bit more about that? Like, what about writing the words helps you learn them?

NEB Student 5: Um, like, you know how to write them, and you know what word it is.

Interviewer: Like, you have to focus on it or concentrate on it more?

NEB Student 5: Yeah.

Interviewer: Okay. And then what about science?

NEB Student 5: Um, it makes it easier because, like, it kind of mentioned dinosaur names and how to write fossils, and how to save fossils.

Interviewer: And then how does that help you get better at Spanish?

NEB Student 5: Um, it helps me get better at Spanish when you mostly write the things down; it just becomes easier for me.

The third reason that some students mentioned was related to their family. For example, one HHG student said, “Aaa creo que sí pero no tanto porque mi familia es de habla español.” [Uh, I think so but not that much because my family speaks Spanish.]
The fourth reason was collaborating and talking to their peers. For example, one HHB student said, “Because we have to talk a lot of Spanish in class... So, I talk a lot of Spanish, even at recess…” A NEB Student said, “Because she has a rule in the class that you cannot, you can't speak English or else you have to stay in for recess and write a paper.” Students felt they had to talk constantly and talk with their peers, as illustrated in the previous example. This reason also included some of the investigations that included a writing and a speaking part. Finally, one student mentioned that the quizzes after reading helped him improve his Spanish because of the instant feedback.

**Impact of iPad Use on Reading**

Students’ perceptions towards the iPads were positive; most of the students who were interviewed liked them and thirteen of them felt they were helpful for their learning, some of them mentioned the challenges they encountered when reading on iPads and the difference between reading on iPads or reading on paper.

**Reasons Why iPads Are Helpful**

The number one reason why students felt the iPads were helpful and they liked them was because they could use Epic! which is another program/reading app used to read kids’ books. Students were allowed to read on Epic! after they had finished their assignments. This is interesting because based on students’ responses, Epic! gives them more options to read and a variety of books in Spanish. Students liked Epic! because it has a lot of choices for them, it was fun for them, and motivating because they could count their words. For example:

Interviewer: Should we talk about reading for a second?

BNE Student: Yes.

Interviewer: Um, so do you ever get to use the iPads when you read?
BNE Student: Yes.

Interviewer: Are there things about working on the iPads that you like?

BNE Student: Yes.

Interviewer: What do you like about reading on the iPad?

BNE Student: Epic!

Interviewer: Epic!? And what do you like about Epic!?

BNE Student: You get to read all kinds of things.

Interviewer: So, you have a lot of choices. Mm. Um, and what's different about reading on Epic! versus reading on paper?

BNE Student: It's fun to read on Epic!

Interviewer: Can you tell me why it's fun?

BNE Student: Because you get to go on a search and find all kinds of stuff.

Moreover, students felt that they could read more when they use iPads, and they liked the different features such as listening to the audio, recording, reading along, and the quizzes after the reading.

Interviewer: ¿Qué fue lo que más disfrutaste de usar iPads para leer? Como Epic! y Reading A-Z, ¿por qué te gustan estas cosas y programas? [What did you enjoy most about using iPads to read? Like Epic! and reading A-Z, why do you like these programs?]

HHG Student: Porque ahí en Reading A-Z, yo escucho lo que dice y ahí yo lo leo y contesto las preguntas también. [Because on Reading A-Z, I listen to what it says, and I read it there and I also answer the questions.]

Interviewer: Muy bien, y ¿qué parte te gustó más? [Very good and what part did you like most?]
HHG Student: Amm cuando yo, cuando yo leo. [Umm when I, when I read.]

Interviewer: Ok, y ¿por qué te gusta cuando estás leyendo? [Okay and why do you like when you read?]

HHG Student: Porque ahí aprendo más cosas cuando lo estoy escuchando y cuando lo estoy leyendo. [Because there I learn more things when I am listening to it and reading it.]

Interviewer: Ok, ¿y qué fue difícil usar iPads para leer? [Okay, and what was hard about using iPads to read?]

HHG Student: Amm, nada creo. [Umm, I don’t think anything.]

Also, they mentioned they could get feedback from the quizzes, and one student mentioned that by recording their voices the teacher knows how to help them and when to help them based on their struggles during the reading. Additionally, some students felt that it was convenient to use iPads because they did not have to keep a lot of papers. One NEB student said, “Yeah, we don't have to keep papers in our binders.” They could also write in their electronic journals. Finally, they felt that they could learn a lot of things and that they could always access the books and get them done faster. In summary, based on students’ answers, they liked using iPads because it gives them more options to learn. They like the features because they recognize that these things help them in their learning process and are more convenient for them.

**Challenges When Using iPads.**

The main reason why students thought that iPads were hard to use was related to technical difficulties; for example, one NEG student mentioned, “Sometimes it just doesn't work because the internet is a little slow and it doesn't work on some of our iPads”. Another NEB student felt that every time they had an issue with the iPad, the class slowed down. For example,
the student said, “Sometimes, like the iPad has a problem. So, then it takes a while to fix it. And then it's slowing down the whole class.” Also, the students felt that they had to redo their work because it was lost due to technical difficulties or because they clicked the wrong button. Finally, some students related the difficulties of using the iPad to their reading skills:

Interviewer: Okay. What was hard about using iPads for reading anything?

NEG Student: Um, usually the pages use, like a tiny word [font] sometime. And sometimes when they use those little recordings on the iPad.

Also, some students mentioned things such as, “It hurts my eyes”, “I lose my place” or “I have to type in the password every time they have to read.” Finally, seven students thought that nothing was hard about using iPads. In fact, three of them thought that reading on an iPad was not different from reading on paper. For example:

Interviewer: Oh, and is there anything that's different about reading on an iPad versus like reading a normal book?

NEG Student: No, not really.

Interviewer: Um, is there anything hard about using an iPad for reading?

NEG Student: Um, kind of… you have to get to the place. And sometimes when we're trying to record ourselves, reading it. Sometimes people go to the finish button, and they have to redo it.

In this example, the student is talking about the feature that Reading A-Z has to record students’ reading in which they need to read aloud when they press the microphone button in order to send their recorded reading to the teacher. In addition, one NEB student said, “on an iPad, it's kind of worse because sometimes when I read, umm, I like, I just kind of like… I don't really know how to explain it, but I'm trying to. Umm it kind of hurts my eyes when you're
staring at a page for so long.” This means that for some students, reading on an iPad can be hard or frustrating.

**Differences Between Reading on iPads and Reading on Paper**

Some of the differences between reading on iPads and reading on paper included tapping the screen to flip the page or definition; the ability to record yourself while reading; the different choices it provides for resizing the letters; and that you do not have to type in the password every time. Also, iPads give students more accessibility to other things in a faster and easier way. In addition, it was motivating for them because it gave them messages at the end of the reading for competition or feedback. However, one student did not like the touch screen because he could not follow along with his finger. Finally, students said that by recording their reading it provided feedback for the teacher to help them improve their reading abilities.
Chapter 5: Discussion

Because the purpose of this study was to explore the integration of literacy, science, and technology, students were asked to participate in reading and science activities using MALL. Students read texts related to science that prepared them for science investigations to help them learn about organisms. For the investigations they were asked to do simulations, games, or hands-on activities; reading scientific texts and writing explanations about the phenomena investigated. These activities required them to communicate with their classmates and share their knowledge in the second language. Therefore, this chapter is organized as follows: First, three factors are discussed that were found to influence students’ learning: gender, MALL, and language background. Next, specific aspects of students’ reading performance will be discussed, along with pedagogical recommendations. The chapter concludes with a discussion of the effectiveness of literacy and science integration, followed by comments on the limitations of the study and recommendations for future research.

Factors Influencing Students’ Learning

The findings of this study showed three main factors that significantly influenced students’ reading and science performance which were gender, MALL, and language background.

The Effect of MALL

After analyzing students' attitudes towards MALL, it was concluded that in general, students are motivated by these devices and have positive attitudes when using them, especially among boys and students with special needs. First, students were motivated and engaged because they liked to have options. Letting students choose their reading resources appears to empower their learning and gives them independence to learn. For example, in this research students were
encouraged to complete their science assignment with the opportunity to read in Epic! Hence, they persisted in reading a difficult text simply because they were able to choose their own books as a reward. In fact, in the interviews students mentioned that one of the main reasons why they enjoyed reading was because of [Epic!], and the many options they had in there. By the same token, using MALL may help students to persist in reading hard materials. This confirms findings about the motivation and engagement that is promoted by the use of MALL (Ermerawati, 2019; Keezhatta & Omar, 2019; Khubyari et. al, 2016). Also, the data showed that in general boys as well as students from specific language backgrounds benefited more from the treatment than girls, as will be discussed in subsequent sections.

Moreover, students enjoyed reading on iPads because of the many features and accessibility they provide. This technology gave students the option to access books that they wouldn’t have in their classrooms; it allowed them to find definitions that they could not find in a regular book; gave them different opportunities to practice reading using the voice recorder to receive feedback; resize the text to see the words better; bookmarked their reading to find the last page they read; and listened to the recorded book to know the pronunciation of the words. Based on students’ interests and the features they liked, it is noticeable that they were empowered in their learning and that helped them be independent by meeting their own needs and desires. In other words, MALL gives students the opportunity to receive individualized learning which allows students to progress at their own pace and level (Lem, 2018; Peng et. al, 2021). In sum, using MALL gave students other tools that they would not normally have when reading a text, such as embedded dictionaries, more opportunities for feedback and the opportunity to hear their own voice for metacognitive strategies.
Teachers may consider the use of MALL to help students be accountable for their own learning and provide motivation in the language classroom. In addition, teachers may need to ensure that boys have more options to choose their texts because they tend to work better independently and like to have choices. However, more research needs to be done about the different strategies to use technology in DLI classrooms for the acquisition of language and content.

The Effect of Gender

When Science RISE Benchmark Test scores in science were analyzed, gender was statistically significant; boys did better than girls. Thus, teachers should be aware of the importance of differentiating students' learning needs and consider their preferences and abilities (Morgan, 2014). A good way to start would be understanding the preferences of each gender and then find the needs of everyone (Zubaidah et al., 2017). This is also congruent with research in which was suggested that boys and girls learn differently, and these differences should be considered to help them learn. On one hand, he mentioned that boys have 35% less hearing than girls due to the cochlea length of the ear, they focus on movement, have difficulties to talk about feelings, friendships are focused on shared activities, they may not ask for help, they deal well with moderate stress, and feel excited with confrontation and threat. On the other hand, girls develop language and fine motor skills earlier than boys, they focus on faces and warm colors, they express their feelings, conversations are important, enjoy relationships with teachers, and cannot deal with moderate stress. Therefore, teachers might need to find a balance to teach boys and girls (Bonomo, 2010).

In addition, these findings are congruent with previous research where it was suggested that in science, girls tend to see themselves as outsiders, lacking confidence while boys see
themselves as insiders (Shakeshaft, 1995). This means that boys tend to be more confident when learning science; they interact and try more things. This confirms research based on gender ideology and the different beliefs and values boys and girls have about their role in education and even society. For example, there is a traditional belief that science careers are for males while arts are for females (Crombie et al., 2005; Sikora & Pokropek, 2012; van der Vleuten et al., 2016). For decades gender roles have been stipulated by their society. For example, Hispanic communities have a tendency to portray males as the strong figure, with smart and successful males while women have been encouraged to stay at home and do simple tasks (England & Barney, 2012; Quiñones, 1996). However, Hispanic communities are not the only ones portraying males as strong figures with more scientific roles (Jones et al., 2000). This is true for other cultures too (Glick et al., 2004). Findings from the present study suggest that perhaps it is true in the community where the study was done. Boys may see themselves as future scientists while girls may not value themselves as future scientists or even professionals. They could value other careers or home related activities more than science careers.

By the same token, another study mentions that by the age of 8, students start making more conscious decisions, perceptions become more realistic and social interactions start to happen, declining academic self-beliefs for some girls (Jacobs et al., 2002). Interestingly enough, 4th grade is a transitional grade where they start developing teenager attitudes and behaviors. As a matter of fact, girls may grow faster than boys and may be more conscious about their own capabilities than males. This could explain the need for social interaction and support. However, they may also compare themselves more with others and see themselves as less capable than boys. For example, during the observations boys were always eager to participate and do the activities without needing a lot of support, portraying confidence and empowerment, while girls
needed very detailed instructions and extra support. This is also congruent with other studies that have suggested that boys tend to be more sociable than girls, they seek for more practice, and they are not afraid of making mistakes with the language (Calvert, 2002; Kayaoglu, 2012; Parks, 2006; Zohar & Sela, 2010). Therefore, in general, boys are more independent and confident to learn science while girls may need more support.

This is relevant because when it was noticed that boys worked better independently, and they struggled less using technology; whereas some of the girls mentioned that they preferred to work in groups and share with others. This could mean that boys were not afraid of making mistakes even if they struggled. Similarly, in some of the observations, girls tended to struggle more with iPads, and they were not as focused on the activity as the boys. In other words, boys may feel more confident when using MALL and working independently, while girls may need more guidance and assurance from the teacher. Moreover, findings from our study showed that boys benefited the most from the integration of reading, science, and technology. This could be because of the structure of the study in which choices were provided by reading apps, they had the opportunity to experiment and collaborate with others without a strict outline to follow, and they had a lot of opportunities to practice reading and writing. It is also noteworthy to mention that boys were more accurate than girls in reading, which could be related to their performance and interest in science topics as well as the confidence they had talking in the target language.

Consequently, teachers may want to ensure that girls get the guidance they need to complete their assignments. Also, teachers may want to consider that girls need more guidance and social interaction to be able to succeed in these lessons and they may need help building up their confidence and understanding of their role in science careers. For example, teachers could provide female students more opportunities to work with their peers or in groups and have
specific time set apart to work with girls while males work independently in their iPads. Moreover, researchers may want to investigate gender behaviors and attitudes in DLI settings to help stakeholders develop better curriculum and differentiated instruction.

**Influence of Language Background**

Students' improvements differed based on language background as well as gender. This is important because teachers should be aware of the differences among students and how these differences affect their learning process. Interestingly, in this study the researcher found patterns that suggest that depending on the language background and gender when using MALL in science, students benefited or not from the treatment. For example, in the results section LH learners benefited the most from the use of MALL in science. However, for reading they did not benefit as much as other NE or HH learners. This could be because the development of both languages for LH students is very limited since most of them are third or four generation. This means that they have not completely developed any of the languages due to the lack of language knowledge of their parents, and even their background knowledge (Bateman & Wilkinson, 2010). It is like the broken phone game, the more the word passes onto other people, the more distorted it gets.

Consequently, when students get to the third or fourth generations, they struggle more because they carry on the lack of academic language knowledge and education of their parents. It is also important to remember their life context and experiences, which plays another important role in their learning and brings a completely different perception of the world into their classes. They don’t have a strong native language to transfer to English and the work they do is harder for them because they don’t have a basic knowledge of the language, lack vocabulary knowledge or even understanding of the pragmatics of their own language and identity. All this results in
lower scores, especially in reading where they have to use their language knowledge. By contrast, science gives them more options to interact and have hands-on activities that allow them to succeed because students learn the academic language that they need for all the new information they interact with through the concrete science activities. In fact, it helps them learn the vocabulary they need to succeed as bilinguals in other contexts as well. In other words, heritage learners are not fully proficient English speakers nor proficient Spanish speakers and they tend to struggle more with reading in both languages, while most of the NE learners have better abilities to read in English. In fact, NE proficiency of their L1 is stronger and they just had to transfer their knowledge to the other language and practice. It is noteworthy to mention that some of the NE learners mentioned that the repetition and practice was what helped them the most. On the other hand, LH had to learn basic concepts to improve their reading.

Another factor that could be consider is the language in which the devices were set, and the exposure students had to them outside of school. Perhaps NE learners had more abilities using the iPads because they have more access to technology outside of the classroom due to different reasons. One reason is because most of the time these devices are set in English by default. Another reason is the accessibility parents have to the iPads, either because they have the means to buy them or because they have the knowledge to use them. In fact, they even use them for work-related activities while LH learners may not have the same opportunities due to their socio-economic status or their parents’ lack of education. In summary, NE learners did better in accuracy, most likely due to their L1 abilities and the knowledge they already have to transfer to school activities.

Consequently, DLI teachers may ensure that the L1 reading of the student is reinforced to help them improve the L2, especially when students struggle with their L1. For example, in this
study it was noticed that LH learners who may struggle in both languages may need extra support to learn and improve their L1 to improve their second language. In addition, teachers may consider providing enough feedback to students along with additional opportunities for practice and repetition. Doing this will give students more confidence and will help them recognize their mistakes while enabling them to be accountable for their own learning.

Finally, teachers should provide enough opportunities for positive peer interaction and peer feedback. In the study some students mentioned that collaborating with other students was helpful for them because they were able to listen to how other people pronounce words; they were able to understand the other language better and imitate other students' actions when they lacked understanding. One student mentioned that the interaction with other students and feedback helped him learn new words. Collaborating with other students helps them improve their learning; language skills; reading ability; and increases content comprehension. This is especially important for settings in which students have different language backgrounds and may need extra support.

**Reading Performance**

**Motivation and Engagement in Reading.**

Motivation and reading are also important to help students learn how to read. In the interviews, students' comments show evidence of their engagement as they were reading and understanding the text, especially because they felt they learned new specific things that were interesting to them (e.g., “the human body has 210 bones”). Motivation is an important factor to consider when teaching students; just as researchers have said before, motivation can foster or hinder their learning in different ways. For example, motivated students develop reading skills faster to fit in with their peers or the environment (Baker et. al, 2012). Motivation increases the
reading amount, therefore, by increasing the reading amount students increase the comprehension of the text (Guthrie et. al, 1999). And motivation in learning helps students increase their attention which makes learning more relevant and satisfactory, giving them positive feelings and confidence about their learning process (Gopalan et al., 2017). In addition, some researchers have mentioned the role of technology and how it motivates students because of its features that help students to read, giving them more accessibility, flexibility, and mobility (Hashim et al., 2017; Lin, 2014). These findings are important because motivation can foster students' learning and empower them throughout their learning. Therefore, teachers could use technology and find different ways to motivate and engage students to help them improve their reading.

**Fluency**

When students’ reading scores were analyzed, the researcher learned that even though all the students made gains in their scores and improved their reading there was still not statistically significant values in reading fluency, but there were statistically significant results in reading accuracy. This may be because of the low levels students had at the beginning of the year and because of the amount of practice they did throughout the treatment. Therefore, it is assumed that the ceiling effect was encountered. This happens when students show improvement because the content was too easy or because they scored so low initially in their reading abilities that they all showed great improvements.

Practice and repetition were one of the main reasons why students felt they had improved their reading in Spanish (Archambault, 2019; Taguchi et. Al., 2012; Taguchi et. Al., 2016; Therrien, 2004). Yet in general, students who read better in English were the ones that read better in Spanish. The same was true for students who had lower scores. Moreover, some of the
students with high fluency levels in one language did not have as much fluency in the other language. This could be explained with the idea that “children learning to read in a second language have slower average CWPM than native LOI-speakers when reading with comprehension” (Dowd & Bartlett, 2019).

Likewise, one high heritage student read better in Spanish than in English, therefore, it was inferred that her stronger language was Spanish. This means that fluency transferred from one language to the other, but when having high levels of proficiency in L1 did not necessarily transfer to the L2 this may be due to the language knowledge and capabilities of each student, confidence, and motivation (Ramirez & Shapiro, 2007). This is congruent with the developmental interdependence hypothesis proposed by Cummins in which he proposed, “the level of L2 competence which a bilingual child attains is partially a function of the type of competence the child has developed in L1 at the time when intensive exposure to L2 begins. When the usage of certain functions of language and the development of L1 vocabulary and concepts are strongly promoted by the child's linguistic environment outside of school, as in the case of most middle-class children in immersion programs, then intensive exposure to L2 is likely to result in high levels of L2 competence at no cost to L1 competence” (Cummins, 1979, p. 233). Therefore, to help dual language immersion students, teachers need to make sure both languages are being reinforced in the academic setting (a concept known as biliteracy), and once students improve their L1, that knowledge will transfer to their L2 abilities.

Accuracy

When the researcher analyzed the accuracy scores, she noticed that the gain scores were more than 20 points on the IDEL test and the gain scores in DIBELS were less than 5 points. This could be because the IDEL test was designed to measure only up to 3rd grade, and the study
was done in a 4th grade class. Therefore, we would expect students to do better in this test than on the DIBELS test. Another reason could be because of the lower scores that students had at the beginning of the treatment when they did the pre-test. The last reason could be because of the repetition of the text, which included the ability to hear the words before reading and practicing it. Interestingly, most of the students said that reading was one of the things that they could not do before the treatment and most of them felt that they could read and even feel confident in their reading. Notably, the majority were motivated to read and enjoyed reading.

In addition, feedback from the teacher, peers, and family members was one of the reasons students improved their reading. In fact, students really treasured the help received at home, probably because it is provided in a familiar setting with language that is commonly used or heard. Therefore, it gives them more confidence because it comes from people they trust. In other words, students need to be supported at home by receiving feedback from their parents while increasing their language background knowledge. Also, the feedback students received helped them not just to recognize their mistakes, but also to negotiate the meaning of words which allowed them to practice, make corrections, and increase their language proficiency level.

Teachers could plan for opportunities that allow students to receive feedback inside and outside of the classroom. For example, teachers may need to create more structured activities in which students are required to provide feedback, correct themselves and even seek feedback when interacting with other people. This constant feedback provided by teachers and peers could help students provide feedback to each other automatically, even in situations in which they are not required to provide feedback. This means that teachers need to provide purposeful and meaningful feedback to their students, help students provide feedback to each other and help them acquire the abilities they need to seek feedback when talking to other people, especially
their family. However, due to the lack of research on the influence of family feedback, researchers may consider doing more research to understand better the role of feedback outside of the classroom especially among heritage learners and their language use outside of the classroom.

Retelling

To have a better understanding of students’ comprehension, the researcher looked at the DIBELS and IDEL retelling scores. The scores showed the control group made greater improvements than the experimental group both in English and Spanish. It could be because the academic level of the control group was higher than the experimental group. Also, it could be because of the students’ personalities and confidence when talking to other people or social skills. Interestingly, the gain scores in Spanish were greater than in English. One reason why the Spanish scores were higher could be because the pre-test scores were very low. Another reason could the integration of literacy and science, this means that even though the control group did not used MALL they still had reading opportunities. Another important reason why Spanish was a little higher is because both classes received vocabulary instruction to express themselves, and the researcher encouraged them to say as much as possible whenever a question was asked.

Teachers might assess students' language abilities to help them with their learning and make sure both languages are being reinforced to help them improve their reading abilities. As it has been suggested by some studies the L1 has a strong impact on L2 acquisition, therefore, both languages have to be reinforced (Huang, 2010; Leclercq & Lenart, 2013). Also, it would be important to set intervention groups tailored to the needs of each student's language ability. In these groups they could provide vocabulary knowledge as well as basic reading skills. Moreover, teachers could add repeated reading in their lessons and increase the reading practice to help
students improve their reading fluency and accuracy. Such practice could include peer reading to help students comprehend the texts and ensure that each student is receiving enough feedback. Also, as was mentioned before, teachers may want to consider using investigations to motivate and engage students in their reading assignment and provide them enough feedback.

**The Effectiveness of Literacy and Science Integration.**

Our findings confirm findings from Overvliet’s (2018) study, and provide evidence that gender is an important factor to consider along with the integration of MALL and language background in a DLI setting. Interestingly, Overvliet found significant growth in reading fluency and science. She found that some of the factors that influenced the reading growth were related to peer interaction and repeated reading. This means that students benefited from peer-work activities which helped them with their reading comprehension and language knowledge which was then reflected in their writing. By the same token, she noted that science growth was demonstrated by their general knowledge, conceptual understanding, and creating and defending scientific theories. This was also reflected in their writing reports. Moreover, students thought they had improved in science and showed excitement for the hands-on activities and scientific texts (Overvliet, 2018).

Similarly, the researcher from this study found that students felt that the science activities helped them to learn and improve their reading and their language abilities. This could be because of the repeated reading, the scientific text, the hands-on activities, the peer work, and the writing activities. In fact, the main reason students vocalized was related to the investigations that required them to read and use their interpretive abilities to understand the text.

By the same token, they had to write explanations at the end of each investigation to share it with others. In other words, students had to produce the language to share it in written
and oral forms. Consequently, the explanations that they constructed had more meaning for them, and even when the explanation required a higher level of thinking and complexity, students were able to provide enough evidence of their understanding and the effectiveness of the reading and science integration. In sum, students’ investigations were more meaningful, and they had different opportunities to read throughout the treatment which helped them improve their reading and science learning.

For instance, students felt that they had improved their reading because of the science texts they had to read and the different activities they did in class for their science lessons. This is congruent with the idea that content-based learning is more meaningful for students and their learning improves (Snow, 2001; Swain, 2001). In other words, science texts help them learn bigger words, even though these words are harder for them. Also, they were motivated to read texts that were more complex to complete their investigations. And even though some students struggled and felt that Spanish was hard, most of them agreed that they had learned science and improved on their reading and their Spanish ability.

Notably, both studies demonstrated that the integration of literacy and science was positive for students. In addition, findings from this study offer additional insight into Overvliet’s conclusions. (1) It suggests that the integration of MALL is positive and motivating for students. (2) There is a relationship between students’ gender and their learning process. (3) Language background should be considered when teaching students in a DLI setting.

Teachers should ensure that students have opportunities to read; participate in experiments, simulation, or games with their peers; and write their explanations. This will help students improve their proficiency level by providing them with enough opportunities to read meaningful content; have purposeful communication with others; and write about their
conclusions. These activities foster students’ communication and help them to communicate with other students to build up their existing knowledge. “Such literacy activities reinforce students’ understanding of concepts and push them to strive to express their ideas in a linguistically precise manner” (Haneda & Wells, 2008, p. 131). In other words, these activities will not just help fulfill the ACTFL guidelines, but also align with the SEED Utah standards which require them to conduct investigations and share them with others in various forms. Just as the researcher noticed in this research, integrating these things enables students to learn and provides enough opportunities for them to improve their reading and science skills in a different language.

**Limitations of the Study and Recommendations for Future Research**

Despite the interesting implications of these findings, they should be interpreted with caution because of the small sample size of this research. It would be interesting and helpful to do another study with more students to see if the same results are obtained. Perhaps having a bigger sample size with more classes and classes in various areas of the state to see how the different class environments respond to the treatment could help teachers and administrators make the necessary adjustments to provide good and equitable education for all the students. For example, having different attitudes, background knowledge, and even language backgrounds may create a different environment in the classrooms and produce different results. In addition, it would be enlightening to learn more about heritage learners and how they learn based on their language proficiency in both languages.

Also, even though the IDEL pre-test scores were very low we need to interpret the result with caution because be the IDEL test was intended for 3rd grade students and not 4th grade students. This means that the results from the readings may not completely reflect the language
that needs to be used in 4th grade and it would be interesting to see how a more accurate level of
texts impact students’ reading performance.

Another limitation is that only one instructional unit was tested which may not be interesting to all students. Therefore, the interventions may not have the same impact when students learn other topics due to the interests of the students as well as the complexity of the topic. It would be interesting to see how boys and girls react to topics that are more complex and require different cognitive skills.

Moreover, because the research was not intended to learn in detail about the differences in the learning process, this research raises questions about differentiation in a language classroom. What would be an efficient way to differentiate among students in DLI classes? How can language learning be improved based on students' strengths and weaknesses? In sum, it would be interesting to do more research about different behaviors and the effect of different instructional strategies in language learning depending on a student's gender; their language background; rural vs urban settings; and the different learning processes in language to understand how different intelligences could benefit more from their instruction.

Conclusion

To meet the goals established by DLI, students need to learn both the content and the language. For example, in the 4th grade, science is the main subject students have to learn and it can present a challenge for teachers and students, especially because students need to be able to read scientific texts, understand them and write about them to imitate and develop the skills scientists have. Consequently, students need to improve their language abilities in reading and writing to succeed in the program as well as learn the content. This study shows evidence that the integration of literacy, science, and MALL may be effective in helping students improve their
reading abilities as well as science knowledge. This integration motivates and engages them in the learning process, empowering them in their own learning. The study also highlighted the importance of differentiating learning to help meet different needs such as gender and language background. In fact, this research helped us recognize the importance of understanding the needs and struggles of heritage learners. Due to the lack of understanding language proficiency among heritage learners, more research needs to be done in order to understand learning differences and specific strategies that could help students succeed in immersion programs where they can reinforce their L1 and L2. By doing this, the researcher could help students, teachers, and administrators create a more inclusive learning that integrates literacy, science, and MALL for the benefit of each student.
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Appendix A

Daily practice for repeated reading

The teacher introduces vocabulary and activates background knowledge

a) First day, follow the leader:
   
   Control group: Students read along as the teacher reads to them.
   
   Experimental group: Students read along with an iPad; they will listen to the audiobook.

b) Second day, punctuation reading:
   
   Control group: Students focus on punctuation by using their voices to indicate pauses, stops, questions, or exclamations at appropriate places in the text as they read aloud.
   
   Experimental group: Students with an iPad will listen to the audiobook and will be instructed to focus on punctuation by using their voices to indicate pauses, stops, questions, or exclamations at appropriate places in the text as they read aloud.

c) Third day, detective reading:
   
   Control group: Students focus on high-frequency words. The teacher will introduce three words commonly used in the language. Also, the teacher will explain the meaning of the word, practice phonemic pronunciation. After that students will detect the word in the text every time, they read it (by clapping or making a movement).
   
   Experimental group: Students with an iPad will learn high frequency words using a program that will show them the words and a picture. After that students will detect the word in the text every time, they read it (by clapping or making a movement).

d) Fourth day, partner reading:
   
   Control group: Students will focus on accuracy. In order to do it, students will read with a partner to correct each other.
   
   Experimental group: Self-correcting reading: That means that students with an iPad will listen to their own recording and find 2 things that they did well and 2 things they can improve.

e) Fifth day reading:
   
   Control group and experimental group: Students will record how many words they read per minute on a graph.
Appendix B

Interview Questions

INTERVIEWER: Today I want to talk to you about reading in Spanish. The things you tell me will help me learn to be a better reading teacher. I want to make sure that you can tell me everything you want to while we talk, so you get to choose if you want to talk in Spanish or in English. Which language do you prefer?

STUDENT:

INTERVIEWER: I don’t want to forget any of the important things you tell me, so is it okay with you if I RECORD this and take some NOTES as we talk?

STUDENT: YES NO

INTERVIEWER: How much do you like to read?

STUDENT:

1 2 3 4 5

INTERVIEWER: What part of reading in Spanish is easy for you?

STUDENT:

INTERVIEWER: What part of reading in Spanish is hard for you?

STUDENT:

INTERVIEWER: Is there anything you would change about the reading activities we do in this class?

STUDENT:
INTERVIEWER: Do you think you understand more about SCIENCE? (What makes you think so?)

STUDENT:

INTERVIEWER: Do you think you’ve gotten any better at Spanish? (What makes you think so?)

STUDENT:

INTERVIEWER: What did you enjoy the most about using iPads for reading?

STUDENT:

INTERVIEWER: What was difficult about using iPads for reading?

STUDENT:

INTERVIEWER: Do you UNDERSTAND Sra. Casares instructions in Spanish? Her explanations?

STUDENT:

INTERVIEWER: Tell me about some of the things you CAN DO in Spanish now that you couldn't do before this year.

STUDENT:

INTERVIEWER: What ADVICE could you give to Sra. Casares that might help her teach you better?
INTERVIEWER: Is there anything else you want me to know? Thank you SO much for talking to me!

STUDENT:
Appendix C

Survey

1. What is your name? ________________________________

2. How old are you?
   a. 8      b. 9      c. 10

3. Where were you born?
   a. United States  b. Hispanic Country  c. Other

4. What language(s) do you speak at home?
   - English
   - Spanish
   - Samoan
   - Other

5. Name the adults that live in your home and their native language? ________________
   ___________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________

6. What other languages do adults speak in your home?
   - English
   - Spanish
   - Samoan
   - Russian
   - French
   - Italian
   - Japanese
   - Portuguese
   - Mandarin
   - German
   - Dutch
   - Other

7. Why do you read?
   • Because an adult asks you
   • For fun
   • For homework.
   • Other ________________________________

8. Do adults read to you in English when you are home?
   Yes      NO

9. Do adults read to you in Spanish when you are home?
   Yes      NO

10. Do you read to your siblings?
    Yes      NO
## Appendix D

### Student Survey

<table>
<thead>
<tr>
<th>Question</th>
<th>Very much (1)</th>
<th>Somewhat (2)</th>
<th>A little (3)</th>
<th>Not at all (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much do you like to read?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much did you like the stories we read about science?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much do you think the stories that we read helped you understand Organisms?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much do you think the scientific texts that we read helped you understand Organisms?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After this environment unit, is reading in Spanish easier for you?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q2 Which genre did you find the most interesting?
- The stories (1)
- The scientific texts (2)

Q3 Why was this genre more interesting for you? Check all that apply.
- It’s more fun (1)
- It’s more informative (2)
- I like the illustrations (3)
- I like the pictures (4)
- It’s easier to understand (5)
- It’s similar to what I read in English (6)

Q4 Order the activities from 1 (the activity that you liked the most) to 7 (the activity that you liked the least).
- Daily practice for repeated reading (1)
- Phenomenon activity (2)
- Investigations (3)
- Experiments (4)
- Sharing with other students (5)
- Projects (6)
- Science readings (7)

Q5 Why was activity 1 your favorite?

Q6 Why was activity 7 your least favorite?

Q7 Move the cursor.
0 10 20 30 40 50 60 70 80 90 100
During what percentage of the time in class did you know what to do? (1)
Appendix E

Child Assent (7-14 years old)

Parental Permission for a Minor

Introduction

My name is Talia A. Casares. I am a graduate student from Brigham Young University. I am conducting a research study about the development of science and reading fluency using Mobile-Assisted Language Learning (MALL). I am inviting your child to take part in the research because (he/she) will be part of my class in the year 2020-2021.

Procedures

If you agree to let your child participate in this research study, the following will occur:

- Language Background Survey: This survey will be done at the beginning of the year and it should not take more than 15 minutes.
- Pre-tests: Students will take 4 different pre-tests on reading fluency: DIBELS, IDEL, Aprenda 3 and Science RISE Benchmark Test
- Each test should not take longer than 20 minutes and they will be administered during their class time. **Students do not have to take extra tests; these are already part of the curriculum.**
- Also, students will participate in a science unit where they will be instructed using the strategies proposed in this study.
- Post-test: After three months students will take the post-tests and they should not take longer than 20 minutes. These tests will be done during school hours.
- Interview. Students will be interviewed about their reading experience at the end of the study during their language arts class.

Risks:

- Anxiety: Students may experience anxiety during tests and interviews because they may feel pressure to do well. In order to help them reduced their anxiety level, the teacher will explain to students that their participation will not affect their scores. However, the teacher will explain that they need to do their best because she is going to use the results to help them and improve instructions. Also, activities of mindfulness will be practice before tests and music will be played during the test to lower their stress level.
- Surveys - Students may feel uncomfortable disclosing their language background. For this reason, students will be informed that they do not have to participate in the research if they don’t want to.

Benefits
There are no direct benefits for your child's participation in this project. Your child’s decision to participate won’t affect how they are graded in this class. However, your child’s participation will help language teachers learn to teach DLI students better.

**Compensation**

There will be no compensation for participation in this project.

**Questions about the Research**

Please direct any further questions about the study to Talia A. Casares at talia.casares@nsanpete.org. You may also contact Cherice Montgomery at 801-422-3465 cherice_montgomery@byu.edu.

Questions about your child's rights as a study participant or to submit comments or complaints about the study should be directed to the IRB Administrator, Brigham Young University, A-285 ASB, Provo, UT 84602. Call (801) 422-1461 or send emails to irb@byu.edu.

You have been given a copy of this consent form to keep.

**Participation**

Participation in this research study is voluntary. You are free to decline to have your child participate in this research study. **You may withdraw your child's participation at any point without affecting your child’s grade.**

Child's Name:  _________________________________________________________________

Parent Name: ___________________  Signature: __________________________  Date: _____
Appendix F

Child Assent (7-14 years old)

What is this research about?

My name is Talia A. Casares. I want to tell you about a research study I am doing. A research study is a special way to find the answers to questions. We are trying to learn more about reading and science learning using technology. You are being asked to join the study because you will be part of my class during this school year, 2020-2021.

If you decide you want to be in this study, this is what will happen.

• You will answer a few questions about the language you speak for about 15 minutes.
• During the second week of classes, you will take three tests to show your teacher what you know about reading and science, each test will take like 15 minutes, and you already do two of them, we will just add one in Spanish for the research. Remember, you do not have to worry about these tests because they will not count for your grades, these are just to help your teacher learn about reading and science. However, it will really help her if you can try your best.
• After you take the tests, you will receive science lessons and reading lessons as you normally do, in this part of the research you teacher will guide you through different activities to help you learn science and improve your reading.
• After you finish your first unit of science you will take other tests to show the things that you have learned. Again, you do not have to worry about your scores, these tests are just to help your teacher, but it will really help her if you can try your best.
• After you do your tests your teacher’s friend will ask you a few questions to know how your experience was learning science and reading.

Can anything bad happen to me?

The activities that we will be doing are safe and you have already done these kinds of activities in other classrooms. However, if you get anxious or stress when taking a test or talking to other people you could feel the same. But do not worry, your teacher will help you feel better by making some changes.

Can anything good happen?

This study will help your teacher learn how the teach DLI students better.

Do I have other choices?

You can choose not to be in this study.
Will anyone know I am in the study?

We won't tell anyone you took part in this study. When we are done with the study, we will write a report about what we learned. We won't use your name in the report.

What happens if I get hurt?

This study will not require any kind of activities that could hurt you. However, if you have an accident during class, we may follow the school procedures, send you to the office and get some help. Also, your parents will be informed about.

What if I do not want to do this?

You don't have to be in this study. It's up to you. If you say yes now, but change your mind later, that's okay too. All you have to do is tell us.

*Before you say yes to be in this study; be sure to ask Talia Casares to tell you more about anything that you don't understand.*

If you want to be in this study, please sign and print your name.

Name (Printed): ____________________________  Signature: _________________________

Date: __________________________
Appendix G

Consent to Use Audio Recording, Video Recording and Photograph of Minor

Reading Fluency Development and Science in a Fourth grade Dual Language Immersion Classroom

Thank you for agreeing to allow your child to participate in the study entitled Reading Fluency Development and Science in a Fourth Grade Dual Language Immersion Classroom that will be conducted by Talia A. Casares and Brigham Young University (collectively “BYU”).

During the study, researchers would like permission to audio record, video record, and photograph your child participating in classroom learning activities in reading and science. These recordings will help us to observe, carefully analyze, and identify patterns in students' participation, motivation, and engagement during their reading and science lessons. Your consent below allows BYU to use these recordings/photographs (“Media”) for purposes associated with the study that are listed below.

Consent

I give my permission for researchers to make audio recordings, video recordings, and photographs of my minor child while participating in the study Reading Fluency Development and Science in a Fourth Grade Dual Language Immersion Classroom during the 2020-2021 school year. I give permission for BYU to use this Media in professional publications, professional conferences or meetings, educational presentations, public presentations to non-scientific groups, and other uses related to the Study so long as my child’s name is not used. I agree that all Media will become the property of BYU, and I waive my right to inspect, approve, or be compensated for BYU’s use of the Media.

By signing below, I certify that I have read this Consent to Use Audio Recording, Video Recording and Photographs and agree to its terms.

Name of Parent/Guardian: ________________________________________________________  
(Please Print)

Signature of Parent/Guardian: _____________________________________________________

Date: ________________________________________________________________________

Name of Participant: __________________  
(Please Print)

Signature of Participant if 7 years of age and older: __________________________________

Date: _______________________