Assessing Bilingual Latino Students Understanding in Acquiring Knowledge and Their Motivation in Learning Science with a Computer-based Simulation

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ABSTRACT

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Latinos are not engaging sufficiently in STEM careers, especially in science. Research studies on bilingual Latino students' (BLS) learning in science suggest that educators' expectations for Latinos to meet or exceed language proficiency and academic achievement standards are low. Data reported from the National Assessment of Educational Progress (NAEP) shows that new instructional methods, extra time, and strategies to pass high stake tests were not adequate to close the Latino achievement gap. Regardless of the persistent body of literature identifying the characteristics of effective schools, the BLS achievement gap continues. Latino school failure has been documented since the 1960s. Reasons for this situation include language and cultural differences; however, research two decades later demonstrated these were not the only unidimensional explanations facing Latino students' educational failure. Instead, the situation is more complex and includes such circumstances as multiple social, political, and educational forces at work in schools.

Nonetheless, research indicates bilingual children have a particular higher process of acquiring knowledge and understanding through their linguistic processing system, which allows for more than just linguistics proficiencies. But, the majority of bilingual Latino achievement gap studies have never been done in Puerto Rico, where bilingual schools are well established. More studies in Puerto Rico could provide a more suitable way to identify if the academic gap is due to

language issues that persist among BLS in U.S. schools. Latinos are not engaging in STEM (science, technology, engineering, and mathematics) careers, especially in science.

The purpose of this exploratory study was to implement a constructivism approach to teach an abstract science concept (i.e., velocity) using an innovative mini-lesson in two languages (Spanish and English) and a computer-based simulation (CBS), which serves as a manipulation in assessing the understanding of science concepts and also an intervention to promote the understanding of the science concept velocity. This exploratory study determines if BLS primary language is a factor in favor of or against learning science and if CBS promotes the motivation to STEM careers. This exploratory process used a constructivism approach to teaching the concept of velocity and questioning knowledge acquisition. Two variations of the CBS learning experience were used: (1) assessment of the process of acquiring knowledge and understanding science with CBS in an interactive mode, and (2) comparison to learning the same velocity concept but with an interactive version of the CBS visual material. A group of twenty bilingual Latino students from seventh and eighth grades at a bilingual school in Puerto Rico was randomly distributed in four groups of five students each. All groups received a brief oral explanation of the concept of velocity before beginning each of the CBS or image of CBS learning experiences. The 20 participants completed a Science Motivation Questionnaire (SMQ) with five motivational factors, which was analyzed using SPSS software to identify how each element related to demographic aspects of the study group. Evidence collected from a ten-question interview and observation notes were analyzed using NVivo12 software.

Findings indicate that Bilingual Latino students (BLS) in Puerto Rico who learned about velocity using the interactive CBS provided a more accurate definition of velocity than those using the image of the CBS, regardless of the language used. BLS preferred English over Spanish for learning science. BLS prefer interactive simulation technology over non-interactive imaging of the visual CBS material to learn science. BLS females in this study are more motivated to go into STEM careers than males. The interview notes collected and SMQ confirmed student understanding of the science concept, their preference to learn science in English, and that a majority chose careers in STEM. The results demonstrate that using computer-based simulations as a learning tool can improve students' positive perceptions about learning science. It has also shown that regardless of the language used with the technology, the BLS in Puerto Rico understands the value of technology in modern life as a supportive tool in science and as a motivator for choosing a STEM career.

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The U. S. Supreme Court acknowledges this issue for non-English students in 1974

Lau v. Nichols case decision as they stated:

> "There is no equality of treatment merely by providing students with the same facilities, textbooks, teachers, and curriculum; for students who do not understand English are effectively foreclosed from any meaningful education…The imposition of a requirement that, before a child can effectively participate in the educational program, he must already have acquired those basic skills is to make a mockery of public education. We know that those who do not understand English are certain to find their classroom experiences wholly incomprehensible and in no way meaningful."
>
> **(Gandara & Contreras, 2009; Nichols, 1974, p. 32)**

Dedication

I want to dedicate this work to my mother, Luz V. Felix- Marrero, who studied her bachelor's degree in Education at a time where few women in Puerto Rico have careers. My dedicated mother, whose love for teaching extends up to 46 years of service, far beyond her retirement age. My inspiring and loving mother, who instilled in me the sentiment of never give up my dreams beyond graduate studies, since my years studying my bachelor's degree in Chemistry and Biology at the University of Puerto Rico. My lovely mother, who raised me with strong moral values, independent intellect, and thinking skills.

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Finally, this work is also dedicated to all bilingual Latinos out there who overcome conflict, misconception, and conquer social injustices to fulfill their dreams in life.

"The truth of things is the chief nutriment of superior intellects."

"Learning never exhausts the mind." **LEONARDO DA VINCI**

Chapter I

INTRODUCTION

In my experience as a scientist, Latino professionals are relatively few. Prior research has confirmed this trend of Latinos as an under-represented minority (URM) group in many scientific professions. While working as a substitute teacher for two years in New York City schools, I remember seeing Latino students were surprised when they discovered I was a Latina scientist. They did not realize the incongruity of this situation relative to the evidence of increasing numbers of Hispanics in America. Census demographic projections for 2060 indicate Hispanics will be 30 percent of the population in the United States (Colby & Ortman, 2015). While it is expected that science technology, engineering, and mathematics (STEM) careers will blossom (Bybee, 2013), Latinos make up a tiny percentage of people in STEM careers. Therefore, it is essential to educate Latinos in STEM to allow them to pursue the increasing opportunities in STEM careers.

The Gap in Achievement of Latino Students

Research studies on bilingual Latino students (BLS) science learning suggested that expectations for Latinos to meet or exceed language proficiency and academic achievement standards were low (Rochin & Mello, 2007; Tiendas & Mitchell, 2006). Data reported from the National Assessment of Educational Progress (NAEP) shows that new instructional methods, extra time, and strategies to pass high stake tests were not sufficient to close the Latino achievement gap (Kena et al., 2016). Regardless of the literature on identifying the characteristics of effective schools (August & Hakuta, 1997; Gold, 2006; Montecel & Danini, 2002; Scanlan & Lopez, 2005; Thomas & Collier, 2002), the BLS achievement gap continues. Regardless of new policies, practices, and school reform initiatives, reports continue to show a failure to close the Latino achievement gap (Soifer, 2012). The National Council of Teachers of English (NCTE) stated that besides the implementation of special language programs (i.e., more appropriate assessments, instructional methods, and the preparation of teachers serving English Language Learners), teachers for emergent bilingual students are more likely to be uncertified. Therefore, special language programs, as currently constituted, are not expected to close the Latino achievement gap (Squire, 2008).

This gap in achievement has been attributed to the particular challenges of BLS bilingual status, and insufficient opportunity to embrace American culture and the best affordances of our education system (Schneider, Martinez, & Owes, 2006). Some researchers contradict this negative stereotype of the Latino students. They question the validity of the results of the Regent and SAT exams, and that this may account for the lower scores or evidence of achievement (Mayer, 2008; Piña-Watson, Lopez, Ojeda, & Rodriguez, 2015; Stevenson, 2013).

Research indicated high-stake tests do not always correctly assess students' competencies (Fry, 2003). Standardized tests alone can measure only a few of the essential skills that students can and should learn. Supportive researchers demanded a balanced assessment of Latino achievement, which should include some high-quality standardized testing along with valid classroom assessments (Schneider, 2006).

Latinos and Science Achievement

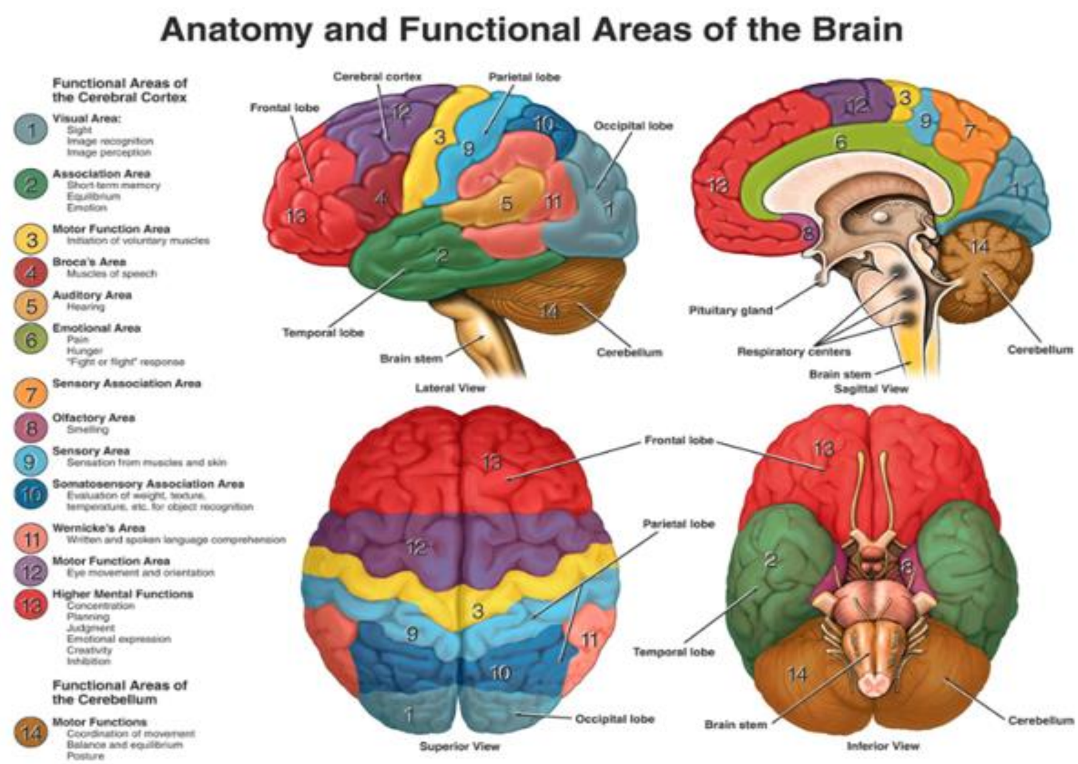
Latinos' culture and language were equally blamed for the difficulty in mastering science (Bryk & Schneider, 2002). Tiendas and Mitchel (2006) indicated BLS' apparent lack of motivation and interest in science is associated with their perceptions of circumstances that lead to failure in the educational system. Since 1960, Latino students in America were classified within a particular cultural group, and often considered inferior, and parents were seen as unable to teach their children on how to function successfully in schools. One study indicated that science ambitions for STEM careers depend on how effectively high competent students achieved in school mathematics and science (Grandy, 1998). In 2000, regardless of the rising number of Latino students enrolled in college, only one of every three Latino students completed the four-year degree (Schnieder, 2006).

The American Council for Education (ACE, 2006a, 2006b, 2007) has reported that as we move more fully into the Information and Communication Technology (ICT) era, there is a limited number of high achieving students in science and technology who could have a secure future career in the scientific and technical workforce. For example, computers have been integrated into the classroom since the 20th century, while expanding information sources via web browsers and streaming videos have also increased, yet competencies required to enter the professions based on these technologies are not fully integrated into pre-college classrooms. However, there are teaching tools for enhancing understanding related to this emerging technology field that can also be used in science classrooms (Dede, 2010).

Advancement in Neuroimaging to Access Functions of the Brain

New neuroimaging tools have identified mental operations and mental functions, making visible images of our brain. For example, the positron emission tomography (PET) helps localize various components of the reading process. The functional magnetic resonance imaging (fMRI) identified areas of the brain where more significant activity occurs in the area for solving mathematical equations. The benefit of PET and fMRI is that it provides a better understanding of brain activities for cognition, like memory, language acquisition, perceptual, motor operations, and all sorts of thinking processes that are so important in promoting learning (McIntosh, 2000).

As shown in Figure 1.1, the frontal lobes (i.e., red color region, and number 13) are where the memory, language, motor functions, and problem-solving skills are happening. Furthermore, conscious or higher-level processing takes place in the cortex (i.e., purple color region and number12).



Credit: Nucleus Medical Art, Inc./Getty Images (Sukel & Image, 2019)

Figure 1.1. Anatomy and Functional Areas in the Brain.

Advocates in favor of neuroscience studies argued it helps the teacher to be more patient and optimistic in understanding students with limited learning capacities. However, critics of this approach claimed ethical issues must be acknowledged because too in-depth application of medical evidence related to neurocognitive functions related to a student’s medical conditions could prompt ethical and legal vulnerabilities, because teachers have the minimal scientific training to understand the difference between cognition, and possible medically-based neuroscience issues students are facing (Dubinsky, Roehrig, & Sashank, 2013). Even when the debate on neuroscience continued, the reality is that new research is needed to understand student learning (Martha, Farah, Hutchinson, Phelps, & Wagner, 2014; Hook, 2013). Published research in science education has applied neurocognitive theory to the teaching and learning of science, mainly at the pre-college level. Some of this research has been summarized in a review by Anderson (2009) and Anderson and Contino (2013), including studies on the role of the cerebral cortex in scientific reasoning and problem solving (e.g., Lawson, 1986; Kwon & Lawson, 2000) and mobilization of prior knowledge and its application to science learning and thinking (Anderson, 1991, 2009, 2011).

Latinos Higher Process of Acquiring Knowledge and Understanding Skills in Bilingualism

A primary concern among researchers and educators is finding a way to identify if BLS is applying understanding during learning science and if these skills are necessary to overcome the achievement gap. If critics claimed BLS is behind in academic achievement, but the opposition blamed the college admission test for lacking adequate assessment of learning and understanding to measure real knowledge acquisition (Sternberg, 1999), then we have to validate the recent findings of differences in learning by bilingual children. These findings may entail an analysis of how they are using higher-level cognitive skills during switching languages. Some recent results provide hope about BLS and their successful learning, and a review of them is presented below.

The previous findings of bilingual children raised the question of the adequacy of measuring intelligence or college success of BLS by using formal assessments. Opponents of the college admission tests for addressing intelligence indicated that society weighs heavily on theory and tests that are inadequate to measure successful intelligence (Sternberg, Grigorenko, Ferrari, & Clinkenbeard, 1999). Sternberg (2004), who notably agreed with Vigotsky (1978), suggested that when assessing children, there is merit in using guided instructions in the assessment instruments as long as the instructions incorporate cultural factors. Sternberg's extensive research confirms that children from other countries (not used to Western-style tests) fail to improve scores from pre-test to post-test because these tests too often lacked a correlation with other cognitive measures such as memory, analytical thinking, creativity, and practical achievement.

Half of all BLS in United States schools are estimated to come from homes where Spanish is the primary language, and in their classrooms, where English is the primary language; and this makes the curriculum challenging (Gandara & Contreras, 2009). In 1970 cognitive research was conducted to assess if Latinos' poor school performance is due to some cognitive deficit (Killian, 1971). This research claimed cultural deprivation affected cognitive abilities and communication skills of first-grade, Spanish-American mono- and bi-lingual children. It also identified a bilingual deficiency in understanding sentences and pictures in English but found that bilingualism did not help Spanish-American students achieve better arithmetic scores compared to arithmetic scores for Anglo American children. Killian stated the possible reasons for low school achievement are probably more related to issues of motivation and encouragement factors.

A more recent study demonstrated BLS switches from Spanish to the English language in conversation during science activities (Reyes, 2009). Research on bilinguals has pointed to cognitive benefits of bilingualism across several types of task situations in specific knowledge structures because two languages facilitate the construction of certain kinds of governing structures (task and control) and therefore guide the performance of particular tasks (Diaz, 1983).

Diaz addressed if there is a complicated systematic difference in the type of bilingualism (i.e., simultaneous and successive acquisitions) of second languages. He found there is a difference in the kind of task's performance and its required competencies, since tasks are contextualized (i.e., conversational) or decontextualized (i.e., schooling).

Technology as a Tool for Education

There is a lack of highly skilled computational scientists and engineers (Benioff & Edwards, 2005). Digital games hold a potential impact to enhance society as a learning tool but are increasingly emerging as a communication tool for individuals of different cultures. Many digital games are mobile gaming tools. However, they also can be used to simulate human neural networks during cognition; or for example, as an intervention in the development of an interconnected ecosystem. Game playing can support knowledge acquisition that enhances general life skills, creativity, planning, and collaboration (Durlach et al., 2000).

Simulations, on the other hand, are considered serious games. Serious games are more high-performance computing tools that provide a play context beyond game-play context and cultural interpretation. Serious games have different intents depending on whether they entail explicit or implicit purposes (Clark, 1970). STEM educational programs, educators, and researchers have explored applications of technology for assessment, cognitive science, educational technology, and some development of serious educational games.

Recent studies confirmed the positive impact of technology in education (Susi, Johannesson, & Backlund, 2007), and research findings successfully have developed computer games and simulations that develop analytical, spatial, strategic skills and insight. Moreover, they may help in various stages of learning, developing recollection capacities, developing psychomotor skills, and visual selective attention skills. But even with technology in the classroom, some Latino students are not positively engaged with or motivated to pursue science careers. Why are Latino students not enrolled in science or engineering careers, when they are considered the "largest minority" group based on census data (Burke, Williams, & Skinner, 2007)? This pressing educational and societal problem challenges us to explore the fundamental question: "What are the reasons?"

The Purpose of this Study

The literature about Latinos' low STEM achievement indicates that low family income and some aspects of their culture and language contribute to barriers for their success (Guardado, 2008). The same concern is believed to add to the negative expectations of Latinos living in locations outside the contiguous U. S. or beyond the metropolitan New York City region (Rua & Whalen, 2016).

When searching for research about Latinos outside of New York City, no studies were found about STEM education of bilingual Latino students living in the U. S. territories located outside the 48 contiguous states. For example, Puerto Rico is a territory of the United States, its primary language is Spanish, and students learn English as a second language from K-12. Evidence suggests students in Puerto Rico did not fit the generalization described in most of the research done with Latino students in the United States. The students in Puerto Rico are not subjected to being identified as "left behind" for the same reasons (i.e., lack of embracing the American culture and language read at home) as in the U. S. educational systems that categorized Latino as low in academic achievement. There are studies of Puerto Rican children attending U. S. schools, where their primary language has been blamed for interfering in Latino motivation to study science (Nieto, 1967, 2000, 2002).

Therefore, in a location like Puerto Rico (where the population is within a low-income status identified by the US Census) where Spanish is the primary language, and there are bilingual education schools; this may have particular challenges. The students may have family and culture that is different from Latinos living in the U. S., especially in New York City. Therefore, Puerto Rico is an excellent setting for research that addresses issues of bilingual education in what may be called an 'authentic cultural milieu.' This is mainly the reason Peurto Rico was chosen as the locale for participants in this study on BLS science learning.

The purpose of this exploratory study was to implement a constructivism approach to teach an abstract science concept (i.e., velocity) using an innovative mini-lesson in two languages (Spanish and English) and a computer-based simulation (CBS) that serve as a manipulation in assessing the understanding of the science concept and also an intervention to promote the understanding of the science concept of velocity. This exploratory study determines if BLS primary language is a factor in favor of or against learning science and if CBS promote the motivation to STEM careers.

Research Questions

The research questions for this study are:

1. To what extent do bilingual Latino students (BLS) perceive a computer-based simulation (i.e., PhET MAZE simulation) as a beneficial way to motivate learning of a science concept (i.e., velocity)?
2. How does the primary language (i.e., Spanish) of bilingual Latino students influence their learning and understanding of science with a computer-based simulation?
3. What are bilingual Latino students' perceptions of the way language and technology influence in STEM fields?

This study assessed science learning by BLS, who attended a bilingual school in Puerto Rico and to determine BLS learning and understanding of science during a computer-based simulation (CBS) lesson. The CBS had two forms: one in Spanish and the other in English, and these two forms of the CBS were used to identify how language may be a factor in helping or hindering BLS in learning of an abstract science concept (velocity).

Organizational Review of Chapters

Chapter I is the Introduction, and acknowledges the Latino demographic as one of the largest minority groups in the US, including the problem of their achievement gap, especially in STEM learning and careers. It includes aspects of advancement in learning technology and its potential to explore the unique higher process of acquiring knowledge and understanding the skill of bilingual Latino students, especially when they switch languages. It also addresses how learning technology is incorporated into schools as an educational tool and how it has provided computer-based programs that help the teaching and learning of science.

Chapter II is the Literature Review containing significant topics related to STEM, the role of brain sciences in learning, and the way technology-supported learning (particularly simulations) relates to science education and may enhance learning by BLS. It also contains a discussion of Bilingualism, Constructivism, Metacognition, and Intelligence as frameworks for studies to assess how cognitive and intellectual development of a bilingual student can benefit from learning with educational technology (e,g., PhET MAZE simulation) as science educational tools. It provides examples from published research about cognitive theories that explain the mental learning process of language and its role in the conceptual understanding of science.

Chapter III presents the design of the study, its methodology and research approach, and the target population (their age and school grade), and the instruments used to gather evidence.

Briefly, the research methodology encompasses random assignment of 20 participants into four groups of five participants each to complete the learning tasks using the PhET MAZE simulation. There are four data collection sources. A detailed explanation is described in Appendices B thru H.

Chapter IV presents the Findings, beginning with information about the demographics of all participants, and sequentially addresses the findings based on the three research questions.

Chapter V contains the Discussion and the Implications and Conclusions of the study by addressing each of the three major research questions in the context of essential study themes that emerged from the evidence obtained relative to each research question. The Discussion chapter ends with Implications and Future Studies that can further the work that is presented in this dissertation.

Chapter II

LITERATURE REVIEW

For the science education of bilingual students, the fields of cognition and neuroscience provide substantial information to guide research and classroom applications to achieve more favorable outcomes, especially for bilingual students. Cognitive studies and brain research has identified evidence about which regions of the brain mediate cognitive mechanisms that support learning, and thus may help teachers to design lessons and tasks that promote a high quality of thinking skills (McGuinness, 1999). This part of the theoretical perspectives is addressed in this chapter.

STEM Education

One of the primary focal points of science in STEM education is to promote students' understanding of science concepts, to develop better learning skills in the areas of science knowledge acquisition, to explain what is science and to grasp a better understanding of the practices of science as proposed in the Next Generation of Science Standards (NGSS Lead States, 2013). The human conceptual system includes perception, memory, language, and thought (Barsalou, Simmons, Barbey, & Wilson, 2003). Conceptual processing of knowledge guides perception, categorization, and inferences within the context of knowledge acquisition. Barsalou, as a cognitive science critic, has argued if the definition of a particular concept is a useful scientific construct, then that concept can represent a category with a specific linguistic form (i.e., words, sentences) or can represent properties of categories. Abstraction means that the knowledge of a group has been generalized from our sensory experiences that serve as a context for the idea. Therefore, for a student learning an abstract concept like velocity, the conception of that abstraction (being a central construct in understanding science) will require the representation of a mental construct (schematic) of a category in memory to help the student distinguish the category of velocity from others categories. In other words, the way each BLS defines velocity will vary per individual, because each one associates her/his definition with their prior experiences that occasioned the development of the concept. As Barsalou indicated, as concepts become detached from physical entities, and are more associated with mental events, they become increasingly abstract (Barsalou, 2003). That is, the approach to studying a conceptual processing task is best accomplished by discovering and describing the relevant cognitive mechanisms that occasioned and supported the mental processing. If concepts are a representation of knowledge and knowledge is a central role in cognitive processing activities, then a modular semantic system helps us communicate what we are thinking and what we are experiencing from the world. STEM education includes the understanding of many abstract scientific concepts, as well as those from specific engineering fields (e.g., electrical and chemical engineering). These often demand the application of complex mathematical calculations (i.e., calculus, including the use of derivatives, knowledge of the symbolism representing chemical reactions, and physical calculations for problem-solving equations). Any teacher or educator needs to understand the mental processing that occurs during conceptual teaching and learning to enhance the student's abstract conceptualization process.

Brain Activation in a Conceptual Task

We construct perceptions of the world through information transmitted to our brains by the five senses. The *modality principle system* for external perception is the first to form by encoding in the visual and auditory systems. The introspection process (internal understanding) mediates if we decide to react, or not, to events, commands, or sensations (called semantic memory system). As standard theories of cognition claim, knowledge resides in the semantic memory system, it represents a modal (word-phrase-sentence) system and is recorded in our brain as an amodal symbol. This mental symbol is part of the conceptual knowledge that is constructed and assembled in semantic memory. It is the way the brain mentally codes multiple inputs that are received as words (sound) or pictures (visual images). We categorize those concepts in our semantic memory. Cognition is created when the modal and amodal systems work together. For example, gaining or learning a new vocabulary word is enhanced when we use the word in context. This semantic memory is also the way that content knowledge is embedded in a situation that co-produces expertise and cognition. In simple language, for a science student to understand a science concept, first he/she creates a mental image of that concept, internalizes what it means, then creates a symbol, or set of symbols, that is retained in memory. If properly conceptualized, that concept is available for reconstruction from memory and is aroused as recall; thus, it can be applied in a variety of different ways in future applications.

Technology and Simulations in STEM Education

The primary benefit of computers in the science field was not educational, but technical. Simulations were used in advanced scientific inquiries to detect evidence such as events during plasma fusion, atomic particle phenomena in wakefield accelerator experiments, and astronomy data analysis (Benioff & Edwards, 2005). But, as STEM education incorporates technology in the classroom (and serious games are classified as education rather than entertainment), the incorporation of such educational tools in science learning can also facilitate the use of these tools for research that addresses issues related to the teaching of science (Miller, Chang, Wang, Beier, & Klisch, 2011).

Significant and systematic research has been done in science education using digital media, including online internet resources, to enhance the learning of sciences (e.g., Linn & Hsi, 2000; Linn & Slotta, 2000). A recent volume of the *Journal of Computers in Education* (Volume 2, Issue 3, 2015) was dedicated to recent advances in using digital technology to enhance science learning. Data analysis of the effectiveness of using computer-assisted instruction (CAI) in teaching science has been indicated to be more productive with drill and practice form followed with a tutorial (Bayraktar, 2001).

Simulations are the reenactment of perceptual, motor, and introspective states acquired during our experiences with the world, the body, and the mind (Barsalou, 2008). The way we decide to solve a problem is partially resident in the prefrontal cortex of our brain. We use the analogy of each new experience with prior experiences to help us strategize during problem-solving decisions, and we use imitation when we are learning a new language. These theoretical mechanisms of acquiring knowledge, as proposed by Vygotsky (1978) and Piaget (2003), are a combination of constructivism and cognitive developmental theory. There have been recent studies demonstrating how effective it is to use computer simulations (as compared with traditional methods) in science instruction. It also found that the cognitive load on a student is reduced by using a simulation with an instructional method (Smetana & Bell, 2012). Also, another study of comparison of multimedia use versus traditional instruction on students' achievement concluded that simulation or multimedia used for science learning were significantly higher than studies using regular lessons (Liao, 1998).

As was stated in a book about pedagogical content knowledge (PCK), any idea in education that stimulates thinking is expected to connect the teachers' expertise with the students' learning and development (Gess-Newsome & Lederman, 2001). Gess-Newsome and

Lederman provided an additional rationale for using technology in the classroom; that is as a new educational idea that connects conceptual knowledge and curricular implementation with a more student-centered approach, and less teacher-centered instruction.

Also, emerging conceptualizations in cognition, such as embodied learning, emphasize the use of action to support pedagogical goals. Embodied learning cognitively locates an action concerning abstraction. This type of learning can occur when children are playing games on a computer, especially if the haptic activity and visual processing aspects are coincident with and supportive of, the internal abstract representations. Recent cognitive research has tested the effectiveness of embodied learning in the STEM fields (e.g., Weisberg & Newcombe, 2017).

Consequently, for BLS to demonstrate a conceptual understanding of science (which requires a higher order of thinking skills), they may have to depend more on haptic and visual processing rather than other modalities, such as the auditory sense. That is an internal representation, created by embodied cognition, that may accrue when using educational simulations or serious games. For example, a teacher may incorporate a hands-on experience to teach science by using a computer-based simulation (CBS). A CBS is an embodied cognition tool for learning complex or abstract concepts in science - like gravity or atomic structures. It can be most effective in terms of embedded understanding of these concepts if the psychomotor activities and knowledge concept representations designed in the CBS are consistent in the design of haptic and cognitive functions and concerning the logical coherence of the science content. A recent research study found that haptic simulations (better than the non-haptic simulation- like an image of a simulation) are active modes of transferring knowledge in a learning situation (Hallman, Paley, Han, & Black, 2009).

Understanding complex concepts is a skill needed in science to conduct inquiry-based investigations. A scientist performs inquiry tasks, typically. Educational tools, like serious games, facilitate science learning as they promote active attention; and they provide a platform for practicing science tasks. For example, in some cases, it allows a bilingual student to select the learning language of their choice. The student takes control of their learning, and it provides visual images of abstract science concepts as the student physically interacts with the CBS. Using simulation concepts for teaching bilingual students can help researchers and teachers promote cognitive learning skills, and also to more effectively assess complex inquiry tasks, something not captured with just paper and pencil tests.

Theoretical Framework

Constructivism as a Learning Theory

One model of instruction, which was previously predominant, assumes that knowledge can be transferred from the mind of the teacher to the mind of the student. This model of education was the basis for educational teaching pedagogies. However, newer pedagogies based on the ideas of Piaget in the 1930s, and others, are built on the model of instruction as constructed knowledge, a dynamic process that changes as learning progresses through an active mental representation of experiences that is under greater control by the learner. It was based on the philosophical principle of "constructivism" and became an approach for teaching and learning. Piaget has been credited as being the first scholar using a constructivist paradigm, who explained the mind of the child as a constructed representation that continues to be expanded and refined as a result of life-long constructive processes. These processes included cognitive (i.e., mental) structures that were named "schemas" in what Piaget called a model of intellectual development. In the process of thought and action, these schemas are transferred from the mental to concrete operations (Piaget, 1967, 2003).

Piaget (1967) indicated that the learning process is based on adaptation or equilibration as the child assimilated new knowledge. He said that as the child grows in education, by the process of analogy with sensory experiences of the world, these sensory experiences are triggered by visual and tactile sensory patterns created as reflexes in the physical body. These accumulate as memories in long- or short-term memory systems. But when things do not proceed in the way the child anticipated, based on prior-gained experiences, the child has to accommodate the reflexes to incorporate these newer experiences within the existing assemblage of reflexes

Piaget's novel theorizing also influenced some research significantly in science education, including the teaching of the physical sciences, across all school levels from elementary school (e.g., Karplus, 1974, 1977) to secondary school and college curricula (Chiapetta, 1977).

In 1980, von Glasersfeld, a constructivist philosopher and researcher, questioned how the learner constructs an understanding of what is perceived (i.e., precepts). He advocated that construction is a process in which knowledge is both built and continually tested (Von Glasersfeld, 1981;Watzlawick, 1984). Jerome Bruner, in 1960, another constructivist researcher, supported Glasersfeld's theories and advocated for learning as an active process to construct ideas and concepts based upon the general instructional framework of cognition (Bruner, 1960, 1966, 1973). Bruner implemented these ideas in science programs that emphasized the reasoning processes for language learning in young children.

Bruner (1960) agreed with Glasersfeld (1981) and Piaget (1967) that a child's mental work is mostly on establishing the relationships between experience and action; and that the child learned to manipulate his/her symbolic world (i.e., concepts) to solve problems in concrete operation stages when the child enters in social interactions. Sharing this idea, Vygotsky's theoretical framework known as the Zone of Proximal Development (ZPD) identified the potential for a child to develop cognition on their own, or by way of a more mature, guiding individual, who enhanced the child's developmental passage through the ZPD (Vygotsky, 1978).

One of the most influential constructivist researchers for this study (Rieber, 1987) further developed ideas based on Vygotsky's research by identifying the problems that are constrained in learning and challenges posed by developmental issues. His work promoted the preponderance of research literature into the new emerging Theory of Cognition. Overall, constructivism is based on the work of Vygotsky and Piaget; and the subsequent cognitive instructional strategies that promote genuine learning.

Maturation. This aspect of cognitive learning theory indicates that conceptual knowledge depends on states of learning, as Piaget and Vygotsky pointed as being part of a child's learning development process. In other words, theoretical understanding is innate, original programming that unfolds as we grow up and learn more. This process in learning expands to a mature point when the child acquires the ability to think and solve problems. The accrual of this cognitive achievement allows developing rational thinking skills and no longer requires perceptual processes based on the touching and movement of objects. In this study, the issue of maturation was carefully considered, and all participants were at the same level of maturation, they were at the same age or grade level (all middle school students, ages 12-14).

Knowledge Acquisition Theories, Language and Situated Simulations

As discussed before, the brain receives stimulus information by the visual and auditory modes (modal) and retains those images for later recall (amodal). In the same way, technological advances in new methods of learning, especially computer-generated simulations, facilitate learning through the enhancement of a variety of sensory and cognitive modalities. Sweller (1994) conducted extensive research to confirm the split attention effect and dual processing model (visual-auditive patterns) of working memory to demonstrate learning with computers. His study, and that of others, provides ample evidence of the value of applying cognitive principles to multimedia learning (Moreno & Mayer, 1999). As a child experiences the world through the perception of their senses, their brain captures these experiences across modalities progressing from amodal to modal symbolism (Figure 2.1).

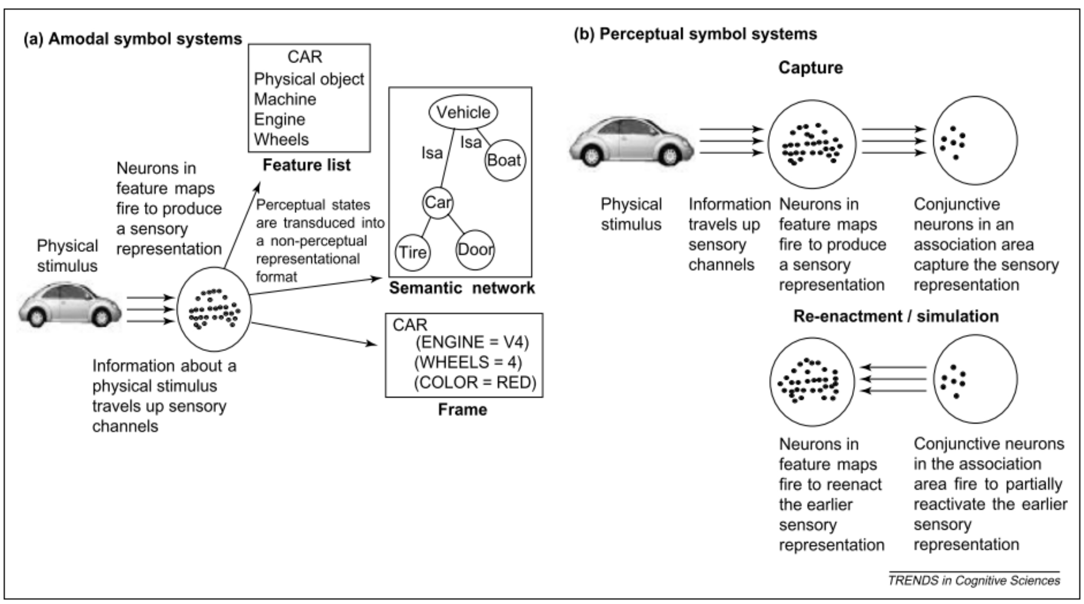


Figure 2.1. Diagram of Trends of amodal and perceptual symbols system. In amodal symbol systems, neural representations are established initially to represent objects in vision. Subsequently, however, these neural representations are transduced into another representation language that is amodal, such as feature lit, semantic network, or frame. Once established, these amodal descriptions provide the knowledge used in cognitive processes, such as memory, language, and thought. *TRENDS in Cognitive Sciences* (Vol. 7, No. 2, February 2003, p. 85).

As shown in Figure 2.1, the modal symbolism of language allowed us to represent these perceptions as becoming knowledge as we defined them as concepts (Fodor, 1983). The human conceptual system, as indicated by Barsalou et al. (2003), contains people's knowledge of the world. This conceptual system is a kind of experience that has a central role in several phases of learning, namely, throughout the spectrum of cognition, guiding the construction of perceptions, categorization, and inference processes.

This body of cognition accounts for a form of gained knowledge known as *grounded cognition* (i.e., our body captures/expresses our understanding in a complicated coordinated way with the information processing of the brain). It results in a modal simulation representation that extends even across our cerebral hemispheres (Barsalou, 1999a). Therefore, when properly designed, learning with technology is an embodied form of learning that promotes STEM learning (Weisberg & Newcombe, 2017). In other words, a practical simulation is a reenactment of our physical perceptions of experiences (i.e., visual and auditory) expressed through our motor activities (i.e., physical movement), and our introspective states (i.e., mental reasoning) (Barsalou, 2008). As the brain captured those modalities and integrated them as multimodal representation, it created a mental description of an image. The mind keeps this memory, among other forms of representation, as mental imagery for later recall as needed. Mental imagery is now considered a cognitive mechanism (Kosslyn, 2005), and it is essential when learning abstract concepts like velocity and acceleration as demonstrated in this study. In the same way, a serious game simulation reenacts activities for application of cognitive skills; and in the process, students gain knowledge.

Thus, based on research of the brain mechanisms for conceptual processing, identified as comprehensive functions, these are localized partially within Wernicke's area, and the production functions for vocalized representations are in the Broca's area of the brain (Figure 2.1) There is also additional supportive research evidence that shows how computer-assisted instruction (CAI) improves children's skill in numerical comparison, verbal counting, and a control task (rapid serial naming) (Rasanen, Salminen, Wilson, Aunio, & Dehaene, 2009).

Metacognition

Latinos are recognized as having high cognitive skill development when switching languages; it is a self-trigger mechanism. In Fodor's (1983) definition of which brain functional modules establish conceptualization, he indicated that language is one of those processing modules. He stated listeners have no control over the (initial stages of) processing of the linguistic inputs. But when the question is, "What about processing the inputs of a second language?" That is when Fodor stated that the processing of the first language shares resources as part of the first language processing and produces considerable convergence to what is called a self-trigger mechanism. In other words, when a bilingual person listens to a concept in his/her primary language and verbalizes it as a definition (i.e., translation) using the second language, the internal mechanism of processing the translation is automatic. Fodor claimed speech perception is a modular process, modularity that encapsulates information to be later reconciled into a representational form in thoughts, which are automated or autonomous like modular processing. Depending on the level of bilingual proficiency, we bilinguals can simultaneously translate from one language to another using this self-trigger mechanism.

Convergence between two language skills promotes understanding and together provides higher cognitive capacity for solving cognitive problems that are typically presented as part of school task problem-solving cognitive operations. These school tasks are impervious to the language in which the issues are presented as they are equally solved by the bilingual child (Cummins, 2001). Therefore, Flavel (1979, p. 906) defined metacognition as "knowing ones' cognitive process." Latino students have control of their thoughts, knowledge, and actions, and they are doing it through the higher order of cognition in the form of metacognition. The application of metacognitive theory in this study is used to identify those participants who appear to respond based on reflection and self-awareness – and, thus, correctly define velocity during the interview after completing the two different forms of CBS-based learning experiences.

Bilingualism and Intelligence

Bialystok (2001) argued against the use of formal measures of intelligence with bilingual children because there are a variety of factors that make associating bilingualism with cognitive outcomes very complex. There are a variety of reasons or factors influencing bilingualism and its relation to complex tasks such as school learning. Some of these are immigration, quality of family's education, temporary residence, extended family, social class, education opportunities, expectations, access to support system and opportunities to enrich experiences and home language systems. Each of these factors influences the cognitive and intellectual development of children and obfuscates the fact that a bilingual child has at least partially mastered two languages. Bialystok proposed that instead of assessing intelligence with the psychometric measurement (i.e., IQ test), a bilingual's knowledge should be evaluated using cognitive process indicators under a range of diverse cognitive tasks, including looking for the potential differences between monolingual and bilinguals.

Wechsler Intelligence Scale (WIS)

In the1920's, there were views opposing bilingualism, suggesting it contributes to lower cognitive understanding performance. Saer (1923) reported that Welsh children (i.e., bilingual) scored lower than monolingual children based on the Stanford Binet Intelligence test (Saer, 1923). Binet intelligence testing only emphasized verbal ability (Sullivan, 2014). That Intelligence test classified bilinguals as inferior and having mental confusion. The present IQ test also found bilinguals as inferior to new native-speaking peers (Hakuta, 1986). In 1967, the Wechsler Preschool and Primary Scale of Intelligence provided a broader definition of intelligence.

WIS for children was initially developed in 1936 by Wechsler to estimate general intelligence. A recently updated version of WIS is the WPPSI-IV (i.e., Wechsler Preschool and Primary Scale of Intelligence, Fourth Edition). This test decreased processing speed and word reasoning to incorporate measuring visual engaging and game-like activities. It also includes an ink dauber (i.e., a motor-control marking system) to avoid the old method of children using paper and pencil test marking.

Bialystok (2007) indicated that an inhibitory control process (ICP) in bilingual testing eliminates intrusions during the formal application of languages – that is, the bilingual speaker can selectively inhibit one language, which typically may be dominant while activating the other. ICP in bilingual children duplicates the mental representation of two languages, a process that is not present in monolingual children. This sophisticated ICP shares space in the complex mind and determines learning and cognition. Similarly, Vygotsky's (1978) argument that the role of language is directing thoughts is relevant to explore the functions of ICP. Research by Nelson and Narens (1990) showed a semantic memory organization in young children responsible for their ability to perform more complex cognitive tasks.

BLS who function successfully as dual-language users have the ICP mechanism. There is an additional large number of neurocognitive studies that have provided new evidence that neuroplasticity occurred in the brain during second language learning (Ping, Legault, & Litcofsky, 2014). These findings, supported by structural neuroimaging methods like fMRI, provide evidence showing a growth of gray matter density, relating to other learning and understanding skills, when an individual has developed multiple language abilities.

Chapter III

METHODOLOGY

Research Questions

The research questions for this study, as presented in Chapter I are:

1. To what extent do bilingual Latino students (BLS) perceive a computer-based simulation (i.e., PhET MAZE simulation) as a beneficial way to motivate learning of science concept (i.e., velocity)?
2. How does the primary language (i.e., Spanish) of bilingual Latino students influence their learning and understanding of science with a computer-based simulation?
3. What are bilingual Latino students' perceptions of the way language and technology influence in STEM fields?

Research Design

Mixed-Method Research Design

The research is an exploratory study that used the design of a Mixed method (Creswell, 2015a). In this exploratory study, I used multiple approaches to answering the research questions. Mixed methods research combines qualitative and quantitative research; thus, it requires persuasive and rigorous quantitative and qualitative data collection and analysis. I have four data collection sources for quantitative methods and two data collection methods for qualitative methods. Mixed methods for this study is intended to be persuasive in defining BLS learning science using technology in two different languages (Creswell, 2015a, 2015b).

The mixed methods, qualitative, and quantitative data were collected in the format of a case study. Through this exploratory research (Stakes, 2005), I intend to find if BLS perceive the use of CBS as beneficial to learn science, to identify if Spanish as primary language of Latinos have some effect in learning and understanding science when using CBS, and finally to identify if BLS perception about language and technology has some effects in their choice of STEM fields.

The exploratory study, as outlined in Figure 3.1, is designed to collect data from different sources and to conduct an analysis of the data collected. In this exploratory study, I examined how the concept of velocity in physics is learned by BLS when the participants use two different approaches and how the learning mode is related to interest in STEM careers.

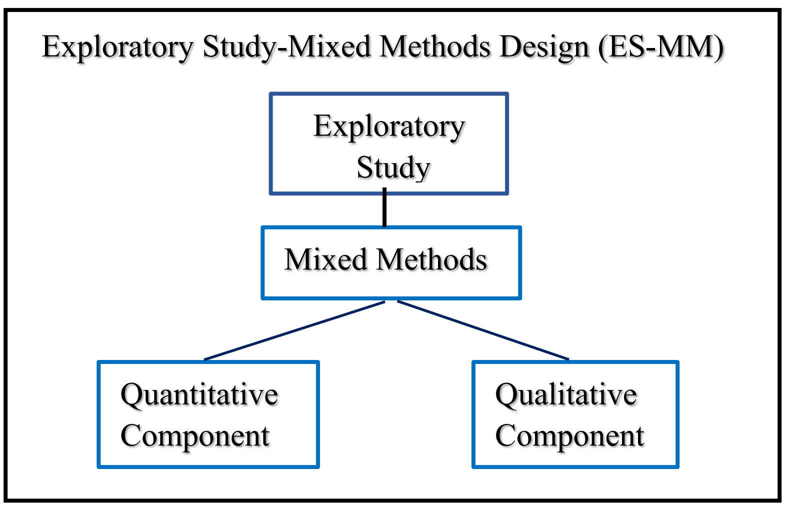


Figure 3.1 The case study mixed-method design.

The study integrates well with mixed methods because the qualitative and quantitative components support each other in answering a research question. For this exploratory study, evidence from both statistical (quantitative part) and narratives (qualitative part) are presented in Appendix A. The results of this exploratory study are then combined as narratives through the integration of qualitative and quantitative forms of evidence. The results are shown in visual graphics or tables by using Qualtrics, Excel, SPPS and NVivo.

In overview, this exploratory study investigates Latino students' learning of a science concept (velocity) with two different teaching tools: (1) an interactive computer-based (CBS) simulation and (2) an image of the CBS interactive visual screen that the participant uses to imagine how they would interact with it if they were running the simulation.

Design of the Exploratory Study

Technology mode	Language mode: Spanish	Language mode: English
Interactive use of PhET MAZE	Group 1 (Five students) Verbal tutorial in Spanish on the concept of velocity while seeing the MAZE screen view, followed by an interactive session using the PhET MAZE with student think-aloud, and subsequent interviews (10 ques.) to gather qualitative evidence. Students complete the EPT and SMQ instruments.	Group 2 (Five students) Verbal tutorial in English on the concept of velocity while seeing the MAZE screen view, followed by an interactive session using the PhET MAZE with student think-aloud, and subsequent interviews (10 ques.) to gather qualitative evidence. Students complete the EPT and SMQ instruments.
Imaginary use of PhET MAZE	Group 3 (Five students) Verbal tutorial in Spanish on the concept of velocity while seeing the MAZE screen view, followed by an imaginary task of running with the ball on the MAZE screen (not interactive), with student think-aloud, and subsequent interviews (10 ques.) to gather qualitative evidence. Students complete the EPT and SMQ instruments.	Group 4 (Five students) Verbal tutorial in English on the concept of velocity while seeing the MAZE screen view, followed by an imaginary task of running with the ball on the MAZE screen (not interactive), with student think-aloud, and subsequent interviews (10 ques.) to gather qualitative evidence. Students complete the EPT and SMQ instruments.

Figure 3.2. Summary of the study design listing the four groups of participants and the arrangement of the treatment variables (Language mode and Technology mode), including the

participant experiences and the corresponding evidence gathered for each of the four groups. EPT is the English proficiency test; SMQ is a Likert-type survey to assess motivation.

Both learning situations incorporate a mini-tutorial lesson about the concept of velocity that is presented before the presentation of the CBS phase, as summarized in Figure 3.2.

As Creswell and Poth (2018) indicate, a mixed-methods case study is a sophisticated design; and as such, it should be conducted systematically and thoughtfully to yield a complete understanding of what the BLS is expressing, including what they are thinking. The latter includes their perceptions of potential interest in STEM careers, their reflections about using technology to learn science, and how they feel their primary language hinders or enhances their learning of science (Creswell & Poth, 2018).

A constructivist lesson in science using technology (CBS) was used in this exploratory study. CBS focuses more on conceptual understanding and provides promising evidence that through the use of CBS students can advance in their conceptual understanding of science (Machery, 2016). Evidence of science knowledge acquisition (in assessing CBS understanding) was done in three ways; through the student participating in a CBS, or using the Image of CBS, and by asking through an interview all after the teaching with a mini-tutorial lesson on the concept of velocity. One learning process about velocity was by listening to a mini-tutorial lesson at the beginning; a second learning process was by participating in three tasks of haptic manipulation with a CBS, a third learning process was by narrating a strategy of the best method to do the simulation using the image of CBS. The simulation was a manipulation process to learn velocity and was also a teaching intervention to assess the BLS understanding of the concept Velocity.

The interview asking for a definition of velocity, was an assessment of BLS learning of the definition of velocity during the three learning processes described above (the mini-tutorial lesson, the haptic manipulation of CBS, and the description of the best strategy to tackle the maze using only the image of CBS). The interview protocol also addresses if CBS encourages motivation to learn science and facilitates the construction of knowledge in science for BLS. Part of the evidence gathered is to determine if their actions and descriptions fit within the learning theory of maturation.

Field Setting

The simulation study was conducted during the spring 2019 school term in a bilingual school in Puerto Rico with a large number of bilingual Latino students. The bilingual school is located in the township of Bayamon, Puerto Rico. The selected school is situated in the middle to a poor neighborhood, but the school serves mainly a low-income community. Before starting the study, I obtained approval from the Puerto Rico Department of Education (PRDOE) after getting TC IRB approval.

The Participants and Procedures

The PRDOE provided the bilingual school, and I met the school principal who distributed the consent letter to obtain volunteers from parents and students in the seventh and eighth grades. The signed letters of consent were provided to the investigator the following day, and I scheduled each participant for a date and time to individually present the study experiences and collect evidence. Depending on daily attendance, some students were absent on the day called for participation, and they were scheduled for a subsequent day. There were 20 BLS for the study, and they ranged in age from 12 to 14 years. More details about the participants are presented in Chapter IV, where the results of the participants' demographics are reported.

The 20 students were randomly distributed into four groups of five students each. *Group 1* was five students who were presented a Spanish mini-lesson on velocity before actively playing the Spanish version of the MAZE-CBS. *Group 2* was five students who were offered an English mini-lesson on velocity before performing the English version of the MAZE-CBS. *Group 3* was five students taking a Spanish version of the mini-lesson on velocity before engaging interactively with the Spanish version of the MAZE CBS. *Group 4* was five students who received an English translation of the mini-lesson on velocity, and only imagined how they would interact with the visual image of the English version of the MAZE-CBS. Refer to Figure 3.2 for details.

The teaching of the science concept of velocity was conducted in a room assigned by the school principal, and a school representative brought each student from their classroom into the designated study room. The study was set so that four groups of students who were randomly assigned were also randomly called to the designated place to ensure against sequential or situational biases. Each participant was assigned an identification (ID) number that was linked to their last name. During the research analysis, a given student's ID number has also appointed a pseudonym to protect the identity of each participant, and provide a convenient way to refer to each participant by an alias when reporting or discussing the Results. Each student took an hour as scheduled to complete the treatment and data gathering.

Data Collection Methods

The data collection was completed in two weeks, five days per week. In a case study methodology, details of the in-depth data collection process are presented, where several sources of information are collected. There were three data collection methods for quantitative research evidence. They are an English Proficiency Test (EPT), a Science Motivational Questionnaire (SMQ), and the Velocity time scoring for the participants who were active interactants with the

PhET MAZE. There were two sources of qualitative evidence (i.e., a Recording of an interview and Observational Notes while the participants were engaged with the MAZE learning task).

Quantitative Data Collection

All the details on how and when the group data sampling collection was done are in Appendix B). There were 39 steps divided into a six-part process (i.e., Part A to Part F). The process began with explaining to the participants what were the requirements, followed by a description of what each of the participants would be doing for the mini-lesson and the PhET MAZE-related tasks, and ended with Part F, which described the EPT and SMQ data collection. Also, all students were audio recorded during the interview following the MAZE experience phase. Observation notes were hand recorded, English test and science survey, including the transcription documents, were assigned a pseudonym and ID number. The order of evidence collection began with the students using the CBS or imagining of CBS, followed by the audio recorded 10-question interview. The final steps were administration of the EPT and the EMQ. The most time-consuming part of data collection was the EPT and EMQ because the EPT had 50 multiple-choice questions, and the SMQ had 25 Likert-type items.

CBS or imagining running the CBS image. The technology tool was a simulation that required hands-on application to learn the science theme when running in the intended mode of an interactive learning experience. A technology simulation that teaches the concept of velocity, the PhET MAZE simulation, is available in both languages of Spanish and English. This CBS is an instructional game where the student practices science tasks and then resolves science problems but with a visual and manual learning tool. The CBS does not engage the student in oral discussions - like the classroom - so the bilingual Latino student is assigned a language (i.e., Spanish or English) to perform the science tasks as presented on the CBS screen; and to respond to the interview, or give their explanations of strategies they use during interaction (Groups 1 and 2), with the CBS; or would be using if imagining how they would run an image of the simulation (Groups 3 and 4). More details on the CBS is in the Instrument section below.

CBS tasks. Groups 1 and 2 got the mini-tutorial lesson about velocity. Each student completed the hands-on practice to be familiarized with the simulation. The CBS hands-on tasks were a self-learned process when interacting with the simulation. This self-learned process allowed the students to demonstrate the best cognitive tactic as the level of difficulty is increased while trying to minimize the task time. (See Appendix C-1 and Appendix C-2).

Imagining running of CBS tasks using mental imagery. Groups 3 and 4 got the same mini-tutorial lesson about velocity and were asked to explain the best strategy under the three levels of difficulty to tackle the ball and move it to the final destination using a visual image of the CBS (presented on the screen in the language assigned to the group). The image was used to display a hypothetical situation of simulating as the student narrated or pointed on the image, indicating the best strategy to avoid the barrier at each level of difficulty. The image of CBS represents the visual image the teacher used in the regular classroom lesson, where the teacher asked the students to describe what is depicted in the image to provide a solution to a scientific or engineering problem. The image of the CBS requests the BLS to describe a strategy to run the ball through the maze avoiding the ball to hit the walls. The image of the CBS is like a schematic device to indirectly build conceptual knowledge of velocity. The BLS has to correlate actions with the information in the mini-tutorial lesson and describe a solution to run the CBS without any casualty of hitting the walls. (See Appendix D-1 and Appendix D-2). During the practice, observation notes were taken to record the actions and verbalizations of all students.

English Proficiency Test (EPT). The English Proficiency Test (EPT) addressed the level of English grammatical, vocabulary, and reading comprehension that is expected in U.S. school systems to classify Latino students' ability to communicate in English. The purpose of this test was to confirm all Latinos in this exploratory study are bilingual (See Appendix E).

Science Motivational Questionnaire (SMQ). This survey, created by the University of Boston, is available online. The SMQ, based on the concept of motivation to learn, is derived from the Social Cognitive theory that provides a multi-component construct to the definition of the concept of motivation. Because measuring motivation in science is challenging, the questionnaire was developed to represent empirical indicators (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). The survey contained 25 items in Likert-scale format and asked students to rate their responses using five levels of agreement ('Never' to 'Always'). There were five questions per level (see Appendix F-1). The SMQ, which is available in many languages, was given in Spanish or the English version, as shown in Appendix F-2. The reason for using the Spanish version of SMQ was intentional. I wanted to observe students' mental cognitive capacity of transitioning from English to Spanish or vice versa during the written portion of the study. (i.e., English test and Motivational Survey). I noted any advert reaction, or if they smoothly completed the test when presented in a given language (Genesee, Lindholm-Leary, Saunders, & Christian, 2005)**.**

Also, since the SMQ has five components of motivation in the 25 questions, Spanish seems to relax the BLS after responding to 50 questions on an English test. For this study, the results within the five categories of motivation are reviewed against each participant's responses to the ten interview questions. The twenty-five, 5-point Likert scale SMQ questions, were analyzed quantitatively for each student and compared among the five motivational criteria:

Intrinsic motivation, self-assessment, self- determination, career motivation, and grade motivation and the interview responses. The student responses were converted to numerical values; "zero" for "never"; "1" for "rarely," "2" for "sometimes," "3" for "usually' and "4" for "always." The Means and Standard Deviations were computed and used to identify which aspects of the evidence were more outstanding and for which participant, including how the quantitative data relates to the interview coding on the participants' percepts of motivation.

Qualitative Data Collection

Audio recorded interviews. The interviews served two purposes. First, to obtain evidence of their impressions of their experience learning with the two variations of the CBS and secondly, to collect the narratives of the participants' real-life experiences, including what motivates their interest in science. Additionally, all audio recordings of interviews, notes based on observations of their interaction with the CBS, the English test, and the science survey, including the transcription documents, were assigned a pseudonym and given an ID number. At the end of all tasks, the interviews with the students were based on their responses to the ten interview guide questions presented in Spanish (See Appendix G). Some questions identify the respondent's narrative concerning the areas of this exploratory study, i.e., interest or themes identified as central to this study: (1) science, (2) language, (3) motivation, and (4) technology. But as the colloquial interaction developed, more information was voluntarily provided by the BLS addressing what their preferences were in learning science and their perception and understanding of science. The Spanish audio-recorded interviews were translated and transcribed by the researcher who is proficient in Spanish. The sorting of questions was done before transcriptions were uploaded into NVivo12 to code into the four areas of interest and to generate a list of sub-codes based on the way participants responded to the primary ten interview questions.

Observational notes. The observation notes of each student were written at the end of the interview process and after they completed the CBS task or only Image of CBS exercises. To identify each participant's observation record, the note included the age, grade, and pseudonym. It highlighted each participant's unique personality traits like introvert/extrovert, tone of voice, conviction, fears, body behavior, and some physiological characteristics that helped later on to remember their faces and associate each BLS to the descriptive notes. The best time for note-taking was while the participant was completing the EPT and SMQ. Observation notes taken for each participant covered task participation when using the interactive version of CBS or the imaginary run task using the CBS image, and also their disposition while completing the EPT and SMQ. Nonobstructive notes were taken for all four groups. Data collected from nonobstructive observational notes relate to the research theme dimensions (i.e., science, technology, motivation, and language) of all students, including the data from EPT and SMQ in the study. The evidence was statistically analyzed using SPSS statistics software. All the instruments for data collection and analysis are displayed in Appendix I.

The CBS Instrument

The instructional method used in this study is the MAZE simulation from the PhET Project. The PhET project (University of Colorado) is a series of interactive teaching simulations to engage students in learning science through inquiry. The PhET Project has developed over 100 interactive simulations that provide animated, interactive, and game-like environments that enable authentic scientific explorations appropriate to the age level of the learners. They emphasize the connections between real-life phenomena and the underlying science, make the invisible visible (e.g., atoms, molecules, electrons, photons), and include the visual models that experts use to aid their thinking (PhET, 2012). The students engage with the MAZE simulation using a traditional mouse-based interface to perform the tasks of moving a red ball image to the final blue dot ball. However, for this study, the participants used a tablet rather than a computer, and instead of moving a mouse to move the green arrow (i.e., vector), the students touched the screen and engaged in more hands-on control over the vector. The images used to instruct students on the features content depends on the language of the group assigned. As shown in Figure 4.1, per this image simulation, all groups considered the three alternative routes to reach the Finish dot.

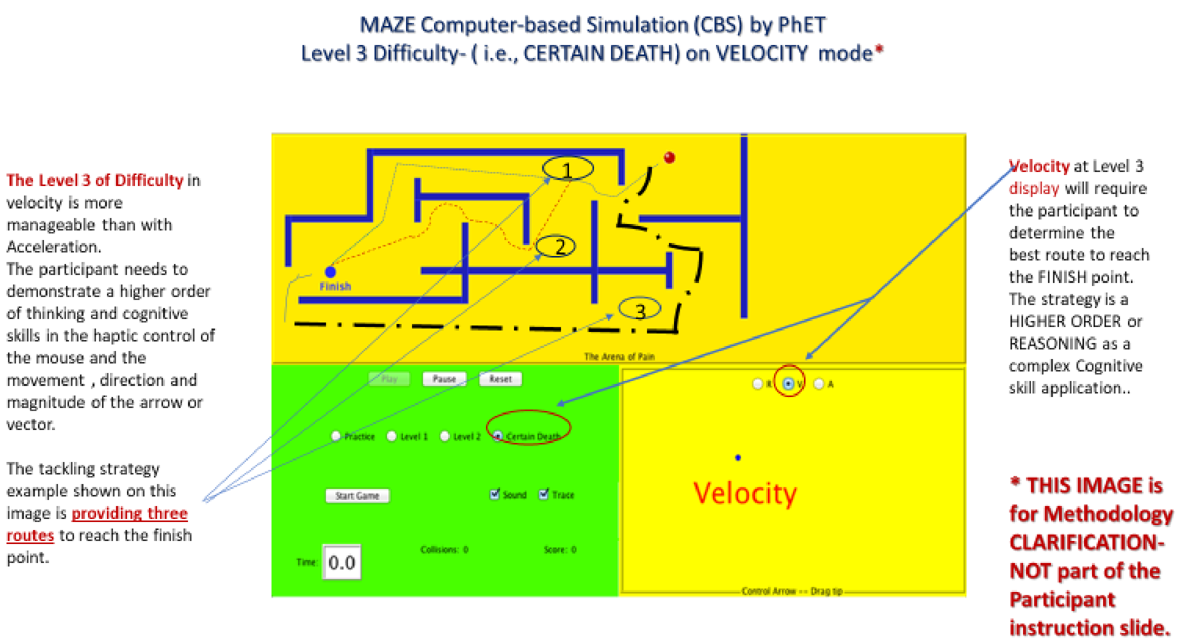


Figure 4.1. MAZE Computer-based Simulation (CBS) by PhET Strategies Route using the red ball in the upper-right sector of the maze ***.**

The technology was provided as a learning tool in two different languages (Spanish and English) and utilized it to analyze students' learning based on the plan shown in Figure 3.2. The

MAZE-CBS is an embodied cognitive teaching and learning tool, because it allows the participant a haptic-embodiment experience (i.e., hand-coordinated, mouse movement) to self-teach an abstract science concept (i.e., velocity). The CBS assesses the understanding of an abstract concept beyond the mini-lesson definition of the concept because participants have to create a mental model on how to extrapolate the action of walking the street (as narrated in the mini-lesson) and associated it to the CBS MAZE (or image of CBS) with running a ball through different maze routes. The MAZE simulation is intended for the discovery of how position and velocity vectors work but mainly was used here to support students' understanding of the fundamental definition of velocity. The simulation through the manipulation of a ball speed connects the definition of velocity through a different real-life condition (like riding a vehicle rather than walking to school).

The science learning of the concept of velocity is provided in two ways. First, a mini-tutorial lesson describes what velocity is, and all BLS listen to the mini-tutorial lesson. Secondly, two groups of the four practice using haptic engagement with CBS as a learning tool while the other two groups used the image of CBS as the learning tool. After completing the CBS exercise, all BLS are asked the definition of velocity. They see the effects on the red ball when the arrow is an extension of the thickness and direction of the arrow (shown as a circle P letter on the game in Appendix D-2). The participant discovers the arrow variations on selected positions, magnitude and direction. The green arrow magnitude and direction variations have different effects when the activity of the velocity it is in just one area of the maze. The participant has to discover what is represented by these variations to decide which is the best tactic to complete the task of getting the red ball to its final destination at different levels of difficulty or barriers.

The hands-on, interactive mode to learn velocity was activated by clicking the button shown as the circled V letter (see a red circle at the lower right side in the yellow panel labeled velocity of Figure 4.1). The PhET creators state the total MAZE game takes from 45 minutes to one hour for completion of the three levels of difficulty on two science concept practices. Mastery of the virtual-simulation is assessed by the reduction in time required at each attempt to complete the tasks, particularly with increasing challenges created by the changing barriers in the maze. These tasks measure the speed of performance in time units. The virtual green-arrow stretches or shrinks in different directions of the simulation and reflect the participant's movement and direction of the mouse. The green-arrow represents a vector (i.e., a measure of magnitude size and orientation).

In the first part of the study, two groups (Groups 1 and 2 the CBS students) practice how to manipulate the computer simulation using their fingers on the screen of a table mode computer (hands-on). The students learn the effects of each feature of the game and learn how to manipulate the magnitude (direction of the green arrow) or set the haptic green arrow in the right direction and position to movements to successfully make the ball reach the final target.

The two virtual buttons (one for velocity practice and the other for acceleration practice) varied the exercises and complexity of the simulation. For this study, only the velocity practice was used. Technology games or simulations typically require persistence in training to gain mastery.

In the second part of the study (Groups 3 and 4; the imaginary use of image-CBS students), the learning of the same velocity content was assessed, but without haptic activities. They were given just a tutorial lesson followed by using only an image of MAZE-CBS while using mental imaging to determine the interpretation of the game features and the possible outcomes and strategies to interpret the concept of velocity. This second set of two groups of students (3 and 4) also received the min-lesson tutoring in English and Spanish, as was presented to Groups 1 and 2, but without the haptic experience; they narrated a strategy (like engineers do to solve problems and like the teacher do when using images to support a class discussion), to navigate the maze without hitting the walls. The tutorial incorporates guiding discussion questions to assess the understanding of the concept.

Data Analysis

Statistical Methods

Quantitative data of the SMQ was analyzed in the first step using NVivo12 to identify major categorical themes. The Likert item statements were loaded into NVivo to sort them into the five motivational factors. When using these factor categories, the respondents' responses to the Likert-type items were analyzed to identify the mean and standard deviation of the 20 BLS' responses per Likert item. This analysis identified for each group of five-questions within each motivational factor, which characterized the respondents' choices.

On the whole, most often, the BLS respondents chose 'agreeable' options. Also, using SPSS computer software, I analyzed the SMQ results (once results were converted into numerical values) and calculated the mean and SD of the Likert items per the motivational theme. Also, this was done to relate the data findings with the three study questions categorized within the four primary themes: science, language, technology, and learning/understanding (i.e., velocity definition). The themes were assigned as principal codes for nodes that were identified during the sorting of the SMQ data, and the Interview fragments, using NVivo quantitative analysis for patterns of responses of BLS. Comparative analyses were obtained based on demographic outcomes (i.e., NVivo12-identified information of gender and age of participant as

"Demographic" data). Triangulation of some findings was used to identify possible overlapping recursive linkages or nodes of data that express a pattern in the behavioral outcomes of those students in both language MAZE simulations (Creswell & Poth, 2018).

Qualitative Methods

The audio-recorded interviews. This data was transferred into NVivo 12, and major themes or codes were identified (i.e., Science, Technology, Language, Learning, and Understanding), and fragments related to the three study questions were displayed (Appendix N). All the Interview questions were sorted into these four themes and then the Nodes were created (Appendix O) and portions of the responses were sorted into the codes (Appendix P).

The Observational notes. The Observational notes were used to create the information in Appendix I, showing how each of the participants was distributed in their corresponding group observations as they related to the four major themes of this study (i.e., Science, Technology, Motivation and Language). The intention was to use this theme evidence for triangulation with the interview responses, which also were sorted using NVivo 12 around the four major themes. Also, the observational notes were used to create Appendix I. This shows the triangulation of the quantitative analysis of the SMQ (i.e., Mean and SD) with the interview responses. It indicated that they were mutually supported.

In summary, the data analysis and presentation of findings (Chapter IV) include charts, diagrams, and figures to facilitate the explanations of the results and to more fully develop answers to the three research questions of this study (Boeije, 2010; Kuckardtz, 2014).

Chapter IV

RESULTS

The purpose of this exploratory study was to implement a constructivism approach to teach an abstract science concept (i.e., velocity) using an innovative mini-lesson in two languages (Spanish and English) and a computer-based simulation (CBS) to serve as a manipulation in assessing the understanding of the science concept, and also an intervention to promote the understanding of the science concept velocity. This exploratory study determines if BLS primary language is a factor in favor of or against Latinos' learning science and if CBS promotes students' motivation to enter STEM careers.

Two variables of language (i.e., bilingualism), and two learning methods (with interactive technology and without the interactive mode of technology) were used. The learning science topic was a physics concept (i.e., velocity). The BLS learned the concept of velocity listening first to a mini-tutorial lesson where the term velocity is narrated with an imaginary aerial view of their neighborhood as they (1) walked a straight line distance from home to school (as the CBS route one in the computer display) and (2) they have to change the path to pick up a friend in another location (as the CBS curved route). The mini-tutorial lesson used a familiar activity that many Latinos who are living in low-income communities experience - walking from home to school. The findings are reported by presenting the study participants' demographics first, followed by a summary of the results for each of the research questions.

Participants Demographics

All students are categorized within the US Census definition of coming from a low-income family. All participants lived in the town of Bayamon in Puerto Rico. A total of 19 students were born in Puerto Rico except for one female from Ecuador. They were all fully bilingual in Spanish and English. Some of the students were more extroverts than others, but they all were willing to complete all tasks assigned. The 20 students were divided up and placed into groups of five participants in each group. All 20 students were given an ID number and a pseudonym. The random distribution of the 20 BLS into groups is displayed in Table 4.1.

Table 4.1

BLS Groups Distribution per Learning Languages with Computer-based Simulation (CBS) or Image of Computer-based Simulation

Number	Pseudonym	Age	Gender	Grade
Group1-Spanish CBS				
PJ-05	Carmen	13	Female	7th
PJ-09	Jessy	12	Female	7th
PJ-11	Jockey	13	Male	8th
PJ-15	Eddie	13	Male	8th
PJ-18	Issa	14	Female	8th
Group 2- English CBS				
PJ-02	Ally	12	Female	7th
PJ-04	Mary	12	Female	7th
PJ-08	Barbie	13	Female	7th
PJ-12	Hero	13	Male	8th
PJ-14	Myra	13	Female	8th
Group 3- Spanish with Image of CBS				
PJ-01	Sherry	13	Female	7th
PJ-10	Jennie	12	Female	7th
PJ-13	Jerry	13	Male	8th
PJ-19	Evah	13	Female	8th
PJ-20	Joey	13	Male	8th
Group 4- English Image of CBS				
PJ-03	Yanny	12	Female	7th
PJ-06	Kally	12	Female	7th
PJ-07	Maria	13	Female	8th
PJ-16	Gladys	14	Female	8th
PJ-17	Elly	14	Female	8th

Findings of Technology Task Performance using CBS and Notes

After sorting the 20 CBS in groups as shown in Table 4.1, Table 4.2 depicts the 10 BLS who participated using the CBS in both languages (see column 3) including Maria, the only participant who was in the English image of CBS group, who was allowed to play with the simulation making the total number of 11 CBS. The importance of this table is to highlight six of the 11 BLS (marked with superscript alphabet letters a to f) who had behavioral patterns of interest during their CBS game playing process.

It can also be observed from Table 4.2 that among 10 BLS in groups 1 & 2 who completed the CBS 3-tasks, five BLS (50%) accomplished their highest-scoring within a 2-5 second range. The best scoring performance (i.e., when the simulation was set at the most challenging task: level 3) was Jockey, an eighth-grade BLS who did not like science.

Maria was the only BLS who tried the most challenging route at level 3. Among the five BLS who succeeded with a lower time score in all three levels, three BLS were from the Spanish simulation and two BLS from the English simulation. Table 4.2 displays the results of the ten students who ran the CBS simulation and their scoring per level of difficulty, including Maria, who was the only CBS from the English - Image of CBS group allowed to play the CBS.

The gender distribution ratio between females to males was 15:5. The grade distribution indicated nine BLS (45%) from seventh grade and 11 BLS (55%) from eighth grade. Age distribution ranged from six BLS (30%) of 12-year olds, eleven BLS (55%) of 13-year olds, and three BLS (15%) of 14-years olds. All BLS males were 13 years old. All of the 12-year old BLS females were in the seventh grade, and only two of the six females were in the eighth grade. This information is displayed in Table 4.1.

Table 4.2

Computer-based Simulation Three Levels Difficulty Scores

Id. No.	Pseudonym	Simulation Language	Level of Difficulty Timing Score in Seconds		
			Level 1	Level 2	Level 3
PJ-05	Carmen	Spanish	4.5	5.5	6.3
PJ-09	Jessy	Spanish	8.0	10.3	10.8
PJ-11	Jockey	Spanish	5.5	4.2	5.3[a]
PJ-15	Eddie	Spanish	4.1	3.4	9.5[b]
PJ-18	Issah	Spanish	4.3	7.1	11.9
PJ-02	Ally	English	2.6	10.0	9.5
PJ-04	Mary	English	6.1	9.4	11.6 (12.5)[c]
PJ-08	Barbie	English	5.6	6.0	8.2
PJ-12	Hero[d]	English	3.6	6.8	7.2
PJ-14	Myra[e]	English	5.2	3.8	7.8
PJ-07	Maria[f]	English	4.7	5.4	9.0

Note The majority of participants score several times, but only chose at random a score. [a]L3-best score. [b]Eddie practices more than 30 times at level 3 until he chooses this final score. [c]This score (12.5) was from taking the most challenging route of the MAZE game, [d]Hero was undecided after many scoring/levels, which scores to select as the best score. [e]Myra tried only once each level of difficulty. [f]Maria was allowed to run CBS after completing the interview when she indicated she was very competitive.

Observational Notes of Highest Score Simulation

Additional Notes taken from the six BLS who got the best scores at the three levels are presented here to identify the way BLS interact with the CBS during scoring participation. For more observational notes, see Appendix I.

Ally PJ-02, Group 2- Best score Level 1 (2.3 seconds). Ally expressed a career interest in the technology field. She stated she liked to play games online. As a participant in Group 2, English simulation, she had no problems getting the best score (i.e., the lowest timing) on level 1 of all participants.

Eddie PJ-15, Group 1- Best Score Level 2 (3.4 seconds). Eddie's best score was at level 2 – running the ball through the tunnel. Eddie at level 3 ran in through the fewer curves route.

(i.e., route one as shown in Figure 4.1). He has some trouble scoring in less time while running level 3. He was very competitive and spent 30 trials before he chose a score of 9.3 seconds as his best score. His playing technique was to run the ball faster, but he was hitting the wall most of the time. He was using one hand for level 1 and 2 scorings, but when level 3 became difficult, he used both hands during time scoring

Jockey PJ-11, Group 1- Best Score Level 3- (5.3 seconds). Jockey has played many games online, and he likes multi-player games. So, for him, it was easy to learn to navigate the CBS and score low numbers on the timing score. He was the only simulation participant who scored the lowest time on the most challenging leve1.

Mary PJ-04, Group 2- She only played each level once and got her best scoring at Level 2 - 3.8 seconds). Mary is just 12 years old, and she expressed herself clearly in English because her grandfather was born and raised in the US and came to live with her family. She engaged in conversation with him.

Myra PJ-14, Group 2- Myra scores 11.6 seconds for level 3, but she volunteered to try the most challenging route at level 3. She also played the most challenging path at Level 3 - scoring 12.5. This is where the maze has two twisted curve areas. The CBS simulation requires some dexterity, typically, to manipulate the ball through the maze display, but Myra was the only participant who wanted to run the most challenging route. Even when Jockey completed level 3 in the shortest time, he did not select the most twisted curve route at level 3.

Maria PJ-07, Group 4-She practiced with the image of CBS. She was allowed to run the simulation, and her scores were good. During the interview, she claimed she was a very competitive person. She was meticulous, playing the simulation in the curve portions. She learned the simulation faster than the rest of the CBS participant groups. She felt frustrated when she could not win in her competitions. She took less time than the other participants doing the EPT. She has a cheerful personality and laughed every time she made a mistake in the simulation practice. She got a better score (9.0 seconds) at level 3 than Eddie (9.5 seconds) in the most curvaceous route (i.e., path two on figure 4.1) of the game. Maria was the only BLS who identified that the curve areas on the game as being narrower than the rest of the maze path. Maria's winning strategy for level 3 difficulty was to run the ball slower through the maze. She learned all the features of the CBS in less time than all BLS using the CBS.

Findings of Learning Velocity Using Image Computer-based Simulation

None of the participants from Group 3 & 4 had the same strategy or explanation on how to run the game using the image of the CBS. They were entirely accurate in predicting a precise outcome of the ball behavior through the different maze difficulties. Only six of the 10 BLS using the image of CBS defined velocity incorrectly as "the 'time' needed to get to a destination." Discussion about hypothetical strategies required using the imagination of an unknown outcome, the same way an engineer may propose a solution for a problem unaware of the outcome.

For this exploratory study, among the BLS using the image of CBS, they imagine a strategy for the ball's movement in the maze game in the same way an engineer tackles a given problem looking for the best solution (or strategy) to resolve it. Only Jennie had experience with a maze competition before, she was 12 years old, and had won 4 out of 5 prize-competitions.

All participants of Group 3 & 4 at the end of their activity were given a visual tour of how the simulation was run to provide all participants the option of knowing the different ways to learn about velocity before the interview process. Nonetheless, for some participants, the exposure did not affect their preference for responding mode of both systems or their choice for classroom image over the computer simulation.

Findings for Definition of Velocity

General Findings

Velocity is defined as the measure of distance covered from one point to the second point of location divided for the time-period, and it is also defined as the speed needed to move from one point to another point. In this exploratory study, the innovative mini-tutorial lesson about teaching a science concept (i.e., velocity) and using innovative technology (CBS) not only was considered an excellent Constructivist method, but BLS also perceived CBS as a motivator tool. They also considered it their preferred choice to learn science.

In this exploratory study, evidence of science knowledge acquisition (in assessing CBS understanding) was done in three ways: through the student participating in a CBS, or using the Image of CBS, and by asking their responses through an interview. All of this occurred after they were taught with a mini-tutorial lesson about the concept of velocity. The evidence confirmed that using CBS was a valid method for teaching science and could serve as a motivating tool for teaching BLS about science. The process of learning about velocity using only an image of CBS was a method to elucidate how BLS understanding of the concept of velocity could be used to explain the best strategy to run the Maze simulation. The simulation was found to be a good manipulation process to learn velocity. Also, CBS served as a successful teaching intervention to help BLS understand the concept of Velocity.

The CBS best time scorings accrued by 11 of 20 BLS using both languages of Spanish and English simulations are presented in Table 4.2. Maria, from the English image of the CBS group, was allowed to participate in the CBS tasks after her completion task using the image of

CBS. The total number of CBS participants increased from 10 to 11 by adding Maria's scoring. Of these 11 BLS best scoring of CBS, five of the 11 (45%) were from the Spanish CBS group and six of 11 (55%) from the English CBS.

The purpose of the interview question asking for a definition of velocity was to obtain an assessment of BLS learning of the definition of velocity during the three learning processes described above (the mini-tutorial lesson, the haptic manipulation of CBS, and the description of the best strategy to tackle the maze using the image of CBS).

The interview protocol also addresses if CBS encourages motivation to learn science and facilitates the construction of knowledge in science for BLS. Part of the evidence gathered was to determine if their actions and descriptions fit within the learning theory of maturation. Similarly, a total of 11 of 20 (55%) BLS were able to explain velocity correctly during the interview process. Looking at Table 4.1, BLS group distribution of CBS that used language and CBS, or only image of CBS, the 11 BLS (listed in Table 4.3) indicated that 7 of 11 (64%) of BLS were from groups 1 and 2 (using the CBS), and four of 11 (36%) BLS were from groups 3 and 4 (using the image of CBS). As for the correct definition of velocity by those who experienced the language version, 8 of 11 (72%) were from the Spanish groups (1 and 3). Only 3 of 11 (27%) were from English groups (2 and 4). Maria, from the English image of the CBS group, was allowed to participate in the CBS tasks after her completion task using the image of CBS, and she also provided a correct definition of velocity (see Table 4.3). As shown in Table 4.3, Maria provided a correct definition of Velocity. But since Maria belongs to the image of CBS group, her correct definition of velocity is one within the four of 11 (image of CBS groups). The remaining nine of 20 BLS who defined velocity incorrectly defined it as a measurement of time that takes to move an object from one point to another.

Table 4.3

CBS Participants with Correct Velocity Definitions, EPT and Simulation Scores

ID. Participant	Grade	Age	EPT Score (%)	Language Spanish or English	Simulation or Image	3 Levels Difficulty (seconds)
PJ-01	7th	13	70	Spanish	Image	Not applicable
PJ-05	7th	13	86	Spanish	Simulation	Level 1 4.0
						Level 2 5.5
						Level 3 6.3
PJ-07*	8th	13	80	English	Image	Not applicable
						Level 1 4.7
						Level 2 5.4
						Level 3 9.0
PJ-08	7th	13	58	English	Simulation	Level 1 5.6
						Level 2 6.0
						Level 3 8.2
PJ-09	7th	12	74	Spanish	Simulation	Level1 8.0
						Level 2 10.3
						Level 3 10.8
PJ-11	8th	13	50	Spanish	Simulation	Level 1 5.5
						Level 2 4.2
						Level 3 5.3
PJ-14	8th	13	90	English	Simulation	Level 1 5.2
						Level 2 3.8
						Level 3 7.9
PJ-15	8th	14	92	Spanish	Simulation	Level 1 4.1
						Level 2 3.4
						Level 3 9.5
PJ-16	8th	14	60	English	Image	Not applicable
PJ-17	8th	14	82	English	Image	Not applicable
PJ-18	8th	13	86	Spanish	Simulation	Level 1 4.3
						Level 2 7.1
						Level 3 11.9

*The only BLS has allowed running both methods-CBS and Imaging CBS

Table 4.3 also incorporates the scoring results of the CBS participants. Sherry (PJ-01) elaborated more on her definition of velocity and referred to the mini-tutorial lesson example to expand her definition of velocity. Only six of 20 (30%) BLS claimed to have no previous lesson on what "velocity" is. The remaining 14 of 20 (70%) BLS had taken a lesson on velocity in fourth and sixth grade or eighth grade. A total of six of 20 (30%) BLS defined velocity as "speed over time," which is the same definition found in an online dictionary.

One BLS associated the definition of velocity with "increases/ decreases" of movement from one place to another. A total of 35% of BLS defined velocity in terms of the "time" needed to move an object or "time" required to move from one point to another.

A total of 3 of 5 (60%) BLS from Group 3 (Spanish Image) was able to define correctly the term velocity and only one BLS from the English image group. However, 7 of 10 (70%) BLS from Group 1 and 2 and 4 of 10 (40%) BLS from groups 3 and 4 defined the definition of velocity correctly.

Findings of Velocity from Interview and Observation Notes

This section incorporates particularities of the 11 participants who got the correct definition of velocity. As part of the triangulation process, the interview was conducted after the interactive simulation or imaginary simulation tasks, and students were asked about their prior knowledge of velocity. Their possible career interests were included in this narrative to identify if all of the BLS who got the definition of velocity correct shared a typical pattern on the science motivation survey items, or if their personalities exemplified unique characteristics that were not shared among themselves; beside the observation that they all properly defined velocity.

Also, because some of the participants (70 %) had prior knowledge about velocity in previous grades, I wanted to identify if that prior knowledge influenced their correct definition of velocity as compared with the description provided during the mini-tutorial lesson. I wanted to know if the previous experience was related to the application of new knowledge in short-term memory (i.e., the mini-tutorial lesson) or long-term memory (i.e., recalling from previous grades knowledge what was defined as velocity).

All participants using the image of CBS were shown the CBS after they completed their image tasks. Otherwise, the interview question about their preference for using technology to learn science could not have rendered a valid assessment of choice. All 11 BLS during the interview indicated they preferred learning science with technology. And they also preferred using technology to learn the topic of velocity over an imaginary use of the CBS.

Sherry PJ-01, Group 3 Spanish with Image of CBS. Sherry stated she had no prior experience learning about velocity. Her definition of velocity was correct. Sherry was the only participant that not only defined the term correctly, but she provided the example presented in the mini-tutorial lesson to make the mathematical definition of velocity. She is a very sporty person who likes to compete a lot. She finds the CBS was similar to her online gaming. She wants to study astronomy.

Carmen PJ-05, Group 1 Spanish CBS. Carmen has no prior experience learning about velocity, but she defined the term correctly. She is Ecuadorian and came to Puerto Rico the previous year. She wanted to be a doctor and considered she needed to be knowledgeable in technology, mathematics, and science to have a career as a doctor. She was one of the five participants with the highest score in the EPT (i.e., 86%) and seemed to be self-assured in her intentions to be a doctor.

Maria PJ-07, Group 4 English Image of CBS. Maria learned about velocity in 6th grade and now was in 8th grade. She was the only BLS to get the opportunity to practice the simulation after she completed the image of the simulation exercises. She learned the simulation faster than the other simulation participants, and her scoring time (i.e., 9.0 seconds) was lower at level 3 than many of the BLS from the simulation groups.

Barbie PJ-8, Group 1 Spanish CBS. Barbie had no previous lesson about velocity. She was an extrovert who used both hands during the exercises and looked closer to the table monitor while doing the three tasks simulation. She speaks English fast, but clearly. She indicated she is very competitive in games. Barbie wants to be a web designer in the field of Technology.

Jessy PJ-09, Group 1 Spanish CBS. Jessy learned about velocity in 6th grade. She is not competitive, and she sat with her head on her left arm on the table when taking the EPT. She played the simulation at a slow pace and was the only BLS with the highest timing scores (i.e., levels 1 through 3 ratings: 8.00, 10.3, and 10.8 seconds) of all participants, meaning she took the longest time to complete the tasks. Jessy wanted to be a veterinarian.

Jockey PJ-11, Group 1 Spanish CBS. He is very hyperactive but very observative. He had learned about velocity in 6th grade. He wanted to be a pilot, and he preferred multi-participant online gaming. He is very social and did not show any nervousness doing any of the tasks assigned, mainly answering the EPT and SMQ. He was the only participant who wanted to do the acceleration portion of the game, but on level 1 difficulty during acceleration practices, he quit the practice once he discovered it demanded a lot of practice to master it.

Myra PJ-14, Group 2 English CBS. Myra indicated she learned about velocity this year in eighth grade. Even when the interview was in English, she defined velocity first in Spanish and then translated it into English, even though when she was assigned to the English language group for the CBS. Myra likes Biology but is not sure which will be her final career choice. She is very competitive to the point that she continued practicing level 3 until she got a lower time score.

Eddie PJ-15, Group 1 Spanish CBS. Eddie indicated he had studied velocity in sixth grade. He is very introverted and tends to shake, nervously his legs up and down. Eddie was the only participant that was humming a song during his EPT. He was also the single participant that was enunciating in silence the English test sentences before he answered, as I was able to read his lips. Eddie wanted to study for a Forensic career and work for the FBI. He had the highest score on the EPT (92%) and got the lowest time score for level 2 (3.4 seconds).

Gladys PJ-16, Group 4 English Image of CBS. Gladys learned about velocity in sixth grade. She shook her pencil during the EPT and swung nervously back and forth her right leg. Gladys confessed she talked with her peers in the science class because she found learning science boring. Gladys preferred war-games because they helped her keep focus. Gladys liked biology because she related biology topics to her daily life.

Elly PJ-17, Group 4 English Image of CBS. Elly said she had no prior experience learning velocity. She was timid and spoke in a low voice. She displayed confidence and no nervousness when taking the EPT and SMQ. Elly wanted to study Zoology. She explained very clearly her best strategy with the image of the simulation.

Issa PJ-18, Group 1 Spanish CBS. Issa indicated she learned about velocity in third, fourth, and sixth grades. She is one of three participants who were 14 years old. Issa's definition of velocity was correct. She wants to be a psychologist. Issa liked mathematics, science, and technology. She scored 86% in the EPT. She took a long time manipulating the ball through the task but got a good score at level 1 (4.3 seconds).

Findings of Languages from the English Proficiency Test and Observation Notes

The English Proficiency Test (EPT) was a multiple-choice test, used in this study to identify the level of English comprehension and English proficiency of all BLS as it was a requirement for this study. In Puerto Rico, all students learned English as a second language; but since this study was conducted in a particular bilingual school, whose enrolment required fully bilingual assessment of English proficiency, it was decided to do the EPT at the end, that is after completion the CBS and Image of CBS tasks and interviews. The EPT was a confirmation tool of the participants' English proficiency level. The EPT covered two sections on grammar, one part on vocabulary and another part on reading comprehension.

The EPT scores of all BLS are displayed in Figure 4.2. The score distribution shows seven BLS scored above 80 %, and seven BLS scored between 70-78 %, and only six BLS had scores below 60% score. A total of two females, seventh-graders, scored 80% and 86%. A total of five (two males and three females) of eighth-graders scored within 86%-92%.

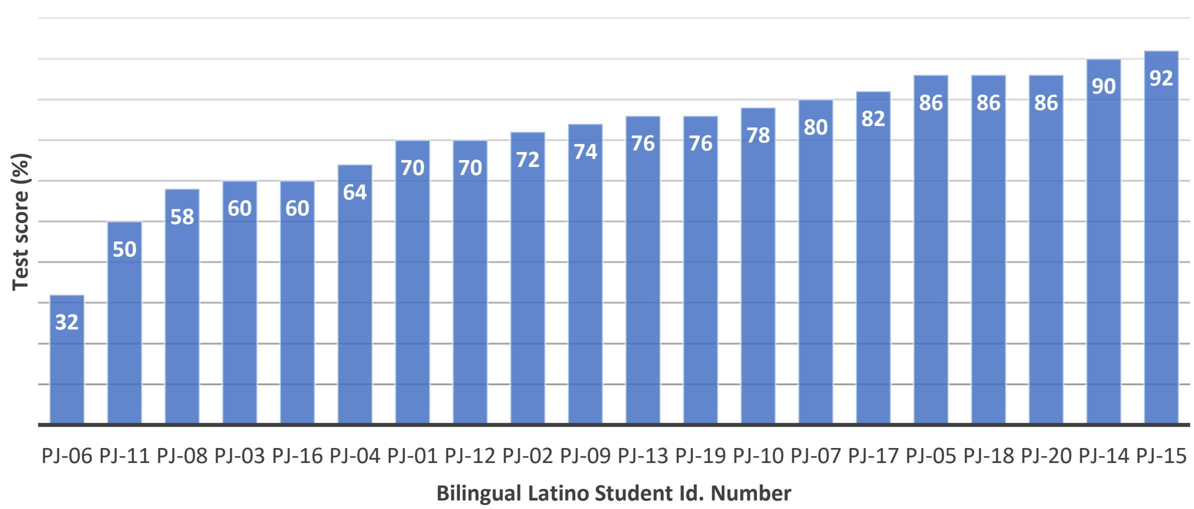


Figure 4.2. English Proficiency Test (EPT) Scores.

The highest scoring EPT participants were seven BLS (i.e., scores ≥ 80%), and the distribution by groups was: two BLS from Group 1, two BLS from Group 2, one BLS from Group 3, and two BLS from Group 4. The purpose of reporting only those higher scorers was to identify if during triangulation with the other data collection tasks (i.e., motivation expression during the interview, CBS and Image CBS outcomes and STEM careers interest) there was a constant factor singular to all higher achievers. Were the same BLS participants scoring high in all tasks of the study? What commonalities did they share? Observational notes for these seven most top test scoring students (with their EPT score in parentheses) are presented in descending order of scoring achievement:

Eddie PJ-15 (92%), Group 1. Eddie's EPT score was the best of all participants. Eddie is a youngster who tends to hum during testing and tends to read while silently enunciating the sentences mentally. Eddie is 13 years old and is in eighth grade. He unconsciously tends to shake his legs up and down.

Myra PJ-14 (90%), Group 2. Myra was not as affluent in speaking English, but she switched simultaneously from Spanish to English during the interview to explain her definition of velocity. Myra is 13 years old and is in eighth grade. Myra took her EPT, reclining her head on the table, and took the longest time to complete it. She claimed she is very competitive.

Carmen PJ-05 (86%), Group 1. She was the only BLS that is not Puerto Rican. She studied all her classes in Ecuador in English from first to sixth grade, when her family moved to Puerto Rico. Carmen is in seventh grade and 13 years old. Since her simulation and interview was in Spanish, the EPT was the only data confirming she can understand English.

Issa PJ -18 (86%), Group 1. Issa studied first and second grade in a bilingual school. She was 14 years old and in eighth grade. She only used one hand (her right hand) to start the timer and move the vector, not like the majority of CBS players, who used the left hand to start the timer while moving the vector with the right hand. Nonetheless, her CBS time scoring for all three levels were similar to other CBS participants

Joey PJ-20 (86%), Group 3. His EPT was within the top 25 % of the participants. Joey did not like math in science and wanted to study business. He understands the simulation game correctly using the image of the simulation and explained correctly his strategy of running the ball slowly through the curves to avoid the collision. Joey is 13 years old and is in eighth grade.

Elly PJ-17 (82 %), Group 4. Elly is shy and talked in a low tone voice, but she was very confirmed about her interest in studying Zoology. She liked animals. She prefers to learn science in English, and she confessed she did not like physics because of the math. Elly is 14 years old and is in eighth grade.

Maria PJ-07 (80%), Group 4. Maria clearly explained in English her strategy to play the simulation using the image of the simulation. When allowed to demonstrate it using the real simulation, she completed the three levels using the same strategy she explained during the image simulation exercise. Maria is 13 years old and she is in eighth grade.

Jockey PJ-11 (50%), Group 1. Even when his English test score was the second-lowest of all participants, he was the best narrator on details of the online games he played at home. Jockey was taking special education classes to facilitate his learning; perhaps he has a mild attention deficit disorder (ADD). For example, I observed that while completing the EPT, he checked all the test pages' content before he began answering them. In the middle of taking the English test, he stopped to engage in a conversation with one sports teacher who passed through our testing room on her way to meet with the school principal. Jockey also was the only participant curious about running the acceleration tasks. He questioned why he could not do the acceleration portion after completing the velocity simulation. I provided him the opportunity to run it, and once he started running level 1, he discovered that the acceleration exercise required a strategy, and when his full attention became about controlling the ball, he lost interest and decided to stop the practice.

Among all BLS, Jockey shows a curiosity and gaming skills above the rest of the BLS. Jockey was a very hyperactive student, but he was also very observative during the study Jockey was focused during his CBS tasks performance, but he did not follow instructions easily.

Findings of Science Motivation from the Science Motivational Questionnaire

The Science Motivation questionnaire was developed to assess five motivational components: intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation that identify the motivation of students to become science majors. It was intended to promote scientific discovery and scientific literacy to sustain strong undergraduate education in science. To become a scientifically literate citizen, it is necessary to understand complex issues and be able to identify critical scientific questions and being able to make proper decisions. Since this study intended to identify the motivation level of students to engage in possible STEM careers, this questionnaire assessed how they felt about themselves, and their performance in science from career motivation to grade motivation. Motivation is defined in Social Cognitive Theory as “an internal state that arouses, directs and sustains goal-oriented behavior” (Glynn et al., 2011, p.2).

Appendix L through M contains the 20 BLS full survey results, distributed per motivational factor by the Means (M) and Standard Deviations (SD). The questions with smaller SD values represent questions that had more agreeable responses by all BLS. Appendix J distributes the BLS preferences by the question in percentages. Appendix K depicts the factor

Mean graphically and the SD scores generated for each BLS factor (i.e., after summing each factor value for each of the-five questions' score, it was divided by 5 to generate a Mean value) These graphic findings were triangulated with the observational notes taken during the interview process. Confirmation of high SD results related to BLS interview responses in the SMQ. To determine the gender difference in motivation outcomes, Appendix L shows which gender response took the lead (i.e., the highest percentage) in a particular preference on the SMQ questions. Appendix M shows gender distribution preferences on the five motivation components. Findings from the four appendices' are summarized as follow:

Intrinsic motivation. A total of 55% (Total N = 20) of BLS were curious about the discovery in science (Item 17), and 45 % (Total N = 20) enjoy learning science (Item 5). Jockey, Maria, and Issa had relatively low mean values (more negative responses) and larger SDs, which is consistent with their comments expressed in the interview that has expressed no interest in their science classes. For example, Jockey stated that science was "boring" for him. Jockey's scores were: Mean = 1.6; S.D.= 1.14. Maria (Mean = 2.8; S.D. = 1.79) expressed she liked computers a lot, and her science class with computers will help her understand better the science class. Issa described the pH experiment (i.e., about physical properties) she had done a prior year in a science class. Also, Issa could not recall the details of the experiment. It was not about biology, which is her favorite science theme. Still, she was not interested in science. When the scores were reviewed for intrinsic motivation based on gender, boys more than girls think science *is important* (i.e., as a field of study) *and interesting,* and boys were also more curious to know science. Girls more than boys think science is *more meaningful* (i.e., in daily life*) and important* to them.

Career motivation. For the five questions under this category, a total range of scoring was between 40% to 60% (Total N = 20) among the BLS who rated their responses in favor of learning (i.e., Item 7), and understanding (i.e., Item 13), as well as knowing the importance of science into their careers (i.e., Item 10). This is an indication they might rate their learning high but not their understanding of their knowledge of science high enough to select a career in science. A high SD score and a Mean low value of Jockey and Hero matched their expressions of not being interested in science careers. Jockey wanted to be a pilot and Hero wanted to be an electrical engineer. The highest mean values with zero S.D. are from Yanny, who expressed she was fascinated with so many fields of study in science, but especially with biology. The highest SD scores were from Jockey, Hero, Ally, and Barbie, an indication they had higher diversity in their responses to this Likert item. Jockey wanted to be a pilot. Hero wanted to be an electrical engineer. Ally wanted to study technology and Barbie wanted to be a website designer in technology. Jessy wanted to be a veterinarian and liked Zoology. Gladys liked biology because it related to the environment and daily life. Elly wanted a career in zoology. Boys more than girls think science will help them get a job. Girls more than boys think science will give them career advantages and benefits since their careers will involve in science, as well as let then apply problem-solving skills.

Self determination. Most of the questions in this group focus on studying hard, putting effort into learning science, and spending a long-time learning science. If the students felt confident in her knowledge about science, they might learn without problems and would need less time to study, with this indicating they would be less likely to believe they need to put effort into their learning. A total of 10 of 20 BLS agreed they often prepare for test and lab (i.e., Item 16), while 11 of 20 BLS sometimes spent a lot of time in learning science (i.e., Item 11). Only 7 of 20 BLS indicated that only sometimes they use strategies to learn science (i.e., Item 6). This motivation deals with control over their learning, and only one BLS got a low Mean and SD value. Carmen got the highest SD (Mean = 3.0; SD =1.0). She is from Ecuador and wants to be a doctor. Evah had the lowest mean value (Mean = 1.4; SD = 0.55). She was self-confident during her interview, responding right to the point, and defined velocity without hesitation. Boys more than girls thought they put more effort into learning science (i.e., Item 5) and prepare more in science (i.e., Item 16). Girls more than boys said they studied harder to learn science (i.e., Item 22) and spent more time learning science (i.e., Item11) and using strategies to learn science (i.e., Item 6).

Self- Efficacy. This motivation dimension deals with beliefs on science achievements. Only 10 of 20 BLS were often sure they understood science (i.e., Item 21), and only 9 to 11 of 20 BLS were always confident to do well in the science lab and tests (i.e., Item16). Only 8 of 20 BLS believe they can master science knowledge (i.e., Item 15) and understand science (i.e., Item 21). This less than half of BLS scores matched their responses in the interviews that science language, the difficulty of science terminology, and particular problems in learning topics was a challenge for them, as discussed more in-depth in the subsection below on interview findings.

Jockey (Mean = 2.4; SD = 1.34) and Sherry (Mean = 2.6; SD = 1.14) had scores lower on their beliefs about science than other participants. Jockey's score was to be expected because he stated he finds science boring. Sherry was very competitive in sports but did not play games online. She said she would like to work outside, doing forensic investigations for the FBI. But comparatively, Sherry's mean was higher than Eddie's score (Mean = 2.00, SD = 0). Eddie scored the lowest Mean. He also had a zero SD score. For a zero SD value meant all his responses were the same, demonstrating that Eddie seemed to be confident of his scientific achievements. Sherry was an extrovert while Eddie was an introvert. That could be the reason why Sherry's Mean score was higher than Eddie's score. Eddie wanted to work also in the field of Forensics doing lab analysis. They were both 13 years old, but Eddie was in 8th grade. Boys more than girls were more confident that they would do well in science tests (i.e., Item 9) and that they can understand science (i.e., Item 21). Girls more than boys feel confident they can do well in a project (i.e., Item 14) and in mastering science (i.e., Item 15) and believe they can get an "A" in the science class (i.e., Item 8).

Grade motivation. A total of 11 to 12 of 20 BLS agreed they often think about getting a good grade or high score in science tests (i.e., Item 24) as they also consider it is important to get an "A" grade in science (i.e., Item18). This finding also matches the interview responses about science. This grade motivation has tangible results like the letter grades for the science class. The highest S.D. scores were Mary (Mean = 3.20; SD = 1.3), Barbie (Mean = 3.20; SD = 1.3), Hero (Mean = 3.40: SD = 1.34) and Joey (Mean = 3.40; SD = 1.34). Nonetheless, all mean values were high showing that all care about their science grades. Evah had the lowest Mean score. Mary wanted to be an engineer and Barbie wanted a career in computer technology. Joey wanted to be a businessman and Hero wanted to be an electrical engineer. Since none of them wanted a career in science, their responses triangulate with not scoring high in the science class. Boys think more than girls about the grade they will get in science (i.e., Item 20). Boys and girls equally considered getting an "A", (i.e., Item 8) or getting a good grade in science (i.e., Item 4) are important for them. Both always think these things are equally important to them. Boys and girls equally think that getting a good grade in science depends mostly on them. Boys more than girls think that they like to get better grades in science tests (i.e., Item 24).

Findings of Audio Recording Interview

The four major themes and codes generated for the interview responses are displayed in Appendix O, and its content was used to create the coding for interview fragmentation by NVivo as shown in Appendix P, which also depicts the total amounts of fragments that were identified as most supportive to the three questions of this study.

Language. In general, the interview findings indicated the 20 BLS preferred English over Spanish, as the language to learn science. Some of the comments appeal for more use of technology in the classroom as a motivator, as 19 of 20 BLS are online gamers. Four of the BLS said they self-taught themselves how to speak English. Some of the students said they learned English by conversations with siblings or grandparents or by reading or doing online games that required dialogue with a game character. They also learned by participating in multi-participant games. All BLS (except for the Ecuadorian female) was born and raised in Puerto Rico. Three of the BLS had studied in the US before joining the bilingual study school. One participant came from Ecuador two years ago but had all his classes in English since first grade. Others have been in Catholic-bilingual schools at some point in their studies.

Science. As far as learning velocity, some expressed an opinion that the English language was difficult for learning some science themes, like the periodic table in chemistry (Joey). Two BLS (Myra and Gladys) indicated they disliked the hand-writing part in science but will welcome having a computer for written work or to work science problems.

Technology. All the students were in favor of using the simulation over the image to learn science, but a few indicated they preferred both methods to learn the science concept. For example, Eddie was the only BLS who expressed a preference for both ways; but only if he could self- teach himself on how to navigate the simulation first, then have the teacher explain the results. Some BLS indicated they liked the science when there was no mathematics or geometry because they did not like doing mathematical calculations. Others stated they preferred technology over science as their career choice.

Career. For perceptions about STEM careers, 16 of 20 (80%) BLS prefer a career in STEM, nine of 20 (45%) BLS prefer the field of science, three of 20 (15%) of BLS in technology and four of 20 (20%) BLS (3 boys and one girl) liked engineering. Among the science career fields of choice, they mentioned veterinary, medicine, zoology and biology, astronomy, forensics, and genomic research. Two BLS (Jockey and Barbie) indicated science was boring, and one of the two (Barbie) said the conversations in the science class were boring. Those BLS whose career preference was not in science expressed not being motivated to prioritize their science studies. The non-science careers were in business administration and piloting aircraft.

Chapter V

DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

In this chapter, I discuss the significant findings from the research questions of the study and offer implications and next steps for research. Finally, I discuss the limitations and give conclusions of the study. There are three goals intended for this study.

First, to assess if BLS attending a bilingual school in Puerto Rico using CBS for solving science tasks can facilitate their understanding of science concepts using technology as a learning tool. Second, to determine if the language (Spanish/ English) is a factor affecting learning science. The third goal of this study is to examine if CBS, as a learning tool with variation in language, demonstrates bilingual control and cognitive mechanism application during learning science tasks. The research questions for this study are:

1. To what extent do bilingual Latino students (BLS) perceive a computer-based simulation (i.e., PhET-MAZE simulation) as a beneficial way to motivate learning of a science concept (i.e., velocity)?
2. How does the primary language (i.e., Spanish) of bilingual Latino students influence their learning and understanding of science with a computer-based simulation?
3. What are bilingual Latino students' perceptions of the ways language and technology influence their interest in STEM fields?

Discussion of Major Findings

The purpose of this exploratory study was to implement a constructivism approach to teach an abstract science concept (i.e., velocity) using an innovative mini-lesson in two languages (Spanish and English) and a computer-based simulation (CBS) serve as a manipulation in assessing the understanding of a science concept and also an intervention to promote the understanding of the science concept of velocity. This exploratory study was done to determine if BLS primary language is a factor in favor of, or against, learning science, and if CBS can motivate students to enter STEM careers.

The findings from the interview and the outcomes of CBS learning indicate that the students prefer learning science with technology. Even when the 20 BLS were fluent in English and Spanish (i.e., a pre-requisite to be accepted in a bilingual school on the Island of Puerto Rico), the majority preferred to use English to learn science. The finding is consistent with the fact that English is validated and recognized worldwide as the language of science, but also that most of the technology access is in English. Besides, BLS expressions like " technology is everywhere" and "science is like mathematics, everywhere," acknowledge that the transition of the old generation of Puerto Ricans who emigrated without knowledge of America has transitioned to a new generation who value, and are aware of, the importance of the English language in the use of technology but also in learning science (Tong, Lara-Alecio, Irby, & Koch, 2014). Technology not only serves as an information tool for learning science but also, much of the design products of the gaming industry are in English.

Moreover, any child today has access to technology, computers, cell phones, and gaming-consoles at home regardless of income status (Katz & Gonzalez, 2016). With this particular group of BLS, a surprising factor was that the school lacked computers in the classroom, one thing that is mostly available in every US school. Nonetheless, all of BLS in Puerto Rico have computers at home, and they also have access to the internet and to all English program TV channels that are offered in America. This technology access was advantageous to their learning of science in this study and increased their engagement to manipulate the simulation in the study.

Evidence from Bowman et al. (2010), demonstrate that multi-tasking activities such as reading while writing using electronic multimedia indicate it takes a longer time to achieve the same level of performance than the academic task. Therefore, using the mini-tutorial lesson and conducting the simulation tasks rather than engage the BLS in taking a test after the mini-lesson would have taken more time assigned for completion of this exploratory study (Bowman, Levine, Waite, & Gendron, 2010)

English is a universal language that is the primary language of science and technology. Of significant advantage in using English is the widely accessible scientific exchange between countries. It is unavoidable that the use of English in science, and its benefits of having English as a universal form of communication, allowed a wider scope of understanding science for scientific progress (Galperin, 1993). English is now used exclusively as the language of science and has an extraordinary effect on scientific communication. It is well known that 15% of the world population speaks English, and only 5% are native speakers. So, it is not expected that the international community of scientists will discontinue their communications in the English language. Therefore, the attitudes of the participants of this study expressed their embracing of English as the primary language used in the world (Drubin & Kellogg, 2012).

Conducting the Simulation and Learning about Velocity

The participants in the study were mostly female (five males and fifteen females), and the female students were more positive about learning science than the male students. One of the reasons for setting the study with this simulation was to utilize it in two modes (interactive and non-interactive, the latter based on imagining its use) that permitted the researcher to have no direct interaction with the participants while doing the simulation and imaging activities. All, however, received the same mini-lesson describing the scientific meaning of 'velocity' before engaging with the assigned technology task. This technology task simulates some of the modern online games downloaded from the internet on phones and tablets, where the participants self-learn how to navigate the game. In this case, a mini-lesson of the abstract concept of science ‘velocity’ provided some background information about the concept before engaging with the technology interface, and provided additional source of information to complement the technology-based learning, when the students were subsequently interviewed to determine knowledge acquisition and memory recall (Adams, Mayer, MacNamara, Koenig, & Wainess, 2012).

Velocity Definition as a Cognitive Expression

One of the intended outcomes of this study was to teach a science concept. One learning mode that was used to learn about velocity was by listening to a mini-lesson at the beginning; a second learning process was by participating in three tasks of haptic manipulation with a CBS, a third learning process was by narrating a strategy of the best method to do the simulation using the image of CBS. In this exploratory study, evidence of science knowledge acquisition (in assessing CBS understanding) was done in three ways; (1) through the student participating in a CBS or (2) by using the Image of CBS and (3) by responding through an interview; all of these after teaching the students with a mini-tutorial lesson on the concept of velocity. The simulation was a manipulation process to learn velocity and was also a teaching intervention to assess the BLS understanding of the concept Velocity.

The interview question asking the respondent for a definition of velocity, was an assessment of BLS learning of the definition of velocity during the three learning processes described above (the mini-tutorial lesson, the haptic manipulation of CBS, and the description of the best strategy to tackle the maze using the image of CBS).

The interview protocol also addressed if CBS encourages motivation to learn science and facilitates the construction of knowledge in science for BLS. Part of the evidence gathered was based on BLS actions (CBS), and on their verbal descriptions (narratives with the image of CBS). These fit within evidence pertinent to the learning theory of maturation.

In this exploratory study, learning with haptic manipulation was used because the BLS applies the concept of velocity using an interactive simulation as a learning and understanding tool. During the interview, participants were asked to define velocity. A total of 11 of 20 BLS correctly explained the velocity concept; the results indicated that BLS using CBS (8 of 11 shown in Table 4.3) as compared with 4 of 11 using the image of CBS defined velocity correctly, showing CBS is a good tool to learn and understand science. The low outcome of incorrect responses (i.e., 9 of 20 BLS) could be related to the emphasis of the simulation in the timer scoring that occurred in the interactive mode. But if that were the case, the users who imagined how to run the ball, rather than to use the interaction, would have defined the term better; because they could have had more time.

The interpretation of these findings could be related to the difference between learning processes and retention processes (Schmidt & Bjork, 1992). Schmidt and Bjork define learning as the process occurring during the actual practice of a task, while retention is a prominent factor occurring after completing the exercise. Schmidt and Bjork conducted several experiments to test the issues of timing. For example, if one time questioning after a fixed amount of training time and trials with no post-training opportunity to test the retention time could mislead the results. Their experiments provided three experimental variations of verbal tasks versus motor tasks. These three experimental variations were: a variation in task ordered for practice, variation in the nature of feedback for learning, and finally, variation in the tasks to be practiced. They concluded that the condition that yielded optimal performance during task acquisition also produced the most reduced long-term retention. But it was also found that expanding the sequence of intervals before testing led to optimal retention performance. The design of this current study, and the available time allotted to work with the students, posed time constraints. It meant that the participants could not be given longer than a few minutes to engage with the particular form of the PhET MAZE task after they had been given the mini-lesson. Also, because of the short time after the task when the interview was given, it was not possible to do a detailed analysis of potential differences in learning acquisition relative to longer-term retention.

Cognitive Principle of Multimedia Learning

Computers are mostly used in every school in America. As mentioned above, the BLS of this study have no computer access at school, but they have computers at home. This fact provides an excellent prior experiential context to support a likely positive outcome for multimedia learning with simulations such as the one used in this study. Multimedia learning entails information processing that is related to emerging theories about how memory functions. Among these is the dual processing theory of working memory, which includes the auditory working memory and the visual working memory. For this study, the simulation provided the visual working memory, and the researcher narrative of the mini-tutorial lesson about velocity provided the auditory working memory source of information. As Sweller (1992) indicated, each person's working memory has limited capacity. And this is consistent with the cognitive load theory (which also emphasizes the limitations to the amount of information that can be effectively processed). Therefore, if we want to promote meaningful learning using multimedia as a teaching tool, it is of prime importance to include coherent presentations of pictorial and verbal information to be encoded in working memory at the same time. If so, the student is more likely to retain relevant information and be able to store it and organize the information for longer term retention. Prior research findings recommended the simultaneous application of visual (images and verbal information such as words on the screen), and auditory information at the same time, when using simulations or multimedia as a teaching tool (Mayer, 1997).

Also, Bren (2010) stated that the latest cognitive neuroscience theory indicated that representational systems such as perception, action, and affects could also be used to represent categorical knowledge (i.e., the modal system rather than an amodal system in modular semantic memory). In other words, what we see has a visual representation in our brains; what we have heard is recorded as auditory representations in our brains, and what we have experienced during psychomotor responding has a motor representation in our brains (Bren 2010). But, from the perspective of knowing based on memory retention, experiencing short-term memory tasks using verbal learning has more potential for higher recall than just experiencing a visual presentation (Salmon, Rossman, & Dipinto, 2012). This fact provided a logical explanation of why 9 of 20 participants had a problem providing a correct definition of velocity. If the simulation used here included audio or written content, appropriate to clarify the definition of velocity, at the same time that the simulation was running, maybe, more the participants would have defined the velocity concept correctly.

There is also a research paper that distinguished between online embodiment (i.e., situated cognition of specific processes that interact with the environment) and offline embodiment experiences, which are cognitive activities that are decoupled from the real-world environment, forcing the mind to create a mental image. If we assess this exploratory study, the simulation being a situated cognition experience to the CBS participants is associated with the mini-tutorial lesson that associates the definition of velocity with the participant walking home from school, a real-life experience. The image that CBS's participants have to think about themselves when playing the CBS game includes having to make inferences of the real game results if engaged with the CBS. The only particular factor to support those four of 10 CBS who properly defined velocity using the image of the CBS is their prior knowledge of the concept velocity or their prior experience of playing maze games. As indicated by a relevant published paper (Niedenthal et al., 2005, p. 187), online cognition (prior maze gaming) constitutes the knowledge that is later used in offline cognition (image of CBS participation without haptic practice). This effective function, as occurs in bilingual language processing, makes bilingualism a form of linguistic multitasking. This finding was observed when Myra was asked about the definition of velocity in English, and she began to explain the definition in Spanish but immediately switched into English to provide her answer (Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005).

But on the other hand, since 11 of 20 participants provided the correct answer, the conceptual learning process for these participants indicated a possible better modality effect (i.e., verbal explanations synchronized well with their auditory system for short-term retention). However, all this discussion must be informed by the fact that many of these students had studied velocity previously in school. And, it is not possible to determine how much of their recall after the experimental learning experience was due to relearning of prior-gained information, and how much was new learning.

Metacognition and Multitasking Skills and Hyperactive Behavior

The majority of literature on hyperactivity in children focuses on the neural disorder that is expressed by maladaptive levels of inattention in children (Graetz, Sawyer, & Baghurst, 2005). But recent studies have link bilingualism with multitasking. Poarch and Bialystok, findings indicated that by managing attention to avoid interference of the second language, the bilingualism cognitive switching process, is also considered in favor of executing multitasking functions. Therefore, the case of Jockey, who was able to play online with multi-players and narrated better than the other BLS, how he prefers online games to be played, indicated his multi-tasking skills (Poarch, J.& Bialystok, 2015).

To understand multi-tasking in a modern society where kids are instant messaging and interact with computers, we have to refer to the multi-tasking behavior as happening in the frontal cortex called the Broadmann area (see Figure 1.1). Research supports that when people are distracted or multi-tasking, they used different regions of the brain, showing activities in the striatum. The striatum is the area where learning new skills and activities occur in the hippocampus - the region for storing and recalling information (Rosen, 2008). The BLS of this exploratory study, as a new generation of Puerto Ricans, have access to computers at home, and even cell phones were, as they stated, they used them to play games online. Therefore, they are able to learn and do multi-tasking events using their cognitive skills.

Although a study has revealed that gaming improves multi-tasking skills; thus, helping children improve cognitive functions, it also indicated that bilingual and trilingual children performed significantly better than monolingual children in multi-tasking activities. Finally, bilingual children as a lifelong user of two or more languages can be viewed as being in a constant form of multi-tasking. Processing differences between conducting a task and language-switching was observed in this study during the interview process (integration of verbal and the early visual processing of the CBS task) by those CBS users (Nonverbal control). It has been seen in this exploratory study how BLS verbal explanation of the concept velocity (through the interview process), and those BLS using the simulation (as a non-verbal control method- just a haptic method), have successfully learned and understood science regardless of the teaching intervention (CBS or Image of CBS) (e.g., Timmer, Grundy, & Bialystok, 2017).

Furthermore, there is evidence that some individuals display the ability to perform complex multi-tasking without a decrease in performance (Watson & Strayer, 2010). Such was the case of Jockey, who properly defined velocity (see Table 4.3). Jockey's gaming in multi-players environments and his hyperactivity benefits his multiplayer gaming skills. Also, additional research findings have indicated that there should not be a negative stereotyped view of students with hyperactivity in the classroom because many of them are very intelligent. The topic of hyperactivity and multitasking skills are discussed in this study due to the possibly erroneous assumption that some people may make. Namely, that some of the learning issues that Latinos exhibit, or their lack of adequately communicating in English, may lead to a misdiagnosis that they are slow learners or troubled kids in schools. Such an incorrect conclusion may have affected their scholastic achievement, such as the case of Jockey in this study, and possibly contribute to their dislike of science.

Two BLS (Jockey and Gladys) displayed hyperactivity and impulsive behavior, and they have expressed finding science classes as "boring." Both BLS are very competitive individuals. Gladys indicated, "liking war-games to keep herself focused." Jockey was the only BLS that took a less timing scoring in the most challenging task of the simulation, and he was the only BLS that was curious about playing the acceleration part of the CBS. Jockey also indicated he likes to play with multi-players online. On the other side, to those opponents of multitasking, it is found that brain efficiency varies among individuals, and those with multi-tasking skills can achieve a single- focus while switching the attention between stimuli and multitasking. Jockey is one of those examples; he was able to play his multi-participant game regardless of his hyperactive behavior (Rothbart & Posner, 2015) **.**

In contrast to the frequent inaccurate predictive association of these symptoms to learning problems, the students' performance with the interactive simulation (Jockey), and the imaging version of the simulation (Gladys), allowed them to define the velocity concept eventually correctly. Gladys prefers learning science in Spanish due to difficulty in understanding certain concepts in science. Jockey expressed he likes to learn science in both languages. Gladys indicated she tends to talk a lot with peers in science classes and does not pay attention to the teacher. However, she is focused on war games and expressed she is attentive to science classes if the topic is biology.

Velocity learning as a Misconception.

An exploratory study by Rivard and Straw (2000) focused on the role of talking and writing on learning science for effect on the retention of integrated and straightforward knowledge. Rivard and Straw's findings indicated that as separate activities (speaking or writing) did not enhance the retention of science learning as the combination of talking and writing did. Therefore, another possible explanation why 6 of the 10 BLS (using the image of the CBS) who did not define velocity correctly, could have been that their talking about their strategies to run the simulation, without the haptic experience, could not enhance their retention of the velocity concept.

For the 9 of 20 BLS who wrongly defined the velocity concept, this could be discussed as a misconception. Some studies indicate that students hold flawed ideas that interfere with learning when they try to visualize abstract concepts (Smith, diSessa, & Roschelle, 1993). For example, when Issa was explaining one experiment that she did in 7th grade using baking soda as a test reagent for pH in different types of soils, she originally referred to it as a chemistry experiment rather than a measurement of a physical state of the soil. The language of science and what one calls an analysis or what is considered science can be misleading to students and thus, misconceptions occur (Chadwick, Kumaran, Schacter, Spiers, & Hassanis, 2016). Chadwick and team identified that false memories (including learned, or improperly recalled, misinformation) occurred in the temporal pole of the brain, where auditory and verbal information is stored), and can be responsible for the conceptual component of false memories. This misinformation includes false semantic memory. When this semantic representation mechanism of knowledge agreed that an illusory memory which has been extracted from a false memory, it creates confusion in the meaning of phenomenon from the world around us. For example, semantic abstraction representation (i.e., words) memorized for later recall can trigger false rememebring. Such a case can occur when the person had seen another term (which is a semantically related word) but is recalled, although it was not the one learned initially as the abstract word.

Piaget (2003) indicated that children think about the world in a different way than adults. Therefore, whatever misconception the BLS have when defining velocity as a time measurement of distance, it could be related to prior knowledge of what was described as velocity they learned in preceding grades, or how they have experienced velocity daily. The misconception might result due to a continuity of some previous experiential misinterpretation of events, or due to prior knowledge that might have been ignored or underemphasized during the construction of new knowledge. Smith, diSessa, and Roschelle (1993) criticized researchers who overemphasize student's misconceptions in science, and they called it a "constructivism" process that will eventually help the student gain some expertise. However, nothing is likely farther from the truth; since to build expertise as a scientist, the science student needs to construct acceptable representations of scientific knowledge by refining and coherently reorganizing prior learning with new learning (Smith et al., 1993). Smith and his team also indicated that reinterpretation of phenomena, situations and events are within the context of the constructivism of new meaning.

Performance and Learning Based on Interview Evidence

The original intention of this study was to implement a deductive approach to the data collected as a direct response to address the three research questions. However, fortunately, the availability of a suitable cohort of BLS in Puerto Rico, and the open welcome by the bilingual school administration, allowed ample time to collect a large amount of qualitative and quantitative evidence suitable for a more inductive, case study, approach. The sufficient time gave me as the researcher a deeper connection with the students during the interview process. The interview questions became a more inductive interview. Regardless of the language in which the interview was conducted, the disposition of the students to narrate and expand their responses provided additional opportunity to get more details based on their answers and to know what they learned from being participants.

Having no restrictive timing per participant allowed more questioning during the interview. BLS were more open to communicating when the interview was done in a more inquiring mode. BLS were accessible to sharing more when the interview was done colloquially and informally (especially in their native language of Spanish), allowing more of the nervous participants to relax and helping the shy ones to narrate personal information more freely (Engkent-Pietrusiak, 1986). For example, Evah confessed her fear to talk in public; and she also said she understands why kids are teaching many bilingual parents English. Many of the BLS in the study learned English on their own as well as using computers at home, thus gaining skills to expand their knowledge of what they learned in class. The recent expansion of research findings of the learning associated with digital media provides new insights about meta-cognitive skills (i.e., learning on their own). These skills are defined as the optimal control of our learning as a new way of allowing students to take control of their education (Metcalfe & Kornell, 2003).

Many of the BLS in the study learned English on their own as well as through the use of computers at home to expand their knowledge, in preparation for, and as a result of what they learned in class. For a low-income population and parents who mostly speak Spanish at home, the BLS are in a different situation to use accessible digital sources of information to ascertain control over their plans to study STEM careers (Ryan & Deci, 2016). It is all the more likely compared to students in American schools who have not seen their country devastated by the force of a natural disaster as occurred in Puerto Rico and may have motivated these students to explore aspects of this life-changing event through online resources.

Besides, in today's expanding definition of intelligence, it is seen as a more complex system to identify students' varied expressions that provide a broader view of intelligence. The multiple intelligence theory has proposed seven forms of multiple intelligence that range from linguistic, logical-mathematical, spatial, musical, bodily-kinesthetic (like dance and sports) to interpersonal and intrapersonal (useful understanding of oneself) (Gardner, 1983). Multi-media learning systems can be used to tap more effectively into these multiples ways of knowing and representing experience if they are properly designed to build on students' prior experiences and encourage them to expand their reflective analysis of many different forms of expressing these experiences. Within the realm of affective representations, this study has confirmed that language does not impede bilingual Latinos' motivation to learn science and to perceive that they can succeed in their resilient interest in STEM careers. All the BLS in this study described and performed with behaviors that fit in one, or more than one, of these multiple intelligences. Some

BLS claimed to fear to speak in public, others like mathematics and science, some like science but dislike mathematics or geometry or science with equations.

Motivation. More information on motivation is presented; one is enhancing findings from the SMQ analysis, supported by the interview responses, was that the vast majority of the BLS who reported favorably on learning of science with technology and who indicated an interest in studying a career in science or STEM. Even those BLS whose career goals were not toward STEM expressed the importance of having technology in the classroom to learn science. Much research on middle school gender differences indicates that attitudes about science begin to appear in adolescence, where boys are more likely than girls to envision the use of mathematics and science as adults (Oakes, 1990). Also, the studies indicate young women also have a high level of performance anxiety and little confidence in their abilities in science and sometimes attribute their successes to luck rather than effort and skills (Lockheed, Thorpe, Brooks-Gunn, Casserly, & McAloon, 1985). Lockheed et al. (1985) discussed the finding in the difference between performance in science, engineering, and technology among female and males minority students, recommending a different approach to address the disparity in interest, participation and achievement indicating the literature review unfairly depict the lack of opportunities to learn science engineering and technology that these minority students are getting. That could explain some of the SMQ gender results obtained here (see Appendix L - Career Motivation Chart), including why BLS females, regardless of their interview circumstances, were competitive, but their perception of STEM careers was less positive than that of boys.

In a paper by Luther, Luthar, Cicchetti, and Becker (2000), they identified resilience as a dynamic process where a positive adaptation is obtained within the context of significant adversity. Individuals who have been significantly exposed to a threat or severe adversity demonstrated the ability to develop adaptation. In the case of the BLS from Puerto Rico, they did not express any distress or mention any distress caused by the passing of Hurricane Maria, the prior year of this study. All the students (including the Ecuadorian participant), expressed positive attitudes or demonstrated a positive adaptability skill as a resilient skill. It was found during the interviews and the SMQ results, all BLS were highly motivated for STEM and non-STEM careers plan (Luthar, Cicchetti, & Becker, 2000).

Implications and Next Steps

Puerto Rico's historical transition from the perspective of Spaniard governance to that of the United States territory has influenced its culture and language. On the island, the primary language is Spanish; but it is also required that the students assimilate English as a second language (Grosfoguel, 2003). The history of bilingual education in Puerto Rico, as well as in the mainland, has been a struggle of more than 70 years. For example, in NY City, the transitional bilingual education (TBE) programs are entirely different from the bilingual developmental education (DBE) in the Puerto Rican education system. With Puerto Ricans being US citizens, their migration back and forth to the U. S. has benefited family members and children in schools, who speak the language and help each other develop language proficiency. One benefit that the Puerto Rican bilingual students have over the bilingual Latinos in America is that they can engage in English conversations with siblings or grandparents at home. It creates reciprocity in both participants, benefiting, and ensuring the mutual gains of practicing and learning English (Bourdieu, 1993).

Bourget (2015) questions the grasping aspect of some abstract knowledge, for example, someone in a dark room can imagine red tomatoes, but once in the bright room the imagination of that red color concept brings new knowledge into her imagination of the idea of the color; and seeing the color will help her grasp the nature of that color. In the same way, the participants of this exploratory study have never played the MAZE -CBS, and they were grasping by playing the game, the concept of velocity. Would they correlate the definition of velocity in the mini-lesson to the practice of the MAZE game? These are some of the possible future research assessment that can be explored with additional research studies (Bourget, 2015).

Recent devastation on the island in September 2017 by Hurricane Maria, has increased a mass exodus and dispersion of Puerto Ricans throughout the U.S., while the island continued the slow process of recovery. At the time of this study, regardless of this recent crisis, most of the Puerto Rican students showed no traumatic negative effect on their educational achievement goals as they continued their lives. The bilingual school resumed the activities showing no indication of struggles as it kept the regular school daily attendance and work performance.

For science education, evidence of disproportional degree attainments in STEM fields between Latino males and females have been yearly reported by the US Census Bureau (2010), the US National Center for Education and the US Department of Education (Bureau, 2010; US Department of Education, 2012; US National Center for Education Statistics, 2014). The findings of this study show that young BLS are interested in science and science-related fields as careers. More opportunities to excite them, through technology, and to give them more information about pursuing STEM degrees leading toward STEM careers, is crucial if they are going to reach their full potential in the emerging modern societies, globally (Gloria & Kurpius, 1996).

Study Limitations and Future Research

There are several limitations to this study. First, the uneven gender participation limits a fair and robust comparison between genders and the relatively short time of completing the activities in the study design. The second limitation, relating primarily to the affective findings, is the importance of changing attitudes that vary from one moment in time to another. Young people and their career goals and interest in STEM and STEM-related careers could change as they grow older since, in this study, the participants are only 12 to 14 years old. The third limitation is the possible bias of the investigator (myself) who is Puerto Rican and may influence some of the themes and topics used to explore the students' learning and motivation responses. However, this personal knowledge also can be useful in providing more authentic insights into likely dimensions of evidence about the learning and motivation perceptions of the Puerto Rican participants.

For future research, a study might consider more in-depth questioning, regarding science attitudes and interests, for a larger size sample of respondents, including those who are Puerto Rican and other Latinos and ethnic groups. When learning with simulations; also, it would be productive to conduct a longitudinal study to assess this group of participants (especially the Latinas) to see if their motivation regarding science careers continued into high school. Also, conducting a case study on participants such as Jockey and Gladys, to determine how their interests in gaming and science learning may continue to develop as they mature, would be an interesting follow-up, longer-term study.

Conclusions

The research findings of this exploratory study demonstrate that using computer-based simulations as a learning tool can improve students' positive perceptions about learning science. It has also shown that regardless of the language used with the technology, the BLS in Puerto

Rico understands the value of technology in modern life as a supportive tool in science; and also as an inspiration to more seriously decide about studying for or not for, a STEM career. Finally, Spanish is the primary language in Puerto Rico, but the majority of the BLS prefer English to learn science; whereas some have no preference between English and Spanish. Only two of the BLS preferred Spanish for learning science. This finding of the English language preference for learning science was a surprising outcome, especially knowing that the primary language on the island is Spanish. The study was conducted in one of the few Bilingual schools in Puerto Rico, and this finding showed the importance of planning their future educational experiences, which might have been expected because of the participants in the study attending this bilingual school show proficiency in both languages. However, some of the results also showed that these students perceived English to be vital because they recognized it is more likely to be used in communication among scientists than other languages.

One of the goals of this study was to demonstrate how BLS are learning science. The misconception, as found in many published claims, that BLS' language is impeding them from achieving scholastic is a fundamental reason for this investigation to more fairly assess their learning capacity in science and their potential of success in a STEM career. Also opposing scholars [i.e., Bialystok (1993), Barsalou (1999a, 2003, 2008) and Ryan (2016) and Contreras (2011), among others] have provided evidence about this misconception that Latinos lack in academic achievement or motivation. The results of these prior studies supported the findings of this study about assessing Latinos' learning and intelligence skills. Bialystok's (1993, 2001, 2007) research established the beneficial importance of language switching mechanisms of bilingual students as a higher cognitive skill. It has also supported Bilingual Latino's intelligence, and learning skill potential, by being a second language (i.e., English) speaker.

In the majority of American schools with large populations of Latinos, there is limited availability of bilingual teachers (i.e., proficient in Spanish as well as English). Without bilingual teachers, this impedes a realistic assessment of their BLS' intelligence; and hence perpetuates the misconception of Latinos inability to learn. For example, Schneider, Martinez, and Owes (2006) stated that Latino families many times have limited educational resources to engage their children in early literacy activities; thus, hindering the Latino students' academic success. Schneider and his team (Schneider et al., 2006) addressed teacher stereotyping and low expectations for Latino students as a factor in undermining their academic achievement.

The normative of the science classroom practices required students to engage in science discourse (like the discussion of CBS strategies discussion for the BLS groups using only the image of CBS). Engagement in any science and engineering practices demands to construct an explanation for science and designing solutions for engineering. The mini-tutorial lesson in combination with the request to explain the strategies using the image of the CBS can be considered similar to the explanation for science (narrative of how the game is best played) and finding a solution for engineering (i.e., avoiding the ball hitting the walls) (Lee, Quinn, & Valdes, 2013).

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APPENDICES

APPENDIX- A

Research Design Matrix

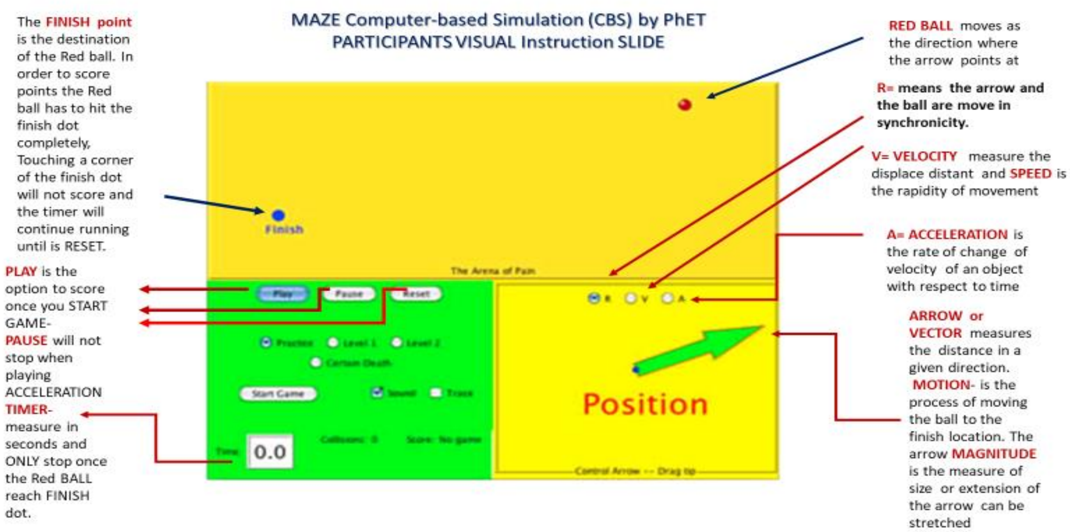
	Data Collection		
Research Questions	Qualitative	Quantitative	Data Analysis
1. To what extent do bilingual Latino students (BLS) perceive computer-based simulation (i.e., PhET MAZE simulation) as a beneficial way to motivate learning of a science concept (i.e., velocity)?	Interview responses to questions 4,5, 6 7, 8 & 9 Observation notes during Image simulation responses and simulation participations	PhET Simulation 3-level scores as they relate to Interview responses.	
2. How does the primary language (i.e., Spanish) of bilingual Latino students influence their learning and understanding of science with a computer-based simulation?	Interview responses to Questions #2,3 and 10 Triangulation between EPT and Interview responses	EPT- 3 levels of proficiency as Grammar I & II Vocabulary Reading Comprehension	EPT Interview response to question #2 Triangulation data of mean and SD, SPT score and Interview responses
3. What are bilingual Latino students' perceptions of the way language and technology influence their interest in STEM fields?	Interview responses to questions 2 & 3, 5,6	Science Motivational Questionnaire (SMQ) Xcel- Mean and SD as they relate to observational notes.	

APPENDIX B

Research Methodology Layout and Qualitative/Quantitative Data Protocols

PART A-General requirements to all participants

1. All 20 students for the study have duly signed consent forms (they have signed and by their parent) before any study data collection activity.
2. All qualified students were given an ID number and a pseudonym- for data grouping purposes and protection of student identity). The students were randomly assigned in each of the four learning modes.
3. All selected students reminded of their right to remove themselves from the study. The parental consent form was distributed and collected two days before the scheduled simulation day.
4. Each student in Groups 1 and 2 for the MAZE language group (i.e., 5 students per group) received a mini introduction lesson on what is Velocity in the language (Spanish or English) as assigned for the MAZE simulation.
5. The laptop with the simulation was provided by the researcher to run the MAZE simulation because the bilingual school in Puerto Rico does not have computers.
6. The interview was conducted in the language group assigned to the student. The researcher translated and transcribed into English those ten interviews conducted in Spanish. As English is the language that the data is analyzed with NVivo and SSPS software, the translation is completed before the interview data is transferred.



7. All students complete the English Proficiency test(EPT) (see APPENDIX E) and a Spanish version of the Science Motivational Questionnaire Part II (SMQ-II) (See APPENDIX F-1 and F-2) at the end of each simulation and image simulation exercise.
8. The EPT and SMQ (English versions) were uploaded into Qualtrics.
9. The EPT and SMQ data were transferred into Xcel, SPSS, and NVivo for quantitative and qualitative analysis

PART B-Group 1 and Group 2- Mini-Tutorial lesson and MAZE Simulation-task instructions

10. Students are scheduled on a day to do the MAZE simulation tasks with their respective mini-tutoring lessons on the language of the group assigned.

11. Students in Group 1 and 2 see the MAZE simulation screen view and are given a mini-tutorial lesson on what is velocity and its related terminology. The narrative mini-tutorial lesson used the same content just in the language of the group assigned (i.e., Group 1- Spanish and Group 2- English) (SEE APPENDIX C-1 and APPENDIX C-2).

12. Group 1 and 2 students completed the MAZE in less than 5 minutes using the hand practice with the MAZE simulation and familiarized themselves with the features of the simulation. Each student notified the investigator once ready to run the simulation with the time meter.

13. All students were interviewed using the same list of 10 questions (see APPENDIX G) at the end of the simulation in the language the simulation assigned. Spanish interview is translated and transcribed by the investigator. All interviews were recorded, transcribed, and translated from Spanish into English for Groups 1 and 3.14. The researcher took notes during the MAZE simulation performance of tasks or the tutoring lesson period. The notes were used for comparison of interview and SMQ data analysis during the triangulation process.

Part C-Group 1 and Group 2-MAZE Performance Tasks -10 minutes

14. TASK1
    a. Each student on Group 1 and 2 starts the simulation activities under the Velocity mode (shown on the image as P button) – to familiarize them with the features on the simulation
    b. Time-clock will be used to count the seconds the performance practice is conducted. Successful scoring is considered when the student reaches the finish area with the ball. The researcher will take timing. Once the ball hit the finish-dot, and the music is played, the score will be recorded.
    c. Student's performance at level 1 for velocity is complete when a student indicates to the investigator, which is their best scoring. Only the best time was scoring records to count the end of the task.
15. TASK2
    a. Each student continues at Velocity mode, at level 2 simulation.
    b. Timing-clock is used to count the second the performance practice is conducted. Successful scoring is considered when the student reaches the finish area with the ball.
    c. Student performance at level 2 for velocity is complete when a student indicates to the investigator, which is their best scoring. Only the best time was scoring records to count the end of the task.

16. TASK 3

a. Each student continues at Velocity mode, at level 3 simulation.
b. Timing-clock is used to count the seconds the Performance practice is conducted. Successful scoring is considered when the student reaches the finish point with the ball.
c. Student's performance at level 3 for velocity is complete when the student indicates to the investigator, which is their best scoring. Only the best time scoring records and count the end of the task.

17. The researcher record each student in groups 1 and 2 best scoring time per task performance task on level 1 through 3 of the **Velocity Vector**, as follow:

Level 1: ______
Level 2: ______
Certain Death: ______

18. The researcher will take notes after each student completion of each task.

19. The researcher conducts the interviews using questions (See APPENDIX E**)** at the end of all levels of task difficulty describe above.

20. Each student completes the EPT and SMQ. Completion of the EPT and EQB marked the completion of data collection.

PART D- Group 3 and Group 4-Mini-tutorial lesson on Velocity and tasks instruction using Image of MAZE Simulation

21. Students of Group 3 and 4 will get a mini-tutorial lesson on Velocity using an image of the Velocity mode of the MAZE simulation (See Figure 3-1 & Figure 3-2 **).**

22. The narrative mini-tutorial lesson has the same content. Just the language varied per group assigned (i.e., Group 3- Spanish and Group 4- English). (See APPENDIX C-1 and C-2).

23. Group 3 and 4 get an explanation of the three levels of difficulty of the Maze simulation using the Image of the simulation. Using mental imaging determines the interpretation of the game features and possible outcomes and strategies to interpret the concept of velocity.

PART E- Image MAZE Simulation Practice- 10 minutes

24. TASK1

a. To look at the visual image of the MAZE simulation and to imagine running the ball through level 1 (i.e., the barrier is the lower horizontal line) of difficulty on the Velocity mode.

b. To narrate the best strategy running the ball avoiding hitting the line barrier on level 1, from to the visual image of the MAZE simulation.

25. TASK2

a. To look at the visual image of the MAZE simulation and to imagine running the ball from start to through level 2 (i.e., the barrier is a horizontal tunnel) of difficulty on the Velocity mode.

b. To narrate the best strategy running the ball, avoiding hitting the upper and lower barrier on the tunnel on level 2 from the visual image of the MAZE simulation.

26. TASK3

a. To look at the visual image of the MAZE simulation and select one of the two routes and imagine running the ball through level 3 of difficulty (i.e., full maze) on the Velocity mode.

b. To choose one of the two ways from the visual image of the MAZE simulation and narrate the best strategy running the ball, avoiding hitting the barrier on level 3 from the image of the Maze simulation.

27. The researcher takes notes during each student discussion of strategies from Group 3 and 4 tutorial lessons.

28. The researcher interviews with each student from group 3 and 4 using the interview questions (see Appendix E)

PART F- Comparative of QUANTITATIVE and QUALITATIVE Methods for data analysis

29. The qualitative data for this study was collected from the interviews and the notes. These qualitative data are analyzed using NVivo12.

30. There were four major themes (i.e., based on the three research questions). Each major theme was split into 3-4 sub-themes.

31. The students' responses into parts fitting the four major issues to explain the implicit meaning of their content.

32. The NVivo 12 Codes (i.e., themes, concepts or sentiments, relationships) helped to sort interview themes and sub-themes into Nodes.

33. The NVivo12 Sentiment coding was used to sort interview responses of the participants and were classified as positive or negative about science. The interview questions were administered to each BLS.

34. The Interview significant themes and sub-themes obtained from NVivo 12 are categorized as Nodes (i.e., represents themes, concepts, ideas or opinions) or Sentiment components.

35. Quantitative data was collected from EPT and the SMQ. The SMQ is a Likert-type survey with 25 items with five options ranging from 0 to 4, with equivalents from the lowest level of disagreement (i.e., zero value) to the highest level of agreement (i.e., four value).

36. The SMQ 25 questions were divided t into five major dimensions or motivational components: Intrinsic motivation, self-determination, self- efficacy, career motivation, and grade motivation.

37. Each student's motivational component results (i.e., a set of 5 questions per motivational component) total rating score was used to calculate the "Mean value" and "Standard deviation" using the SPSS software. Each motivational component results were transferred to an Xcel database to plot as Pivot Charts.

38. The same point score data for each question was transferred to NVivo 12 as a chart for sorting each participant's positive/negative sentiment coding.

39. The EPT score will be similar to a GPA score.

APPENDIX C-1

Mini-tutorial Lesson on VELOCITY for Group 2 and 4*

MOTION is described as a change of position to the point of location.

What is an example of motion in our daily life?

Let's assume you walk a straight distance from home to school.

So to know we are moving, we measure the distance we are traveling and divide it by the time it takes us to reach from point A to point B.

In other words, we see ourselves moving from home to school, and we are walking 100 paces (distance) in 20 minutes.

TO measure the distance from home to school we count our paces (for example 100 paces), and we divide it by 20 minutes, and we will know 100paces /20minutes =5 paces per minutes

But if we are late for school, we need to shorten the time it takes us to reach our destination.

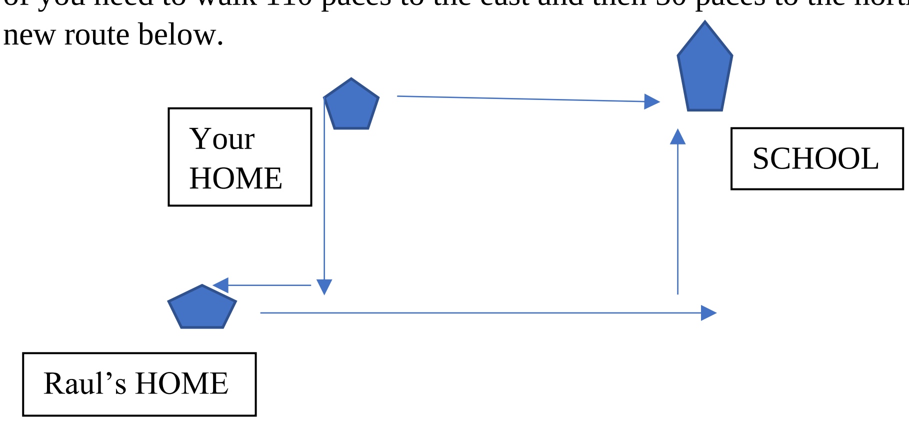
We can run to school if we are in well physical form. So, let's imagine we can run fast and our time is reduced to 10 minutes.

The simple calculation is 100 paces/ 10 minutes = 10 paces per minute. Wow, you are an athlete!

But when we are moving faster (i.e., MOTION) to get to school because we are late, that action is called "SPEED," which means we start to move faster.

SPEED is measured in a unit of the distance at a given time. Remember, MOTION, for now, is just a change in position, and we measure our DISTANCE by dividing it by TIME. We used SPEED when we want to reduce the time to cover the same DISTANCE by running or increasing the SPEED of our paces.

Now, imagine you need to change the route to school because you have to pick up your friend Raul who lives in the southeast of the school (your home is to the west to the school. Instead of walking straight-line distance to the east that you usually walk to school, your new route requires you to walk 50 paces to the south, and ten paces to the west (picked your friend Raul) and both of you need to walk 110 paces to the east and then 50 paces to the north. See the drawing of your new route below.



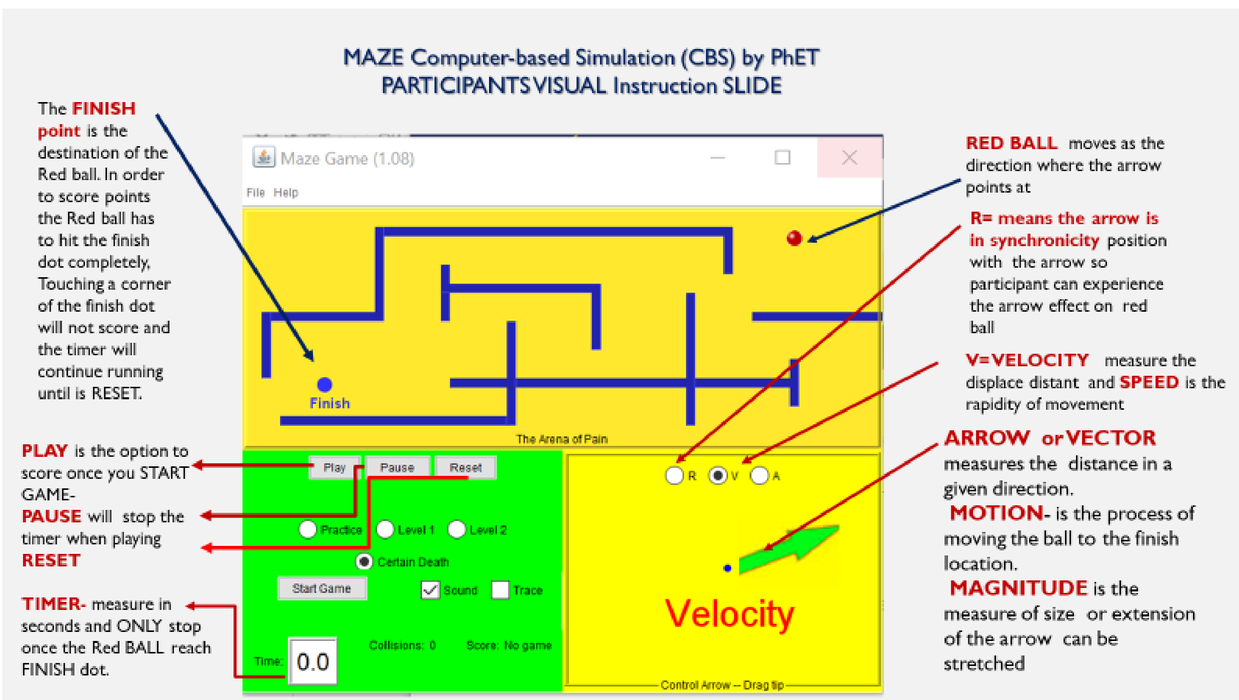
This new route you are taking means your distance to school now has a new DIRECTION (i.e., South- West-East-North). This distance with direction is called VELOCITY. It is said that SPEED is a SCALAR quantity- because it has NO track of the DIRECTION while VELOCITY is VECTOR quantity because it has DIRECTION.

In Physics, the study of MOTION distance, VELOCITY, and SPEED are expressed as quantities of one or two dimensions. In FORCE, the MAGNITUDE (size) and the DIRECTION are essential. The same applies to VELOCITY. To measure VELOCITY, we need to measure the distance covered by a unit of time.

Using the view of the simulation drawing you are going to play, later on, to move that red ball to the FINISH point, you exert some FORCE on the red ball and depending on the FORCE and the DIRECTION of that arrow we hit the final destination. It is a simulation for VELOCITY.

In Science, MAGNITUDE is a measure of the SIZE of VELOCITY as shown by a VECTOR (or arrow we draw to plan your route from home to Raul's home to school). In other words, MAGNITUDE measures the SIZE of a MOTION.

SEE below the IMAGE of the MAZE simulation you will be playing today.



In the simulation, there is this Red Ball at the upper right corner, which you can assume is you at your home (we called before position A). Imagine that your school is the blue dot call FINISH in the lower-left corner of the MAZE. That is why the MAZE simulation has a timer.

Imagine that red ball can be controlled by a green arrow that projects out from that blue dot where the word VELOCITY is-shown (the lower right square area).

You are asked to set the “V” button – which runs the ball in the VELOCITY mode- meaning you have to guide that ball to the finishing dot by expanding or contracting the SIZE of MOTION (called MAGNITUDE) of the green arrow using a mouse in a computer.

You can also manipulate the SPEED of the ball as you extend the tip of the ARROW when setting the direction you want the ball to move without hitting the walls of the MAZE. In other words, you can control the ball VELOCITY toward the FINISH dot.

The difference between a level 1, level 2, and CERTAIN DEATH is the number of barriers you will encounter that blocked your path to the FINISH dot. The MAZE is like the streets in your neighborhood, where you have to develop a plan to pick up Raul and get to school.

Now, let's start your 15 minutes practice with the MAZE simulation to familiarize yourself with the simulation components and levels of difficulty practices. After the practices, let’s talk about your experiences before we start the serious practice where your best timing score on each of the three levels of difficulty will be taken. There are NO CALCULATIONS to make with this simulation.

Finally, a ten questions interview will be audio-recorded, and we will complete your participation in this study. Thank you for your participation!

Any questions before we start?

Let’s start.

APPENDIX C-2

Mini-lección tutorial sobre Velocidad para grupos 1 y 3*

MOVIMIENTO se describe como el cambio de posición en relación a un punto de localización.

¿Cuál es un ejemplo de movimiento en nuestra vida diaria?

Asumamos que to caminas en lien recta desde tu casa a la escuela.

Pues, para saber que te estas moviendo, necesitamos <u>medir la distancia</u> que caminamos y dividirla en el tiempo que nos toma de llegar desde el punto A al punto.

En otras palabras, si nos movemos desde nuestra casa medimos que nos toma 100 pasos en 20 minutos.

Para medir la distancia de nuestra casa a la escuela contamos los pasos (por ejemplo 100 pasos) y los dividimos por 20 minutos y sabremos que 100pasos/20 minutos = 5 pasos por minuto

Pero si vamos tarde a la escuela, tenemos que acortar el tiempo que nos toma llegar a nuestro destino.

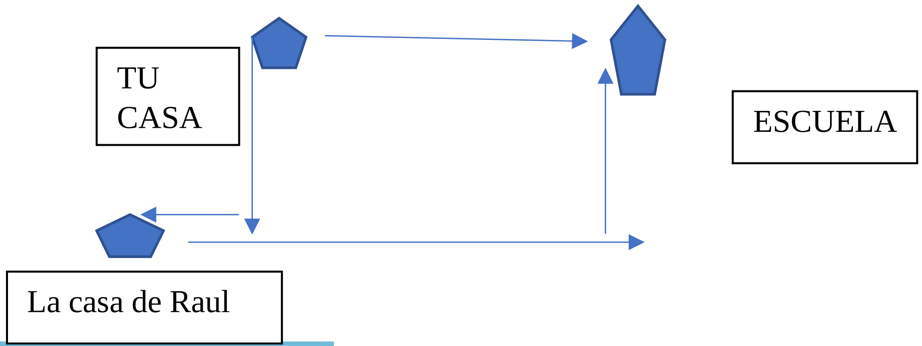
Podemos correr para llegar a la escuela si estamos en buena condición física. Pues, imaginemos que corremos rápidamente y reducimos el tiempo a 10 minutos.

La simple calculación de 100 pasas/10 minutos = 10 pasos por minuto. Wow, somos unos verdaderos atletas!

Pero cuando nos movemos rápidamente (MOVIMIENTO) para llegar a la escuela porque vamos tarde, se llama RAPIDEZ y significa un movimiento rápido.

Rapidez se mide en unidades de distancia a un tiempo dado. Recuerda, MOVIMIENTO por ahora es considerado el cambio de una position un medimos nuestra DISTANCIA dividiendo por el tiempo. Usamos la medida de RAPIDEZ cuando queremos reducir el tiempo en que cubrimos una DISTANCIA y lo hacemos corriendo o aumentando la RAPIDEZ de nuestros pasos.

Ahora imaginemos que tenemos que cambiar nuestra ruta a la escuela porque tenemos que recoger a nuestro amigo Raul que vive al suroeste de la escuela -- (tu casa está localizada al este de la escuela). En vez de caminar en línea recta en dirección al este hacia la escuela de tu ruta normal, tu nueva ruta requiere que camines50 pasos al sur y luego 10 pasos al oeste (recoges a Raul) y ambos caminan 110 pasos al oeste u 50 pasos al norte. Mira el dibujo abajo.



La nueva ruta que ahora estas tomando significa que una nueva DIRECCION a la escuela (i.e., Sur, oeste, este y norte). La distancia con DIRECCION se llama VELOCIDAD.

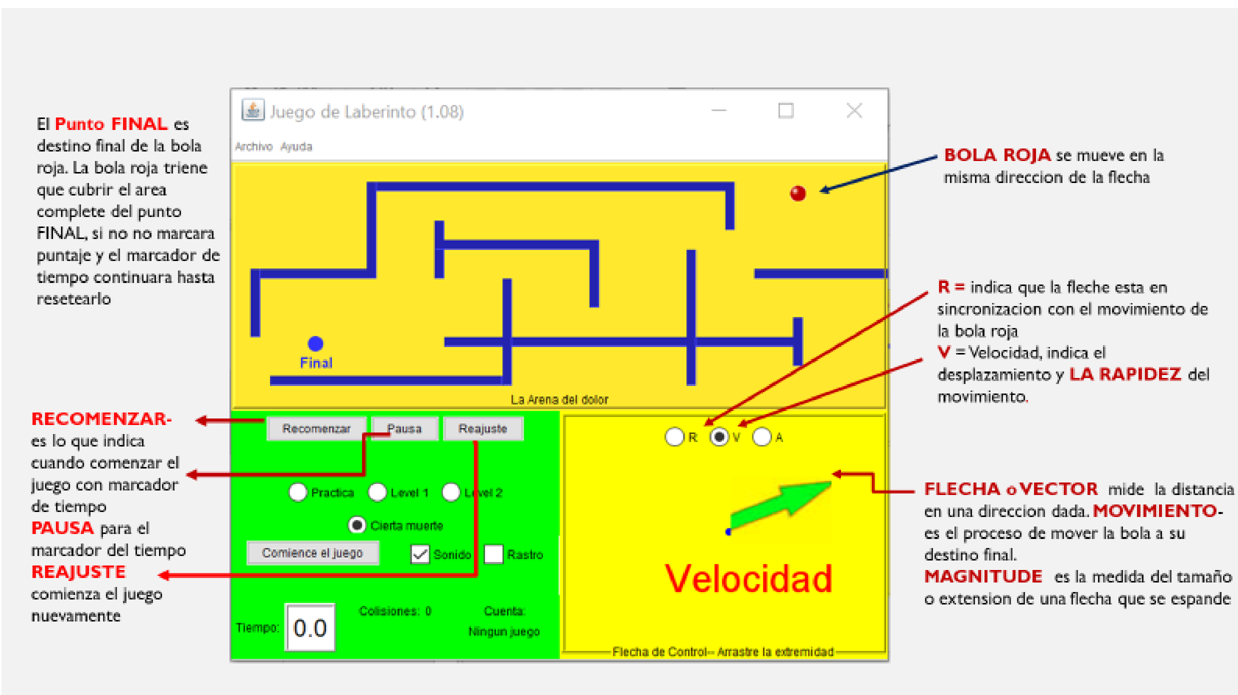
Se dice que LA RAPIDEZ es una unidad escalar porque no tiene dirección mientras que LA VELOCIDAD es un unidad VECTORIAL porque tiene DIRECCION.

En física, el estudio de la distancia del MOVIMIENTO, LA VELOCIDAD y la RAPIDEZ se expresa en unidades de una o dos dimensiones. Para medir FUERZA, la MAGNITUDE (tamaño) y la DIRECCION son importantes. Lo mismo aplica a VELOCIDAD. Para medir VELOCIDAD necesitamos medir la DISTANCIA que se desplaza en un tiempo especifico.

Usando la foto de la simulación con que jugaras puedes observar que la bola roja tiene que pasar por el laberinto hasta llegar a su punto final. La FUERZA con que muevas la bola roja dependerá si puedes pasar las barreras del laberinto. Ésta es la simulación para VELOCIDAD.

En ciencia, la MAGNITUDE mide el TAMAÑO de la Velocidad que se muestra como un VECTOR (o flecha como la usamos pare marcar la ruta desde la casa de Raúl a la escuela.).

En ciencia MAGNITUDE es una medida de TAMAÑO de la VELOCIDAD como lo demuestra el VECTOR (o flecha que dibujamos para indicar tu ruta desde la casa de Raúl hasta la escuela). En otras palabras, MAGNITUD mide el tamaño del MOVIMIENTO. Observa la imagen de la Simulación de Laberinto.



En la simucation, esta la Bola Roja en la esquina superior derecha , que asumiremos eres tu localizado en tu casa. (lo llamamos posicion A). Si imaginamos que la escuela es el punto azul FINAL que esta en la esquina inferior izquierda del LANBERINTO.

Imagina que la bola roja puede ser controlada por una flecha verde en el cuadrante inferior que lee VELOCIDAD.

Tienes que seleccionar el botón “V”- que indicara el título “VELOCIDAD”. En otras palabras tienes que expandir o contraer el TAMAÑO (o MAGNITUDE) de la flecha (o VECTOR) verde usando el “rato n” de tu computadora.

Puedes manipular la RAPIDEZ do la bola según extiendas la FLECHA en la manipulando la DIRECCION para que no impacte las paredes del laberinto. En otras palabras tu manipulas la VELOCIDAD de la bola hasta llegar a punto FINAL.

La diferencia entre los distintos noveles 1 ,2 o “ Cierta Muerte” es el número de barreras. El juego del LABERINTO es como las calles de tu vecindario donde tienes que desarrollar un plan para llegar a casa de Raúl y finalmente llegar a la escuela.

Ahora vamos a tomar 15 minutos en la práctica con la simulación para que te familiarices con el juego y todas sus componentes y niveles de dificultad. Acuérdate solo haremos la sección sobre VELOCIDAD.

Ahora, vamos a practicar por 15 minutos con la simulación para que te familiarices con los componentes de la simulación y los leves de dificultad. Después de la practica hablaremos sobres tus experiencias antes de comenzar las practicas serias donde se tomar la puntuación mejor de tiempo por nivel de dificultad. No hay calculaciones en esta simulación.

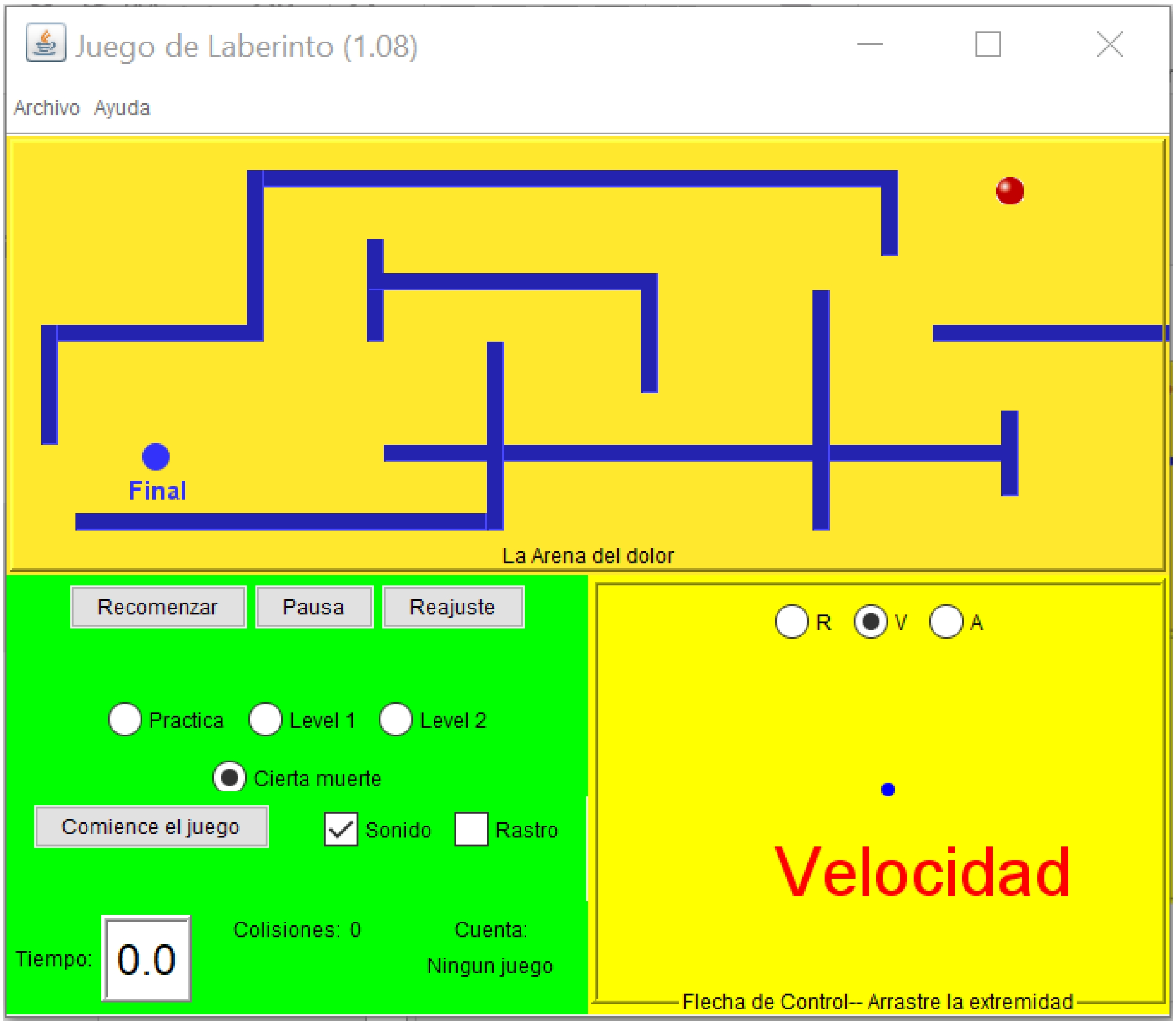
Finalmente, el investigador te hará una entrevista de 10 preguntas. Con la entrevista termina tu participación en este estudio. Muchas gracias, por tu participación!

¿Alguna pregunta antes de comenzar?

¡Vamos a comenzar !

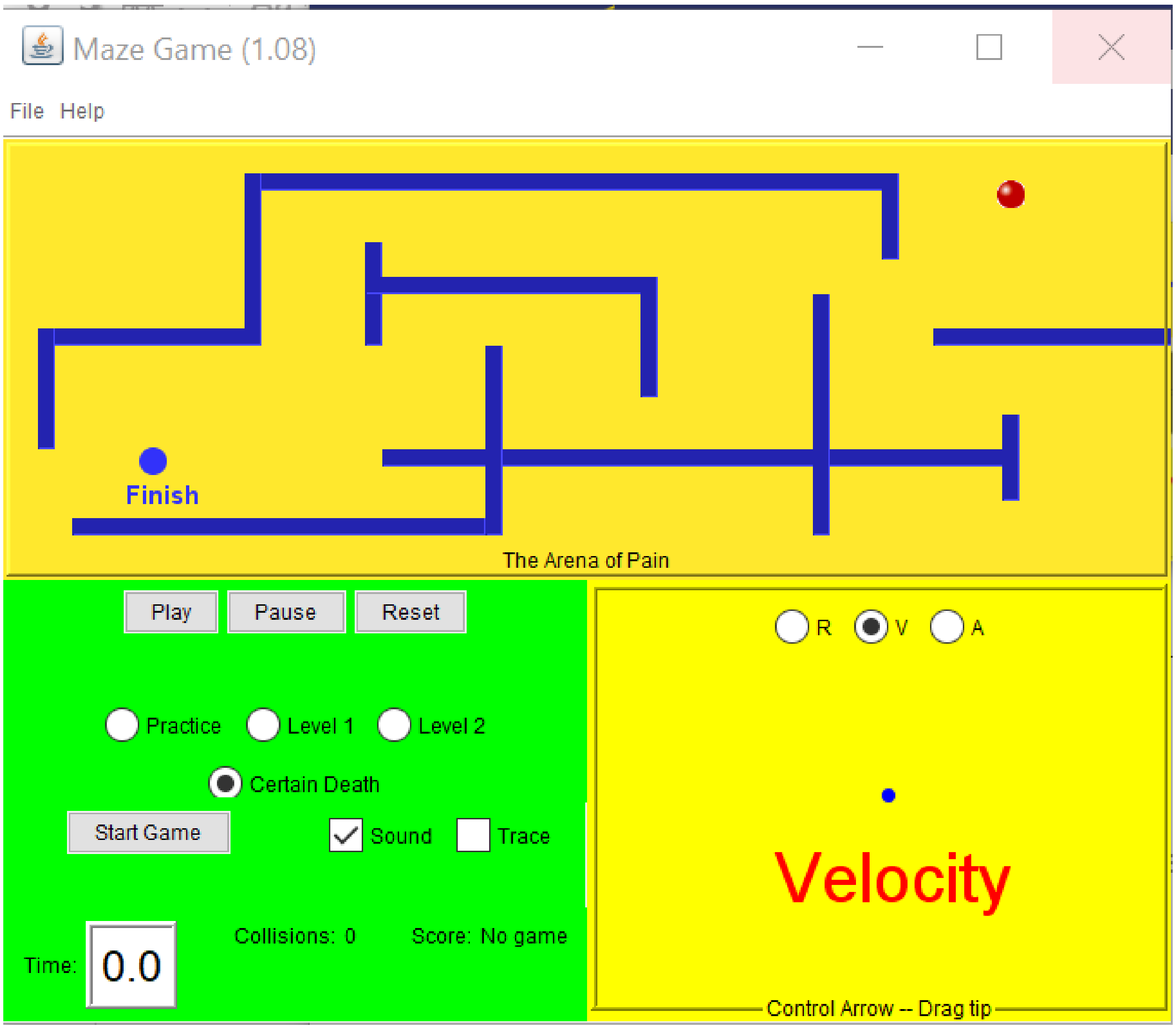
APPENDIX D-1

VISUAL IMAGE of MAZE SIMULATION (SPANISH Version)



APPENDIX D-2

VISUAL IMAGE of MAZE SIMULATION (English Version)



APPENDIX E

English Proficiency Test

Last Name________ ID Number ________ Date: __________

A. Instruction: Select the best answer and put an 'X" on the letter

1 Juan _____ in the library this morning.
- A. In study
- B. studying
- C. in studying
- D. are studying

2 Alicia _____ the windows, please. It's too hot in here
- A. opens
- B. open
- C. opened
- D. will opened.

3 The movies was ____ the book.
- A. as
- B. as good
- C. good as
- D. as good as
- E.

4 Eli's hobbies include jogging, swimming and_______
- A. to climb mountains
- B. climb mountains
- C. to climb
- D. climbing mountains

5 Mr. Hawkins requests that someone_________the data by fax immediately.
- A. sent
- B. sends
- C. send
- D. to send

6 Who is_________, Marina or Sandy.
- A. tallest
- B. tall
- C. taller
- D. the tallest

7 The concert will begin ________ten minutes.

A. in
B. on
C. with
D. about

8 I have only a ________Christmas cards left to write.

A. few
B. fewer
C. less
D. little

9 Each of the Olympic athletes ________four months, even years.

A. have been training
B. were training
C. has been training
D. been training

10 Maria ________never late for work.

A. am
B. are
C. were
D. is

11 The company will upgrade ________computer information systems next month.

A. there
B. their
C. it's
D. its

12 Terry likes apples, ________she does not like oranges.

A. so
B. for
C. but
D. or

13. You were_______ the New York office before 2 p.m.

A. suppose call
B. supposed to call
C. supposed calling
D. supposed call

14 When I graduate from college next June, I ________a student here for five years.

A. will have been
B. have been

C. has been
D. will been

15 Mr. Magoo _________ rather not invest the money in the stock market.
A. has to
B. could
C. would
D. must

B. Select the underlined word or phrase that is *incorrect.* Put an "X" on the letter.

1 The majority to the news is about violence or scandal.
A. The
B. to
C. news
D. violence

2 Tannia swimmed one hundred laps in the pool yesterday.
A. swimmed
B. hundred
C. in
D. yesterday

3 When on vacation, we plan to spend three days scuba diving.
A. When
B. plan
C. days
D. diving

4 Mr. Ferrer does not take critical of his work very well.
A. does
B. critical
C. his
D. well

5 Jenna and Ricardo send e-mails messages to other often.
A. and
B. send
C. other
D. often

6 Mr. Olmedo is telephoning a American Red Cross for help.
A. is
B. a
C. Red
D. for

7 I had a enjoyable time at the party last night.

A. a
B. time
C. at
D. last

8 The doctor him visited the patient's parents.

A. The
B. him
C. visited
D. patient's

9 Paula intends to starting her own software business in a few years.

A. intends
B. starting
C. software
D. few

10 Each day after school, Jack run five miles.

A. Each
B. after
C. run
D. miles

11 He goes never to the company softball games.

A. never
B. the
C. softball
D. games

12 Do you know the student who books were stolen?

A. Do
B. know
C. who
D. were

13 Juan Carlos will spend his vacation either in Singapore nor the Bahamas.

A. will
B. his
C. nor
D. Bahamas

14 I told the salesman that I was not interesting in buying the latest model.

A. told
B. that

C. interesting
D. buying

15 Federico used work for a multinational corporation when he lived in Malaysia.
A. used work
B. multinational
C. when
D. lived in

C. **Instruction: Select the best answer and put an “X” on the letter.**

1 The rate of _________has been fluctuating wildly this week.
A. money
B. bills
C. coins
D. exchanges

2 The bus______arrives late during bad weather.
A. every week
B. later
C. yesterday
D. always

3 Do you ______ where the nearest grocery store is?
A. know
B. no
C. now
D. not

4 Jerry Seinfield, the popular American comedian, has his audiences ___________ .
A. putting too many irons in the fire
B. keeping the noses out of someone’s business
C. rolling in the aisles
D. going to bat for someone

5 The chairperson will ____________members to the subcommittee.
A. appoint
B. disappoint
C. appointment
D. disappointed

6 The critics had to admit that the ballet _________was superb.
A. procrastinate
B. performance

C. pathology
D. psychosomatic

7 Pablo says he can't______our invitation to dinner tonight.
A. angel
B. across
C. accept
D. almost

8 We were ______ friends in that strange but magical country.
A. upon
B. among
C. toward in
D. in addition

9 The hurricane caused __________damage to the city.
A. extent
B. extended
C. extensive
D. extension

10 Many cultures have special ceremonies to celebrate a person's______ of passages into adulthood.
A. right
B. rite
C. writ
D. write

D. Instruction: Read the paragraph and select the best answer with an "X" on the letter

Leave interstate 25 at exit 7S. Follow that road (Elm Street) for two miles. After one mile, you will pass a small shopping center on your left, A the next set of traffic lights, turn right onto Maple Drive. Erik's house is the third house on your left. It's number 33 , and it's white with green trim.

1 What is Erik's address?
A. Interstate 25
B. 2 Elm Street
C. 13 Erika Street
D. 33 Marple Drive

2 Which is the closest to Erik's house?

A. the traffic lights
B. the shopping center
C. exits 7S
D. A greenhouse

Date: May 15, 2018
To: Margarita Romero
From: Gerardo Velez
Subject: Staff Meeting
Please be prepared to give your presentation on the monthly sales figures an out upcoming staff meeting. In addition to the accurate accounting of expenditures for the monthly sales, be ready to discuss possible reasons for fluctuations as well as possible trends in future customer spending. Thank you.

3 The main focus of the presentation will be ________________.

A. Monthly expenditures
B. Monthly salary figures
C. monthly sales figures
D. staff meeting presentations

4 Who will give the presentation?

A. The company president
B. Margaret Romero
C. Geraldo Velez
D. Future costumers

Spend ten romantic days enjoying the lush countryside of southern England. The countries of Devon, Dorset, Hamshire, and Essex invite you to enjoy their castles and coastline, their charming bed and breakfast inns, their museum and their cathedrals. Spent lazy days watching the clouds drift by or spend active days hiking the glorious hills. These hills were home to Thomas Hardy, and the ports launched ships that shaped world history. Bed and breakfasts abound, ranging from quiet farmhouses to lofty castles. Our tour begins on August 15. Call or fax us today for more information 1-800-222-XXXX. Enrollment is limited, so please call soon.

5 Which of the following countries is not included in the tour?

A. Devon
B. Cornwell
C. Essex
D. Hampshire

6 How many people can go on the tour?

A. 10
B. An- unlimited number

C. 2-8
D. A limited number

7 What can we infer about this area of southern England?
A. The region has lots of vegetation.
B. The coast often has harsh weather.
C. The sun is hot and the air is dry.
D. The land is flat.

Anna Szewcycz, perhaps the most popular broadcaster in the news media today, won 1998 Broadcasting Award. She got her start in journalism as an editor as the *Hallsville County Times* in Missouri. When the newspaper went out of business, a colleague persuaded her to enter the field of broadcasting. She moved to Oregon to begin a master's degree in broadcast journalism at Atlas University. Following graduation, she was able to start her career as a local newscaster with WPSU-TC in Seattle, Washington, and rapidly advanced to national television. Noted for her quick wit and trenchant commentary her name has since become synonymous with *Good Day, America!* Accepting the award at the National Convention of Broadcast Journalism held in Chicago, Ms. Szewcyzk remarked, "I am honored by this award that I'm at a total loss for words?" Who would ever have believed it?

8 What is the purpose of this announcement?
A. to invite people to the National Convention of Broadcast Journalism
B. to encourage college students to study broadcasting
C. to recognize Ms. Szewcyzk's accomplishments
D. to advertise a job opening at the *Hollsvlle County Times*

9 The expression "to become synonymous with" means
A. to be the same as
B. to be the opposite of
C. to be in sympathy with
D. to be discharged from

10 What was Ms. Szewcyzk's first join in journalism?
A. She was a T.V. announcer in Washington.
B. She was a newscaster in Oregon
C. She was an editor for a newspaper in Missouri
D. She was a talk host in Chicago

APPENDIX F-1

Science Motivational Questionnaire II (SMQ-II)

In order to better understand what you think and how you feel about your science courses, please respond to each of the following statements from the perspective of "When I am in a science course…"

Statements	Never 0	Rarely 1	Sometimes 2	Often 3	Always 4
01. The science I learn is relevant to my life.					
02. I like to do better than other students on science tests.					
03. Learning science is interesting.					
04. Getting a good science grade is important to me.					
05. I put enough effort into learning science.					
06. I use strategies to learn science well.					
07. Learning science will help me get a good job.					
08. It is important that I get an "A" in science.					
09. I am confident I will do well on science tests.					
10. Knowing science will give me a career advantage.					
11. I spend a lot of time learning science.					
12. Learning science makes my life more meaningful.					
13. Understanding science will benefit me in my career.					
14. I am confident I will do well in science labs and projects.					
15. I believe I can master science knowledge and skills.					
16. I prepare well for science tests and labs.					
17. I am curious about discoveries in science.					
18. I believe I can earn a grade of "A" in science.					
19. I enjoy learning science.					
20. I think about the grade I will get in science.					
21. I am sure I can understand science.					
22. I study hard to learn science.					
23. My career will involve science.					
24. Scoring high on science tests and labs matters to me.					
25. I will use science problem-solving skills in my career.					

Note. The SMQ-II is copyrighted and registered. Go to **http://www.coe.uga.edu/smq/** for permission and directions to use it and its discipline-specific versions such as the Biology Motivation Questionnaire II (BMQII), Chemistry Motivation Questionnaire II (CMQ-II), and Physics Motivation Questionnaire II (PMQ-II) in which the words *biology*, *chemistry*, and *physics* are respectively substituted for the word *science*. Versions in other languages are also available.

APPENDIX F-2

IRB No. 18-366 Cuestionario de Motivación en Ciencias

Para poder entender mejor que tu piensas y como te sientes en tus clases de ciencias, por favor contesta cada una de las siguentes oraciones, asumiendo que tu respuesta es basado en “Cuando estoy en mi clase de ciencias…”

Oraciones	Nunca 0	Rara veces 1	Algunas Veces 2	Usualmente 3	Siempre 4
01. La ciencia que aprendo es relevante a mi vida diaria.					
02. Me gusta obtener mejores resultados que los demás en exámenes de las ciencias.					
03. El aprendizaje de las ciencias es interesante.					
04. Para mi es importante obtener una buena calificación (o buena nota) en la clase de ciencias.					
05. Yo pongo suficiente esfuerzo en aprender las ciencias.					
06. Hago uso de estrategias para aprender la ciencia bien.					
07. El aprendizaje de las ciencias me ayudará a obtener un buen trabajo.					
08. Es importante para mi obtener una “A” en ciencia.					
09. Confío que me irá bien en los examines de las ciencias.					
10. Tener conocimiento de las ciencias me dará una ventaja en la carrera profesional.					
11.Dedico mucho de mi tiempo en aprender la ciencia.					
12. El aprender ciencias hace mi vida más significativa.					
13. Entender las ciencias me beneficiará en mi carrera profesional.					
14. Tengo la confianza de que rendiré bien en mis projectos y laboratorios de ciencia.					
15. Creo que puedo lograr dominar el conocimiento y las habilidades requeridas en las ciencias.					
16. M prepare bien para mis examines y laboratorios en ciencias.					
17. Estoy interesada en saber los descubrimientos de las ciencias					
18. Creo que puedo obtener una cualificación de “A” en la clase de ciencias.					
19. Yo disfruto aprendiendo ciencias.					
20. Pienso en la cualificación que obtendré en mi clase de ciencia					
21.Estoy seguro que puedo entender las ciencias.					
22. Estudio fuertemente para prender en la clase de ciencias.					
23. En mi profesión utilizaré las ciencias.					
24. Obtener altas puntaciones en los examines y los laboratorios en ciencia es importante para mi.					
25. Utilizaré mis habilidades científicas para resolver problemas en mi carrera profesional.					

Note. Spanish version and other languages are also available.

APPENDIX G

Interview Questions

All students interviewed were conducted in Spanish regardless of the CBS or Image CBS language group assigned. All interviews have been audio-recorded, transcribed, and translated into English parenthesis ( ) for transfer into the data analysis instruments.

Preguntas de la Entrevista (*English translation*)

1. ¿Cuantos años llevas como estudiante de ésta escuela?
   (How many years have you been a student in this school?)

2. ¿Prefieres las clases de ciencia en Ingles o Español? ¿Por qué?
   (Do you prefer English or Spanish science lessons? Why?)

3. ¿Que te motivaria a estudiar mas ciencia? ¿Puedes darme un ejemplo?
   (What would motivate you to learn more science? Can you give an example?)

4. ¿ Has tomado una leccion sobre velocidad anteriormente antes de tu participacion hoy? Si o no.
   (Have you taken a lesson in class about what is velocity before this participation? Yes or no.)

5. ¿ Tu crees que aprender y entender la ciencia en la escuela es facil o dificil para ti? Dame ub ejemplo.
   (*Do you think learning and understanding science topics in school is easy or hard for you? Give some example.)*

6. ¿ Te gusta jugar juegos en el internet? ¿ Por qué?
   (*Do you like to play games online? Why*?)

7. ¿ Te gustaria aprender más ciencia usando juegos/ simulaciones educativas o lecciones de tutoria? Responde de acuerdo al grupo donde participastes. Si o no y por qué?
   (*Do you like to learn more science using a game-simulations (or tutoring lesson)? Explain based on group assigned why*?)

8. ¿ Haz jugado este juego del LABERINTO anteriormented al dia de hoy? Si lo has hecho, explicame que te gusta of no de la simulacion del LABERINTO.
   (Have you play the MAZE simulation before today? If yes, tell me what you like or dislike about playing the MAZE simulation)

9. Puedes explicarme en tus propias palabras , que tu entiendes es velocidad? Responde de acuerdo al grupo donde participastes.
   (*Can you explain to me in your own words, what do you understand is velocity? Respond based on the group assigned(tutoring lesson or simulation).*

10. ¿Te gustaría estudiar una carrera en el campo de Ciencia, Tecnología, Ingeniería o Matemáticas (STEM) ? Explica porque si o porque no.
    (Would you like to study a career in any field of Science, Technology, Engineering or Mathematics (i.e., STEM? Explain, why or why not?)

APPENDIX H

Instruments for Data Collection and Analysis

Instruments for Data Collection & Analysis	Science Motivational Questionnaire (SMQ)	Audio Recordings Interview	Observational Notes	English Proficiency Test	Technology for Data Collection
Data Methods	**25 Questions** **Likert-scale** **Qualtrics** electronic SQB **SPSS –** Xcel Tables NVivo12 coding and analysis	**10 Interview Questions** Additional questions for responses clarification	**Learning & Understanding a concept using CBS** Groups 1 & 2 **Learning & Understanding concept with image CBS** Group 3 & 4	**Qualtrics** – an electronic version of EPT and SMQ **Qualtrics** data opened in NVivo 12 and SPSS.	1. Qualtrics 2. NVivo 12 3. SPSS 4. PhET MAZE simulation game
Qualitative Analysis		**NVivo 12 Interview** analysis **Four Primary-Themes** (PT): Technology Language Cognition Science **Inductive coding**[1] for sub-coding identification **Sentiment** phrases Positive Negative	**Categorical analysis** of explicit behavior during practices been correlated with the SMQ responses. For intrinsic analysis of traits and motives on the SMQ.[2]		
Quantitative analysis	**SMQ 4 Motivation Score** rank 0-4 Mean, and SD/ factor plotted The largest SD and lowest mean participants results were correlated with interview responses		**4 Groups Findings:** **CBS-Best** Scores **IMAGE CBS-** Findings **EPT**-Best Scores **Velocity**-Best Definition	**SPSS data analysis**: Grammar I Grammar II, Vocabulary Reading Comprehension The M and SD and correlated with interview responses.	**NVivo 12 data analysis**-look at the response wording and phrases to generate Codes and Nodes as themes for grouping outcomes

[1] Inductive coding-allowed the research findings from dominant and significant concepts, themes during interview responses of participants and correlates their responses to the themes generated from SMQ. (Lieblich, Tuval-Mashiach, & Ziber, 2011) (Leiblich, 1998)[2] (Lieblich et al., p.11,2011)

APPENDIX I

Researcher-Highlighted Observation Notes

Group 1-Spanish Computer-based Simulation				
Id/Name	Learning Science	Technology	Motivation	Language
PJ-05/Carmen	She preferred to learn science in English because she understands the science terminology better in English	She scored better on level 3 of the simulation than levels 1 &2	She wants to be a doctor, so that is why she likes science.	She studied in English from1-5th grades in her country, Ecuador.
PJ-09/Jessy	She prefers learning science in both languages.	She did not care about the timing factor during the simulation. She is not competitive in gaming.	Having more technology in the classroom doing more experiments will motive her. She wants to be a veterinarian.	Very shy. No preference in language to learn science.
PJ-11/ Jockey	Science classes bored him. Expected survey questions were more than just about science.	He has completed the three tasks on the simulation in the shortest time. Curious about doing the acceleration tasks of the simulation. Competitive- expect to win.	He has no interest in the Science career. He explained in detail his favorite game online. Very intelligent- said he got bored in science classes.	Hyperactive. Curious about life. Extrovert. English language preference. He as the most descriptive of all BLS in narrating how to play his favorite online game. He online game has a community of 100 participants.
PJ-15/Eddie	He likes technology in the science classroom as he recognized to study Forensics; he needs to use a lot of technology.	He used one hand to begin the tasks with the simulation, and later-on used both hands to manipulate the timer and the ball. He tried several times using a timer to select the best score as his time scores were too high. He gives up for a score of 9.3 seconds	He feels that having a computer in the classroom will motivate him more.	Very shy and talked in a low voice. Shake his legs while doing the test & survey. Hum music while doing the English test.
PJ-18/Issa	She likes science, math, and technology. Recalled a pH experiment using soil and baking soda.	She likes to play multiplayer- multilayer games.	She took a longer time than peers in practice the simulation before scoring her timing.	She attended bilingual school before from k to 2nd grade. She scores 86% in EPT, completing in the least amount of time of all BLS.

Group 2- *English Computer-based Simulation*

Id/ Name	Learning Science	Technology	Motivation	Language.
PJ-02/Ally	Wants to have technology in science classes	Likes simulation game. Score in lower timing on task 1 and task 3 of the simulation.	Prefers reading and playing games for science motivation.	She considered Spanish more complicated than English due to the complex grammar and accent rules. She attended bilingual private schools up to fifth grade.
PJ-04/Mary	Learning science is easier for her because of the help of short quizzes	She scores the best timing doing the most difficult route at level 2. Her online gaming is for pleasure and relaxation.	She feels if classes were in English, it would motivate her more.	She claimed she could learn faster in English, and she asked peers to explain to her the Spanish words she doesn't understand in the science class.
PJ-08/Barbie	Prefers technology to learn science as being more visual helps her understand concepts in science. She does not like writing too much. Claimed peer and she finds some science topics "not useful" in life" For example Animal from wildlife.	Talkative while playing the simulation. Claimed to get bored in science classes. Very competitive in games. Career interest in computer programming. She uses her thumb and middle finger while gaming. Plays simulation very closed to the screen to focus.	Feels outdoor activities motivates more to learn science. Some science topics are not interesting. Prefer outdoor events to motivate her into science. Prefer science items she can touch.	She prefers Spanish language classes, but she is fluent in both English and Spanish.
PJ-12/Hero	He likes science and agreed simulation is excellent to learn science.	Likes technology. Career interest in engineering. Likes online games	Very competitive and played ten times each task to get a lower score.	An extrovert and seems to like communication in English.
PJ-14/Myra	No language preference for learning science. Not sure career choice., but likes biology and dislikes mathematics.	Very competitive. She gave up trying the 3rd level risk of the simulation but decided to try one more time until she got a low score. Likes simulation finds it appealing due to challenges	Movie character Sherlock Homes doing scientific research investigations motivated her into science.	Respond in Spanish and quickly translated into English. She speaks limited English. Claim problem with Science terminology retention saying she google them to understand them.

Group 3-Spanish Image of Computer-based Simulation

Id/Name	Learning Science	Technology	Motivation	Language
PJ-01/Sherry	Astronomy favorite field in science, the others are boring to her. Career choice Astronomy.	She likes technology for learning but prefers to get instructions with visual images before engaging with the technology when learning science.	She looks at the sky at night and sees all the stars. She feels motivated by movies and videos about galaxies.	She studied in the US from 1st to 3 rd grade and came back to PR. She prefers English to learn science. She has competed in bike races
PJ-10/Jennie	She likes science but not all its topics. Favor technology in science to prevent accidents and to provide a platform to infinitive options and a variety of options to run dangerous experiments.	She considered the simulation and the image both beneficial since the image triggers the assumptions of possibilities outcome, the simulation provides the opportunity to prove them.	She likes science, technology, and math. What motivates her is finding a cure to venereal diseases, and that is why she wants to be a nurse.	She has been in a bilingual school since kindergarten.
PJ-13/Jerry	Prefers science lessons and simulations to learn science. Simulation benefits learning about dangerous chemical reactions. Prefers science classes in English because some concepts are easy to understand in English.	Left-handed and recline is head on his right hand to do the test and survey. He likes engineering games that built things. He said he is good in math	He liked to build stuff. Career plan engineering. Online games are mostly to build something. Prefers to learn the concept of Velocity in Spanish.	English vocabulary learned by playing games where the characters require English verbal commands. He liked word games. Learned to speak English by reading books, by watching TV and videos and online games since he was seven years old.
PJ-19/ Evah	Prefers to learn science in English because the words are easier to write than in Spanish.	Prefers to learn science simulation because of the benefits of seeing what is happening and allows problem-solving to be faster.	Motivation in science due to career choice (as a veterinarian) requires to know lots of science.	She prefers the English language because it is a universal language. Writing in Spanish requires complex grammatical rules.
PJ-20/Joey	Prefers simulations games to learn science help with visuals. He dislikes science (physics) with equations.	He would have preferred doing the simulation that just the image of it because he like online gaming.	Motivation in science depends on themes, but having technology-games will motivate a gamer like him.	No preference in the language (English or Spanish) Understands both languages.

Group 4- English Image of Computer-based Simulation

ID/Name	Learning Science	Technology	Motivation	Language
PJ-03/Yanny	Fascinated by the many fields to study in science as compared with engineering.	Claimed her memory improves when playing online games. She makes the point that the course route is narrower than the straight path.	Vibrant and smiles all the time. Curiosity motivates her, claiming she has an intuitive mind.	She learned to speak English by watching TV programs and movies in English since childhood.
PJ-06/Kally	She prefers learning science in English. She has difficulty remembering science word during her discussion of the exercises.	She likes to play Puzzles games online in both languages.	Interested in knowing the history behind science as it motivates her to learn more.	She learned to speak English by practicing it with her older sister since childhood. She completed SMQ and EPT in 15 minutes- scoring the lowest in EPT.
PJ-07/Maria	Computers in the classroom will make it easier to understand science. No preference for the language the science class is given.	Said technology is the new generation's "thing," as computers run everything in the world. She likes computers a lot; she asked after her image practices if she can do the simulation. This demonstrates she is eager to learn.	Her grandfather, who was born in NYC, taught her English since she was in second grade. He has been her motivation to learn in the English language and her interest in being a veterinarian.	She understands both languages (Spanish and English classes) Asked the teacher to explain more those difficult science words.
PJ-16/Gladys	Prefers learning science in Spanish, as science is harder to learn. Likes biology and math relates to daily life situation and can see it expressed everywhere.	She likes to learn about using technology because she loves games. She prefers war online games because they keep her focus. She tends to get bored in class and talk with peers.	She will feel motivated if the science class was about biology, the topic she likes. She will stop talking to peers and will pay more attention, as she did when playing was games.	She spent one year living in Florida and the science class in English was difficult to learn. She prefers a career in Business.
PJ-17/Elly	A career in Zoology. She dislikes Physics because of math. She prefers learning science in English.	Prefers to learn science -simulations as she is a visual person and simulations engaged her in participation. Good gamer.	Science motivations are its importance in the world. Science evolves and keeps doing more stuff. It has incorporated technology.	Fluently English. Clearly explained her best strategy with the simulation image. Very confident of what she wants to study.

APPENDIX J

SMQ-STATISTICAL ANALYSIS OF FIVE MOTIVATIONAL COMPONENTS

Factors	N	Mean	SD
Intrinsic Motivation			
IM01The Science I Learn is Relevant to my Life	20	2.35	.875
IM-03Lerning Science is Interesting	20	3.00	1.026
IM12 Learning Science make my Life more Meaningful	20	2.15	1.089
IM17 I am Curious about Discoveries in Science	20	3.25	.910
IM19 I Enjoy Learning Science	20	3.30	.733
Career Motivation			
CM07 Learning Science will help me Get a Good Job	20	3.50	.607
CM13 Understanding Science will Benefit me in my Career	20	3.35	1.040
CM10 Knowing Science will give me a Career Advantage	20	3.45	.759
CM23 My Career will Involve Science	20	3.00	1.170
CM25 I will use Science Problem-solving Skills in my Career	20	3.15	.988
Self-Determination			
SD05 I put enough Effort into Learning Science	20	3.15	.745
SD06 I use Strategies to Learn Science Well	20	2.70	.979
SD11 I spent a Lot of Time Learning Science	20	2.45	.759
SD16 I prepare well for Science Tests and Labs	20	3.35	.813
SE22 I study Hard to Learn Science	20	2.85	.875
Self-Efficacy			
SE09 I am Confident I will do well in Science Labs and	20	3.20	.834
SE14 I am Confident I will do Well on Science Tests	20	3.25	.639
SE15 I believe I can Master Science Knowledge and Skills	20	3.05	.887
SE18 I believe I can earn a grade of "A" in Science	20	3.40	.681
SE21 I am sure I can Understand Science	20	3.05	.887
Grade Motivation			
GM02 I like to do better than other students in Science Tests	20	3.00	1.076
GM04 Getting a Good Science Grade is important to me	20	3.50	.607
GM08 It is Important that I get an "A" in Science	20	3.55	.605
GM20 I think about the grade I will get in Science	20	2.75	.910
GM24 Scoring High on Science Tests and Labs Matter to me	20	3.60	.503

APPENDIX K

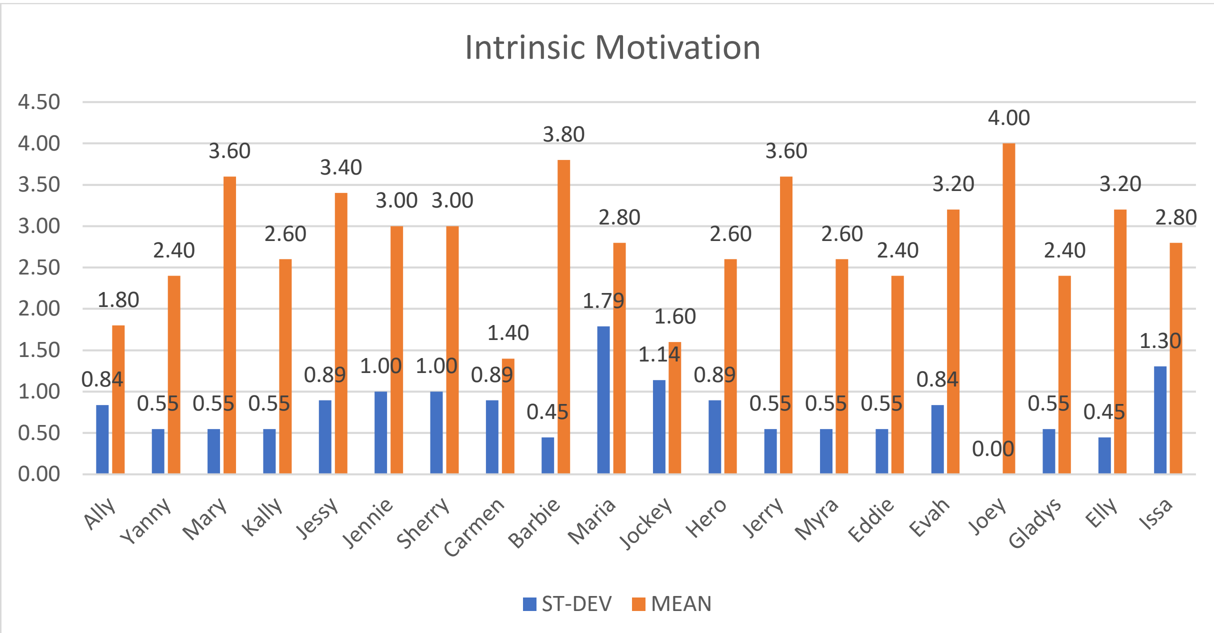
SMQ Responses- Results 25 Questions per Factor Choice within Motivational Category

Factors	Never	Rarely	Sometimes	Always	Often
Intrinsic Motivation					
IM-01The Science I Learn is Relevant to my Life	0	3 (15%)	**9 (45%)**	6 (30%)	2 (10%)
IM-03Lerning Science is Interesting	1(5%)	0	4 (20%)	**8 (40%)**	7 (34%)
IM-12 Learning Science make my Life more Meaningful	2 (10%)	2 (10%)	9 (45%)	5 (25%)	2 (10%)
IM-17 I am Curious about Discoveries in Science	0	0	6 (30%)	3 (15%)	**11 (55%)**
IM-19 I Enjoy Learning Science	0	0	3 (15%)	8 (40%)	**9 (45%)**
Career Motivation					
CM-07 Learning Science will help me Get a Good Job	0	0	1(5%)	8 (40%)	**11 (55%)**
CM-13 Understanding Science will Benefit me in my Career	1 (5%)	0	2 (10%)	5 (25%)	**12 (60%)**
CM-10 Knowing Science will give me a Career Advantage	0	0	3 (15%)	5 (25%)	**12 (60%)**
CM-23 My Career will Involve Science	0	3 (15%)	4 (20%)	3 (15%)	**10 (50%)**
CM-25 I will use Science Problem-solving Skills in my Career	0	2 (10%)	2 (10%)	7 (35%)	**9 (45%)**
Self-Determination					
SD-05 I put enough Effort into Learning Science	0	0	4 (10%)	**9 (45%)**	7 (35%)
SD-06 I use Strategies to Learn Science Well	0	2 (10%)	7 (35%)	**6 (30%)**	5 (25%)
SD-11 I spent a Lot of Time Learning Science	0	1 (5%)	**11 (55%)**	6 (30%)	2 (10%)
SD-16 I prepare well for Science Tests and Labs	0	0	4 (20%)	5 (25%)	**11(55%)**
SE-22 I study Hard to Learn Science	0	1 (5%)	**6(30%)**	8 (40%)	5 (25%)
Self-Efficacy					
SE-09 I am Confident I will do well in Science Labs and	0	1 (10%)	2 (10%)	**9 (45%)**	8 (40%)
SE-14 I am Confident I will do Well on Science Tests	0	0	2 (10%)	**11 (55%)**	7 (35%)
SE-15 I believe I can Master Science Knowledge and Skills	0	1 (5%)	4 (20%)	**8 (40%)**	7 (35%)
SE-18 I believe I can earn a grade of "A" in Science	0	0	2 (10%)	8 (40%)	**10 (50%)**
SE-21 I am sure I can Understand Science	0	1 (5%)	4 (20%)	**8 (40%)**	7 (35%)
Grade Motivation					
GM-02 I like to do better than other students in Science Tests	0	3 (15%)	2 (10%)	7 (35%)	**8 (40%)**
GM-04 Getting a Good Science Grade is important to me	0	0	1 (5%)	8 (40%)	**11 (55%)**
GM-08 It is Important that I get an "A" in Science	0	0	1 (5%)	7 (34%)	**12 (60%)**
GM-20 I think about the grade I will get in Science	0	1 (5%)	**8 (40%)**	6 (30%)	5 (25%)
GM-24 Scoring High on Science Tests and Labs Matter to me	0	0	0	8 (40%)	**12 (60%)**

APPENDIX L

Triangulation of SMQ and Interview Responses

Motivation Table

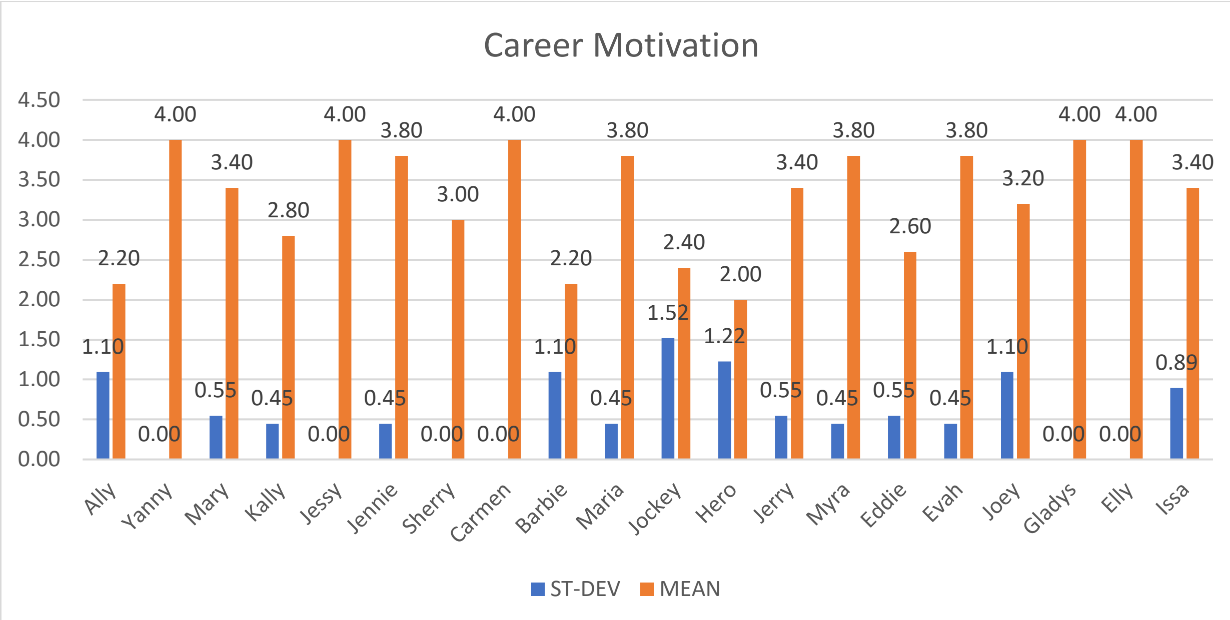


(Glynn et al., 2011) Science Motivation questionnaire is based on the concept that: Motivation to learn is derived from the Social Cognitive theory that provides a multi-component construct to the definition of the concept of motivation. Because measuring motivation in science is challenging, the questionnaire was developed to represent empirical indicators. For this study, the results within the five categories of motivation will be complementary to the analysis of each participant responses to the ten interview questions.

Intrinsic motivation- defined as inherent *satisfaction* in learning science (Glynn et al., p.3, 2011)

Observations:

Larger standard deviations are found for Jockey, Maria and Issa as they have expressed not interested in a science class as he stated is boring for him. Jockey (Mean= 1.6; S.D.=1.14). Maria (Mean=2.8; S.D. =1.79) express she likes computers a lot and expressed her science class with computers will help her understand better science class. Issa has memory gaps when trying to explain the pH experiment she did in her prior-year science class. It shows she was not satisfied with her science learning as she can't recall a science lesson a year after.



Career Motivation is one *tangible end* the student can get from learning science (Glynn et al., p.3, 2011)

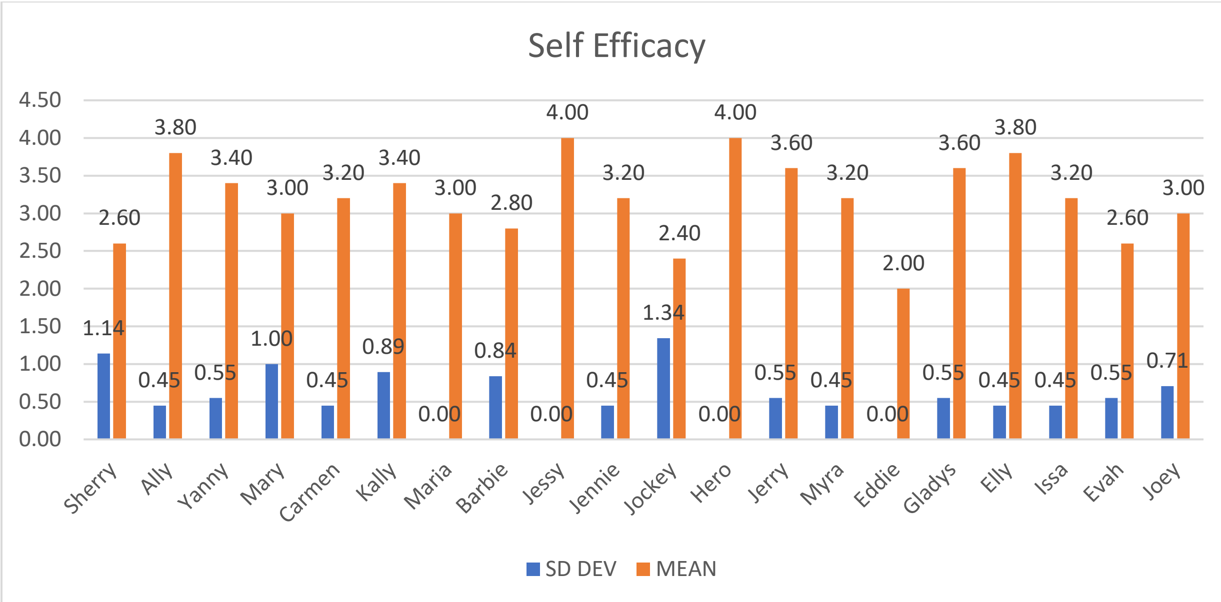
Observations:

The high S.D. and low mean values of Jockey and Hero's data matched their expression that they are not interested in science careers. Jockey wants to be a pilot and Hero wants to be an electrical engineer.

While the highest mean values with zero S.D. are from Yanny. Yanny expressed she is fascinated with so many fields of study in science

The highest SD values are from Jockey, Hero, Ally, and Barbie. Ally wants to study technology and Barbie wants to be a website designer in technology.

The highest means are from Yanny, Jessie, Carmen, Gladys, and Elly. Yanny stated she is fascinated with science, especially biology. Jessy wants to be a veterinarian and likes zoology. Gladys likes biology because it relates to the environment and daily life. Elly wants a career in zoology.



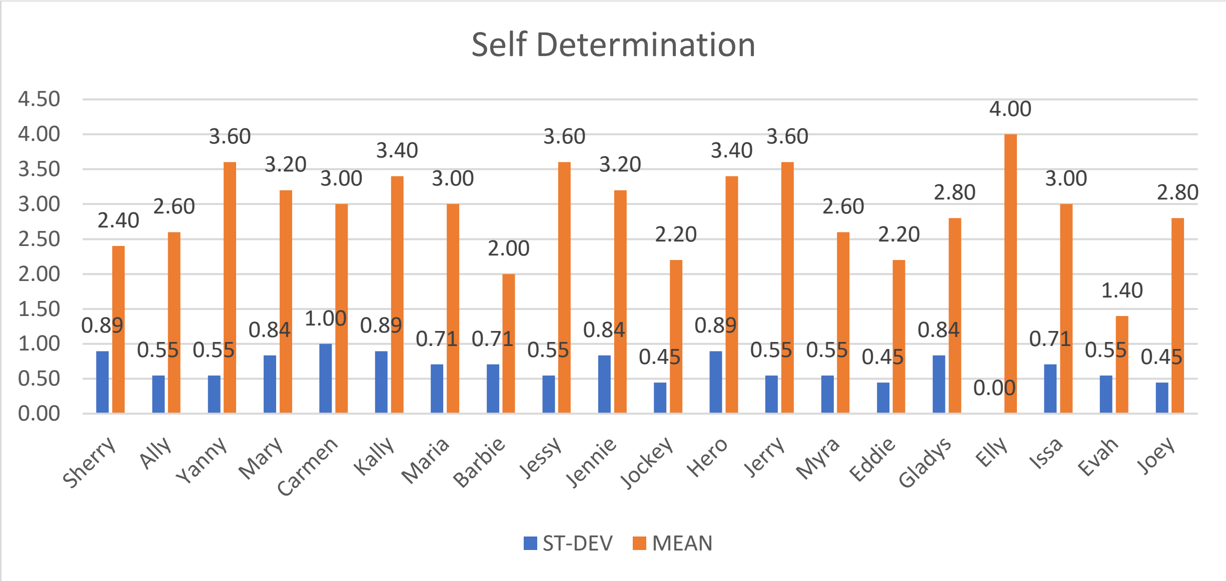
Self- Efficacy- is to what extent *the student believes* they can achieve well in science (Glynn et al., p.3, 2011)

Observations:

Jockey (Mean = 2.4; SD = 1.34) and Sherry (Mean = 2.6: SD = 1.14) scores were among the lower on their beliefs about science.

Jockey's low score was expected, as he stated he finds science boring. Sherry is very competitive in sports, but does not play games online. She said she would like to work outside doing forensic investigation for the FBI.

But comparatively, Sherry's mean was higher than Eddie (Mean = 2.00, SD = 0). Eddie scored the lowest Mean. He also has a zero SD score. For zero SD value mean all his responses scores were the same, demonstrating that Eddie seems to be confident of his scientific achievements. Sherry is an extrovert while Eddie is an introvert. That could be the reason why Sherry's mean values are higher than Eddies. Eddie wants to work also in the field of Forensic science doing lab analysis. They are both 13 years old, but Eddie is in 8th grade.

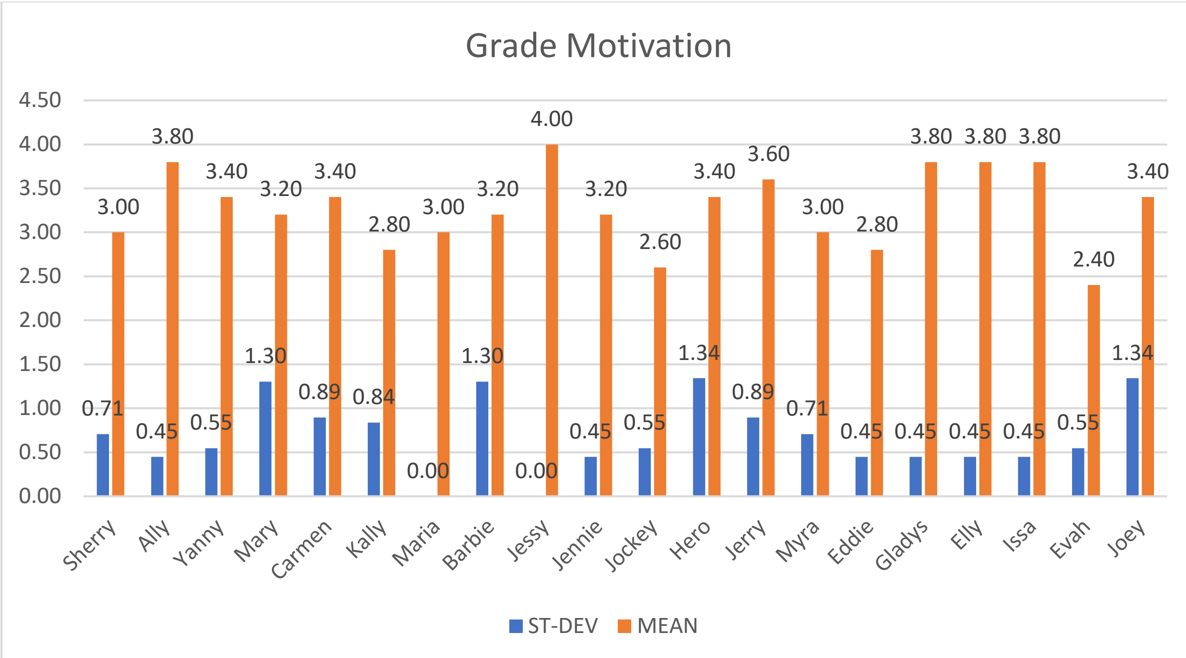


Self- Determination- is the *control* the students believe they have over their learning of science (Glynn et.al., p.3, 2011)

Observations:

Carmen got the highest mean score (Mean = 3.0; SD =1.0). She is from Ecuador and wants to be a doctor. Maybe she has doubts about having an opportunity to study medicine because she is studying in another country other than Ecuador. She represents the foreign Latino students, who feel they cannot control their outcomes in another country.

Evah had the lowest mean value (Mean = 1.4; SD = 0.55), She was self-confident during her interview, responding right to the point and defined Velocity without hesitation. A possible interpretation for her lower score is her possible interpretation of the question related to self-determination. Most of this group of questions focus on studying hard, putting effort into learning science and spending long time learning science. If the student feels confident about her knowledge of science, she might learn without much problems, needing less time to study and indicating less likely to need to put effort into learning, and likely considers someone else might struggle in class.



Grade Motivation- is another tangible goal when learning science. (Glynn et al., p.3, 2011)

Observations:

The highest mean scores and SDs were obtained by four respondents: Mary (Mean = 3.20; SD = 1.3), Barbie (Mean = 3.20; SD = 1.3), Hero (Mean = 3.40; SD = 1.34) and Joey (Mean = 3.40; SD = 1.34). Nonetheless, all mean values were high showing that all care about the level of their science grade. Evah has the lowest mean score among all respondents.

Mary wants to be an engineer and Barbie wants a career in computer technology. Joey wants to be a businessman and Hero wants to be an electrical engineer. Maybe since none of them wants a career in science they might not see a tangible outcome from scoring high in the science class.

It is interesting that both female students got the same scores, and both males the same score for the mean and SD.

APPENDIX M

Motivation Outcomes based on Gender Distribution

INTRINSIC MOTIVATION

	Males	Females
IM-01	60%-3	40%-4
IM-03	60%-4	40 %-4
IM-12	40%-3	47%-2
IM-17	60%-4	53%-4
IM-19	40%-4	47%-4

Boys more than girls think science is relevant and interesting and are more curious to know science. Girls, more than boys, think science is more meaningful and vital to them.

CAREER MOTIVATION

	Males	Females
CM-07	60%-4	53% - 3
CM-10	40% -3	73%- 4
CM-13	40%-4	66 %-4
CM-23	40%-2	60%- 4
CM-25	40%-3	60%-4

Boys more than girls think science will help them get a job. Girls more than boys think science will give them career advantages, and benefits since their career will be involved in science, and that career will let them apply problem-solving skills.

SELF- DETERMINATION

	Males	Females
SD-05	40%-3	47 %-3
SD-06	60%-2	30%- 3
SD-11	60%-2	53% -2
SD-16	40%-4	60 %-4
SD-22	40%-4	30%-4

Boys more than girls think they will put more efforts and will prepare more in science.
Girls more than boys study harder to learn science and spend more time learning science and use strategies to learn science.

SELF- EFFICACY

	Males	Females
SE-09	40%-2	53%-4
SE-14	60%-4	60%-3
SE-15	40%-4	47 %-3
SE- 18	60%-3	60 %-4
SE- 21	60 %-4	47%-3

Boys more than girls are more confident that they will do well in science test and that they can understand science.
Girls more than boys feel confident they can do well in project and in mastering science and believe they can get an ”A” in the science class.

GRADE MOTIVATION

	Males	Females
GM-02	40%-4	40%-3
GM-04	40%-4	40%-4
GM-08	60%-4	60%-4
GM-20	60%-2	40%-3
GM-24	60%-4	60%-4

Boys think more than girls are concerned about the grade they will get in science.
Boys and girls equally considered getting an "A" or getting a good grade in science are important to them. Both genders always think scoring high in lab and tests are equally important to them.
Boys and girls equally think that getting a good grade in science depends mostly on them.
Boys more than girls think that they like to get a better grade in science tests.

APPENDIX N

Fragments of Interview Four Major Categories

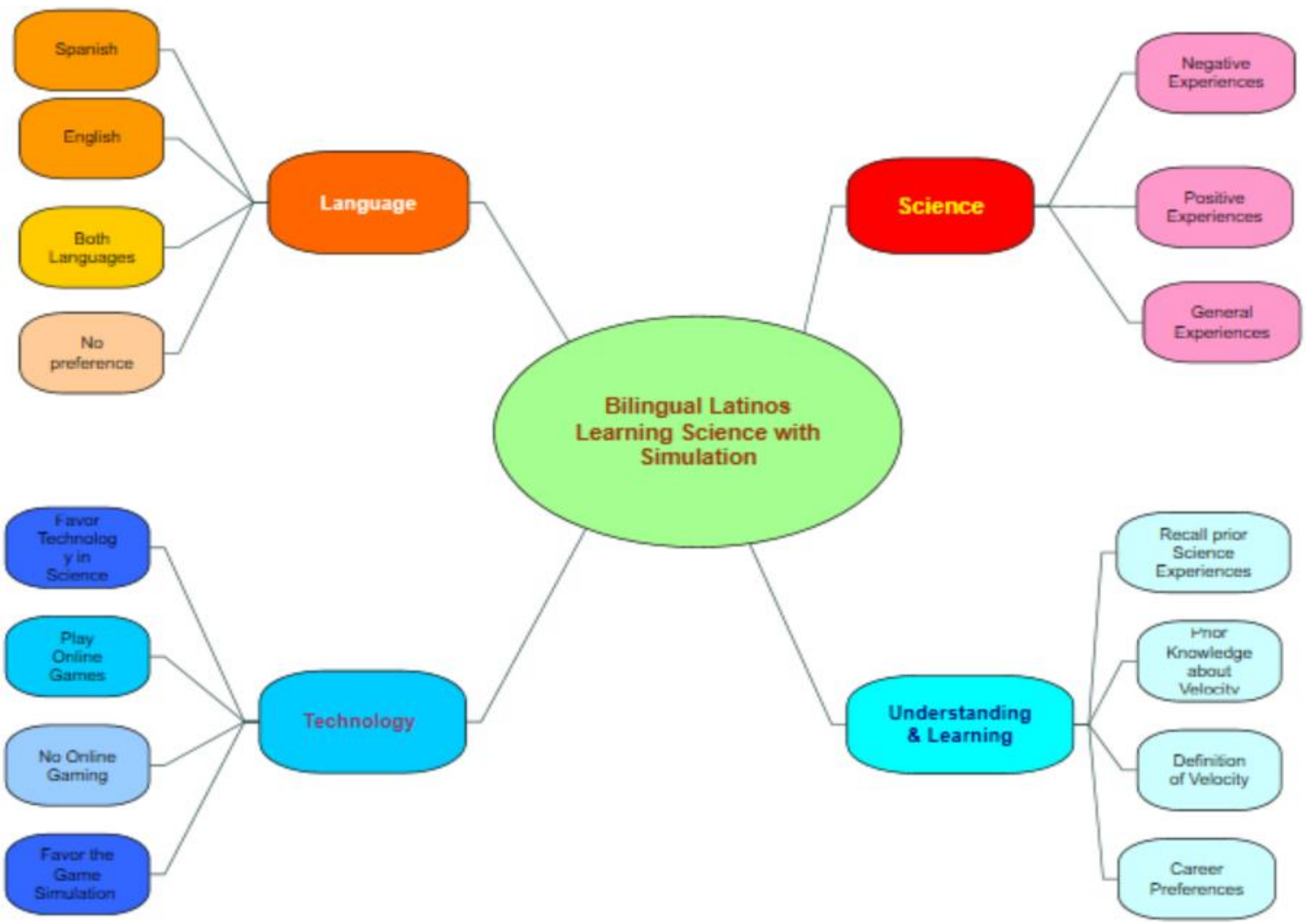
Science	Technology	Language	Learning & Understanding
Having field trips, less writing, more visual learning-Barbie	A computer is a new generation "thing"-Maria	My grandfather began to teach me English when I was in second grade- he was born in NYC-Maria	I learned English by reading books in English, doing Games and watching videos and TV Programs in English- Jerry
Doing more experiment, more internet- Kally	Prefer learning science with a teacher because I cannot ask the game like I ask the teacher-Sherry	I lived in PR until fifth grade when we moved to San Francisco- California, then Florida, and came back to PR. I prefer Spanish. -Gladys	Nobody told me to learn English, but I learned it myself-Janny
I feel science is such an important thing in the world-Elly	I like to learn science with both methods-simulation for practice and image for viewing easier understanding-Jerry	English is a primary universal language than Spanish. English is easier to write than Spanish. Spanish has more grammatical rules than English. -Evah	I learned about velocity in 6th grade by running a wood car and measuring the distance using a cord and a ruler- Jockey
More class participation, not just [observing] pictures or writing in our notebooks-Carmen	Learning both ways is good. First, doing the exercise in the computer by myself, then listening to the teacher explanation after I am done- Eddie	I was in another school before, and it was a bilingual school where I speak English since Kindergarten.- Jennie	I like to play massively multiplayer games online. I like challenges and competition and role-playing games-Issa
Do experiment with the computer-Jennie	Simulations with the visual make you see more and make you feel you are part of it-Kally	I like to learn science in both languages. In Spanish, because of what I can understand, in English because I like it. -Jockey	I played a multiplayer online game that has lots of challenges, with 100 participants playing at the same time. - Jockey
Games will motivate my classmates because they are always playing games-Issa	The simulation will make science more fun, more comfortable to learn, more interesting-Joey	I lived 4- years in the U.S. I like to learn science in English because I understand it better. My first language is Spanish, but I work better with English. –Sherry	I like to play competitive games online-Eddie

Science	Technology	Language	Learning & Understanding
Science is like Mathematics, everywhere. - Gladys	Information is a powerful thing- (technology) - Issa	I learned my English by watching TV and videos. I practice my English conversation with my older sister. - Kally	I want to be an engineer, but I like the science that deals with equations like Chemistry because it has equations like math- Hero
Learning science is not difficult if you practice it- Hero	Technology is revolutionary-Maria	I speak English since I was seven years old. I didn't practice with anyone. I learned it by reading English books, games, videos and TV programs-Jerry	Biologist used technology to look for information, but they can learn more when studying the species directly-Jessy
Character Sherlock Homes who did research motivated me to like science-Myra	Simulation with its visuals make you more engaged in the participation than an image-Elly	I can learn faster in English. I can understand both languages, but I prefer English. - Mary	My favorite field of science is forensic because I want to solve criminal cases using forensic-Eddie
Learning science teach me about the world -Issah	Playing a game is better than just using the image- once you play it you become addictive-Janny	I don't have any language preference to learn science. -Janny	Biology is more about humankind, about what we live every day, on how we can protect this world and how we can live in it.- Gladys
Since I was little, I like the genome kind of things. Science has more fields for my curiosity than Engineering- Janny	Online games- relax the mind-Mary	I prefer Spanish because it is easier to understand (science). -Barbie	Writing in science is boring, using a computer is right for seeing the experiments and because you can change the ingredients of the experiments without danger-Jennie
I feel that some science concepts are easier to understand in English than in Spanish. -Jerry	Game-simulations challenge me, and I like that-Myra	I study in Texas since 1st grade, and Spanish is not that difficult for me, but I prefer both languages to learn science. -Jennie	

Science	**Technology**	**Language**	**Learning & Understanding**
I don't like science, and I don't like math-science is boring-Jockey	I like to do simulations because it amazed me. - Myra	Learning science in Spanish is more difficult to understand-Janny	I search at home on the internet what I do not understand in science class- Janny
I like biology but not physics-Issa	I want to learn more game simulations because I like games. - Gladys	Because my favorite classes are English, Mathematics, and science.	I feel motivated by seeing chemical reactions, and I want to learn more about the world. - Issa
I do not like an Engineering career because there is a lot of math. I do not like mathematics-Myra	I prefer a career in technology because it is fun. I want to be an astronomer-Myra	Understanding science in Spanish is more difficult for me- Ally	I like competitions, and people say I am very competitive-Maria
I do not like writing in the science class-Jennie	Using a computer in science classes can help with doing exercises rather than writing.		
In science, it is harder when you do not get it. Or when you say to yourself, " I do not need this in my life, Why am I learning this?"- Barbie	I do not want to learn science with simulations- Jockey		
The velocity theme is better in Spanish because sometimes it is confusing-Jerry	I do play games when I am bored-Gladys		
It (science) is hard like some words are difficult to understand. .-Myra	In some games, you see them as bad, but when you played them, they can become addictive-Janny		
In Chemistry theme, it will be difficult for me to learn all the elements of the periodic table and their properties-Joey			

APPENDIX O

Distribution of Four Primary Themes and Coding from Interview Responses



APPENDIX P

Interview Parent Codes, Sub-Codes and Sentiments Codes from NVivo

Nodes

Search Project

Name	Files	References	Created On	Created By	Modified On	Modified By
Language	1	1	5/11/2019 8:44 AM	LVG	5/26/2019 7:45 AM	LVG
Both	8	9	5/11/2019 9:13 AM	LVG	5/26/2019 7:45 AM	LVG
English	11	15	5/11/2019 8:59 AM	LVG	5/26/2019 7:44 AM	LVG
No Preference	2	2	5/11/2019 9:19 AM	LVG	5/26/2019 7:45 AM	LVG
Spanish	2	2	5/11/2019 9:12 AM	LVG	5/26/2019 7:46 AM	LVG
Science	8	13	5/11/2019 8:46 AM	LVG	5/11/2019 8:46 AM	LVG
Negative	7	7	5/26/2019 7:32 AM	LVG	6/2/2019 5:46 AM	LVG
Neutral	5	6	5/26/2019 7:32 AM	LVG	6/2/2019 5:46 AM	LVG
Positive	13	17	5/26/2019 7:32 AM	LVG	5/26/2019 6:44 AM	LVG
Technology	11	16	5/11/2019 8:48 AM	LVG	6/2/2019 5:46 AM	LVG
NO Online games	1	1	5/20/2019 5:00 PM	LVG	5/24/2019 1:35 PM	LVG
Online Games	20	27	5/11/2019 9:05 AM	LVG	6/2/2019 5:46 AM	LVG
Preference Technology	16	27	5/11/2019 9:06 AM	LVG	6/2/2019 5:46 AM	LVG
Understanding and Learning	10	15	5/11/2019 8:51 AM	LVG	11/10/2019 3:03 PM	LVG
Career	6	6	5/26/2019 7:40 AM	LVG	5/26/2019 6:52 AM	LVG
Prior Knowledge about Velocity	16	21	5/26/2019 7:40 AM	LVG	7/1/2019 4:31 PM	LVG
Velocity definition	19	20	5/26/2019 7:40 AM	LVG	6/2/2019 5:46 AM	LVG

Sentiment

Name	Files	References	Created On	Created By	Modified On	Modified By
Positive	18	88	5/3/2019 8:02 PM	LVG	5/26/2019 6:54 AM	LVG
Very positive	12	16	5/3/2019 8:02 PM	LVG	5/26/2019 6:48 AM	LVG
Moderately positive	16	49	5/3/2019 8:02 PM	LVG	5/26/2019 6:52 AM	LVG
Negative	11	14	5/3/2019 8:02 PM	LVG	6/2/2019 5:48 AM	LVG
Moderately negative	9	11	5/3/2019 8:02 PM	LVG	6/2/2019 5:58 AM	LVG
Very negative	3	3	5/3/2019 8:02 PM	LVG	6/2/2019 5:48 AM	LVG