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Academic Achievement and Participation in Out-of-School Educational Robotics Competitions for High School Latino/a Students in Southern California

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Academic Achievement and Participation in Out-of-School Educational Robotics Competitions for High School Latino/a Students in Southern California

A Dissertation by

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Brandman University
Irvine, California
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ABSTRACT

Academic Achievement and Participation in Out-of-School Educational Robotics Competitions for High School Latino/a Students in Southern California

by Jesus Leonardo Ulloa-Higuera

Purpose. The purpose of this study was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino/a students in Southern California who participated two consecutive years in robotics competitions and high school Latino/a students who did not participate. A secondary purpose was to examine the difference in mathematics academic performance between Latino and Latina students who participated in robotics competitions. A third and final purpose was to describe the experiences of Latino/a college students who participated in robotics competitions and how those experiences influenced their interest in pursuing a STEM college degree.

Methodology. This study used a mixed-methods ex post facto research design. The quantitative portion of the study involved retrieving archival student data that involved eight high schools from a Southern California secondary school district. The qualitative portion of the study included face-to-face interviews with seven Latino/a college students who participated in robotics competitions. These students were also part of the quantitative dataset.

Findings. The quantitative findings resulted in no significant statistical differences in mathematics performance between Latino/a students who participated and Latino/a students who did not participate in robotics competitions. There were also no significant statistical differences between male and female students who participated. The qualitative findings indicated that mathematics achievement of Latino/a students who participated in robotics competitions was high. Students credited their robotics experiences for achieving at a high level in mathematics. Students described that these experiences had a significant influence on their interests in pursuing STEM college degrees. Students responded that equal opportunity should be offered to all students to participate in robotics regardless of their academic levels.

Conclusions. Participation in robotics competitions can influence Latino/a students to achieve at a high level in mathematics and to pursue STEM college degrees. Latino students did not have a significant higher mathematics performance than Latina students who participated in robotics competitions.

Recommendations. Future research on the influence of robotics on grades should be conducted considering a larger student population across several high school districts to include an analysis of ethnicities, gender, grade levels, and specific academic courses including science.

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CHAPTER I: INTRODUCTION

The United States has become a global economic leader because of its science, technology, engineering, and math (STEM) workers and professionals. The STEM workforce drives the competitiveness and innovation in the nation by creating new companies, products, and services. This influences the country's economic development, and its citizens' standard of living (Edgerton, 2010; Friedman & Mandelbaum, 2012; Kaplinsky & Santos Paulino, 2005; Ybarra, 2016). According to research by the U.S. Department of Commerce, the STEM workforce is essential to the nation's ability to be innovative and competitive in a global economy (Beede et al., 2011).

However, America's leadership has been threatened by the lack of students pursuing careers in STEM (Business-Higher Education Forum, 2011; Lembo, 2016). Over the past decade, there has been a growing concern among policy makers, practitioners, and researchers that America is falling short in developing a steady supply and enough STEM professionals to fill the widening gap of STEM jobs in this country (President's Council of Advisors on Science and Technology, 2010; Ybarra, 2016; Reider, Knestis, & Malyn-Smith, 2016). Additionally, within the current STEM workforce, gaps between males and females and between Whites and minorities keep increasing (Neuhauser & Cook, 2016).

The U.S. Bureau of Labor Statistics (2015) divided the U.S. STEM workforce into three major STEM subdivisions: life, physical and social science; architecture and engineering; and computer and mathematics. More than half of the projected employment in STEM occupations are in the engineering and technology pathway. Moreover, almost all the occupations in the STEM employment cluster require a bachelor’s degree or higher (U.S. Bureau of Labor Statistics, 2015). Conversely, Reider et al. (2016) noted that it requires over 10 years to develop a STEM professional who is capable of taking on high-level scientific research and engineering jobs (Reider et al., 2016).

Numerous studies have been conducted to determine factors that are potentially causing students, particularly females, minorities, or individuals with disabilities, who initially enroll in a STEM college degree program to transition away from their majors. Research suggests that obstacles keeping students from achieving STEM degrees may include uninspiring introductory courses, an academically or culturally uninviting environment to underrepresented populations, negative peer effects, lack of same gender/race of instructors as role models, and lack of adequate academic preparation (Diekman, Brown, Johnson, & Clark, 2010; Griffith, 2010; Riegle-Crumb & King, 2010; Sass, 2015).

Although females make up almost half of America’s population and workforce and nearly half of them are also college educated, they remain underrepresented in the U.S. STEM workforce (Hinojosa, Rapaport, Jaciw, LiCalsi, & Zacamy, 2016; U.S. Census Bureau, 2016; Ybarra 2016). In 2015, the Department for Professional Employees (DPE, 2016), and within STEM occupational clusters, reported that females represented 46.6% of science professionals, 24.7% of computer and math professionals, and 15.1% of all engineering and architecture professionals. Similarly, despite Latino/as increasing representation in the U.S. population, they are still behind other ethnicities in the U.S. STEM workforce representation (Krogstad, 2016b; U.S. Census Bureau, 2016).

The Latino/a population grew 54% from 2000 to 2014 (Krogstad, 2016b). As of 2017, the U.S. Census Bureau (2018a) reported a U.S. population of 325 million people, 18.1% who were Latinos/as and accounted for almost 60 million people. According to a study from the Pew Research Center (Funk & Parker, 2018), the total U.S. workforce is 131.1 million. Over 17 million people are employed in STEM occupations. Of those in STEM employment, Whites represent 69%, Asians represent 13%, Blacks represent 9%, and Latinos/as represent 7%. As a whole, Blacks and Latinos/as are underrepresented in the U.S. STEM workforce (Funk & Parker, 2018).

According to the DPE (2016), a 2011 report indicated that California's STEM workforce accounts for over 13% of the nation's STEM workforce. This percentage adds up to just over one million jobs. The report also found that almost 1.75% of STEM jobs were lost in the past 10 years because of a shortage of adequate STEM professionals. This percentage represents about 19,000 jobs. The largest number of STEM jobs in California was in Los Angeles County with more than 235,000 jobs (DPE, 2016). Moreover, as the demand for STEM workers continues to rise, California has opted to employing foreign-born STEM professionals. California has become the second state with 42.4% of the highest share of foreign-born STEM workers, behind New Jersey with 43.8% (American Immigration Council, 2017).

Without a doubt, America's prowess, global leadership, and prosperity relies on its capacity to produce an adequate supply of high-quality innovative workers in STEM fields (Redmond-Sanogo, 2016; Sanders, 2008). As the need for STEM workers rises, it is critical to prepare K-12 students to pursue and succeed in STEM majors. Particularly, high school student preparedness including female and minority students is vital to strengthen America's STEM workforce (Ball, Huang, Cotton, & Rikard, 2017; Bybee, 2010; Ybarra, 2016).

Background

Student Academic Achievement

According to the U.S. Department of Education, graduation rates for American K-12 public schools have been decreasing in the last 4 decades (Aud et al., 2012; Stark & Noel, 2015). As an illustration, Swanson (2009) reported that in 2008, 47% of students in urban districts of the 50 largest cities did not complete high school. Institutions of higher education, as well as researchers, consider graduation rates as a measure of academic success for schools. On the other hand, individual student academic achievement is usually determined by the student's grade point average (GPA), which is a cumulative measure that includes all the student's individual curricular academic scores (Beron & Piquero, 2016).

The measure of student academic achievement, also usually referred to as academic performance, has emerged as an important issue in education. In American schools, student academic performance is assessed through the use of standardized tests and a variety of assessments. It can be argued that those indicators do not reflect the student's cognitive abilities. However, they determine the student's academic success and are directly related to graduation rates (Angus & Hughes, 2017; Beron & Piquero, 2016; Voight & Hanson, 2017). Research consistently suggests that a determining factor to predict academic achievement and educational accomplishment along with high income can be pinpointed to a student's high school GPA, mostly comprised of As and Bs (Angus & Hughes, 2017; French, Homer, Popovici, & Robins, 2015). Secondary education student academic success involves multiple factors such as taking advanced placement (AP) courses (Smith, Jagesic, Wyatt, & Ewing, 2018), participation in extracurricular or out-of-school activities (Morris, 2016), and course sequence (Riegle-Crumb, 2006). According to Hallinan and Warren (1999), a key component of student achievement in high school is the completion of higher or advanced-level math courses. Consequently, mathematics competency at the secondary level is crucial to determine student academic achievement (Bright, 2017). Typically, students who pursue and attain a STEM college degree follow a high school mathematics course sequence that begins with courses like Algebra or Geometry and culminates with higher level math courses such as Pre-Calculus or Calculus (Riegle-Crumb & King, 2010).

Achievement Gap

An increasing number of educators agrees that academic achievement is not the fruition of only academic performance but the combined results of schools and teachers addressing students' social, emotional, and academic needs. With this in mind, educators are challenged to pay more attention to students in a more holistic way. This includes school-structured activities before, during, and after school (Voight & Hanson, 2017). The achievement gap refers to the disparity in academic achievement between subgroups. Racial achievement gaps are the most widely studied, particularly the achievement gap between Black-White racial subgroups. Moreover, there is an increased interest in Latino/a academic performance, as this subgroup continues to steadily increase in the school population across American schools (Kotok, 2017; McFarland et al., 2017).

Females in STEM

It is also crucial to have a better understanding of the importance of effectively supporting the integration and success of females in STEM fields and careers. Recent data suggest that despite the slow increase in female participation and success in STEM fields female students continue to proportionally fall behind male students, and the gap continues to increase over time (Armstrong & Jovanovic, 2017). According to the U.S. Department of Labor (2017), females accounted for smaller shares of employment among STEM occupations. In 2016, 44.3% of full-time wage and salary workers were female, but only 25.2% participated in computer and mathematical occupations. Further, females had only a 14% participation in full-time positions in architecture and engineering occupations. Moreover, females with a STEM degree are more likely to take jobs in the fields of education or healthcare. However, when compared with their male counterparts they are less likely to take other STEM positions such as engineering or computer science (U.S. Department of Labor, 2017). According to the National Science Foundation (NSF, 2017), female Hispanics (Latinas) were the largest minority group in 2014 between the ages of 18 and 64, accounting for 8% of the overall population in the United States for this age group. Moreover, 61% of employed Latinas worked mainly in two occupational groups: service and sales, and office occupations (NSF, 2017). In a more recent report by the National Science Board (2018), Latinas accounted for 6.4% of all females involved in science and engineering occupations compared with 62.9% of White females.

Hispanics or Latinos/as in the United States

The U.S. Office of Management and Budget (OMB) requires all federal agencies including the U.S. Census Bureau (2018a) to utilize terminology of either Hispanic or

Latino or Not Hispanic or Latino when collecting or reporting data about ethnicities. OMB identifies Hispanic or Latino as a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race. In addition, these terms do not reflect anthropological, genetic, or biological information but a social self-classification (U.S. Census Bureau, 2018a).

A report by the U.S. Census Bureau indicates that the nation's population will reach 400 million in 2051 (Colby & Ortman, 2015). Further, between 2014 and 2060, the U.S. population will increase from 319 million to 417 million. As presented by the U.S. Census Bureau (2017), Latinos/as are the largest ethnic minority in the United States, representing 17.8% of the nation's population as of July 1, 2016. Latinos/as represented 54% of the total U.S. population growth between 2000 and 2014. The largest Latino/a population resides mainly in five states: Illinois (2.2 million), New York (3.7 million), Florida (4.8 million), Texas (10.4 million), and California (15 million). These states alone account for over 65% of all Latinos/as in the nation (Stepler & Lopez, 2016).

Latinos/as and STEM Education

Despite their increasing representation in the U.S. population, Latinos/as remain behind other ethnic groups in completing a 4-year college degree. Latinos/as are less likely to enroll full time in postsecondary education institutions. As of 2014, only 15% of Latinos/as between the ages of 25 and 29 have a bachelor's degree or higher, compared with Whites at 41%, Asians at 63%, and African Americans at 22%. Moreover, Latinos/as traditionally fail to enroll full time in 4-year college institutions (Burke & Mattis, 2007; Krogstad, 2016a).

Latinos/as are also substantially underrepresented in STEM education and occupations (Business-Higher Education Forum, 2011; Hanson, 2013). Since the 1970s, Latinos/as have been underrepresented in STEM fields. Nevertheless, the participation rate of Latinos/as in the U.S. workforce increased a total of 12%, from 3% in 1970 to 15% in 2011. However, the participation rate of Latinos/as in the U.S. STEM workforce is only 7%. The Latino/a participation rate in STEM fields has not matched with the participation rate in the workforce in general (U.S. Census Bureau, 2013).

Latinos/as' participation in STEM education and consequently in STEM fields continue to create anxiety in terms of equity but most importantly in developing the capacity to sustain the increasing demand of the U.S. STEM workforce's pipeline (Hinojosa et al., 2016). The growing shortage of STEM specialists, well-trained technical workers, scientists, and engineers, and the need for competitiveness in STEM fields are at odds with the underrepresentation of one of our largest future talent bases–Latinos/as (Hanson, 2013).

Out-of-School and Extracurricular Programs

Expanded learning opportunities, including extracurricular after-school and out-of-school activities, provide a much needed service to students during nonschool hours and days. These programs hold particular promise for the development of students from lower socioeconomic backgrounds who may not have access to other informal learning settings (National Research Council, 2009; Smith, 2015; Vinoski, Graybill, & Roach, 2016). Extracurricular programs provide students with a wide range of rich experiences and benefits: social, communication, and leadership skills; career exploration; and a greater likelihood that they will engage and be successful in college (Vinoski et al., 2016). Furthermore, students who participate in extracurricular programs and activities improve in academic achievement (Price, 2010; Vinoski et al., 2016).

The effect of participation in school-sponsored extracurricular activities on academic achievement has been a topic of debate for many years. In fact, student involvement in extracurricular activities is now a major criterion for college acceptance (Beckett et al., 2009; Voight & Hanson, 2017). Moreover, the STEM Education Coalition Policy Forum (2016) reported that the STEM educational community continues to utilize nontraditional educational programs as an avenue to strengthen STEM education. These programs include after-school, informal, and out-of-school learning environments. Utilizing out-of-school time in STEM projects such as robotics provides students with the opportunity to explore real-world problems and innovative ways to solve them as well (STEM Education Coalition, 2016).

Educational Robotics

Robots that were initially used in manufacturing facilities and research laboratories have arrived in the world of education. Nugent, Barker, Grandgenett, and Welch (2016) argued that by using robots and through experiential, project-based, and hands-on learning students are able to understand abstract science, technology, engineering, and math concepts. Robots allow students to develop concrete, meaningful, and real-life connections (Alimisis, 2013; Barker & Ansorge, 2007; Nugent, Barker, Grandgenett, & Welch, 2016). Robotics is a field that continues to grow and expand, and it has the potential to create substantial impact in education at all levels, from kindergarten all the way up to graduate school (Alimisis, 2013; J. Johnson, 2003; Mataric, 2004). The use of robotics in education has increased consistently in recent years, particularly in K-12 education. Eguchi (2016) suggested that participation in robotics has demonstrated positive gains in promoting STEM interests in students. The students' learning experiences created by using robotics in education generate interest and create motivation to explore further STEM fields and careers (Eguchi, 2016).

A variety of educators at different grade levels have started to explore ideas on how to use robotics in their classrooms not only to assist in STEM subjects instruction but also in subjects of different types such as social sciences and visual and performing arts (Eguchi, 2016; Nugent, Barker, Grandgenett, & Adamchuk, 2010). However, more information is needed about the impact of robotics in fostering student learning, increasing student academic achievement, and acquiring cognitive, metacognitive, and social skills (Alimisis, 2013; J. Johnson, 2003). In recent years, criticism has surfaced among the robotics community suggesting that there is a need for quantitative research on the role of robotics in student learning measures (Alimisis, 2013; Benitti, 2012). Above all, studies indicate the lack of high-quality quantitative studies in current literature related to the use of robotics in education (Afari & Khine, 2017; Alimisis, 2013; Benitti, 2012; Nugent, Barker, Grandgenett, & Welch, 2016).

Impact of educational robotics in education. The world is changing rapidly and creativity and innovation in teaching and learning are necessary to prepare students for unforeseen novel challenges. Robotics in education can play a crucial role in achieving this (Afari & Khine, 2017). Nugent, Barker, Grandgenett, and Welch (2016) noted that the use of robotics in education represents an attractive mechanism for students because they can use their hands to touch and manipulate the robots creating memorable learning experiences that engage the students' minds. This mind and hands-on experience results in the development of self-directed learners driven by their curiosity. Nevertheless, most research involving robotics in education provides results related to teacher or student perceptions. There is a clear lack of research studies based on the use of educational robotics and student achievement data (Barker & Ansorge, 2007; Benitti, 2012; Mac Iver & Mac Iver, 2013). Mac Iver and Mac Iver (2013) argued that a number of studies have begun to investigate further the impacts of robotics in education, but the research evidence remains rather scarce. Benitti's (2012) study in a scientific literature review on the use of robotics in schools identified 10 articles that included quantitative measurements of student learning related to robotics in education including a pre and post quasi-experimental study by Baker and Ansorge (2007) to measure achievement in science, engineering, and technology that reported gains at teaching concepts like engineering, computer programing, and mathematics.

Academic achievement and robotics. Recent studies in the use of robotics in education suggest the possible impact on student learning in specific subjects such as physics and mathematics along with the development of 21st-century essential skills of problem solving, creativity, teamwork, collaboration, communication, and decision-making (Afari & Khine, 2017). Moreover, recent arguments regarding noncognitive factors influencing academic performance have accentuated the importance of developing an academic mind-set to influence academic behaviors such as homework assignments, class effort, and attendance. An academic mind-set can build a sense of competence not only in elective activities like robotics but also in the core academic classroom (Mac Iver & Mac Iver, 2013; Nagaoka et al., 2013).

Out-of-school high school educational robotics competitions. As reported by Robinson (2014), robotics competitions started to receive attention in the 1980s. The competitions initially involved only college and some precollege students and educators. However, since early 2000, educational robotics competitions have gained momentum in school-age students around the world (Eguchi, 2016). Druin and Hendler (2000) declared that robots and dinosaurs lead up when grasping the attention of school-age students. Moreover, robots are very effective at attracting the attention of students toward career pathways related to STEM (Druin & Hendler, 2000). With that in mind, robotics competitions have been used mainly to spark interest and establish student exposure to STEM fields and careers. Furthermore, the growth of robotics competitions in schools has the intention to increase student content knowledge in STEM related courses (Nugent, Barker, Grandgenett, & Welch, 2016; Robinson, 2014). Bevan (2013) contended that educational robotics competitions fit in between formal classroom settings and informal out-of-school program environments. However, most of the competitive robotics teams conduct their activities in out-of-school settings (Bevan, 2013). Further, these activities occur in an informal learning setting where students do not follow a formal curriculum and do not receive a grade for participation or for their performance. Moreover, typically and depending on the robotics competition platform, students meet several days per week after-school to design, build, test, and improve their competition robots (R. T. Johnson & Londt, 2010; Robinson, 2014; Robinson & Stewardson, 2012). Out-of-school robotics competitions emulate sporting events' environments that generate an exciting atmosphere where robotics teams may compete in multiple regional or local events including tournaments and robotics leagues. By participating in multiple events, teams can learn from their failures, experiences, and improve their robot design within the same season (Robinson, 2014).

To illustrate the educational robotics competition growth and as reported by Robinson (2014) the VEX Robotics Competition (VRC), organized by the Robotics Education & Competition (REC) Foundation, is one of the international robotics competitions with the largest rates of participation in the world. VEX robotics reaches over 500,000 students in the world, 15,000 students in 29 countries, and 45 U.S. states compete in VRC events (Emeagwali, 2015). The REC Foundation (2018b) reported an audience of over 30,000 people that were composed of 1,648 teams from 30 different nations during their 11th annual VEX Robotics World Championship. This event took place at Louisville, Kentucky during the month of April for a full week of competition. This event broke their already established Guinness World Record title of the largest educational robotics competition (REC Foundation, 2018b).

VRC was developed with the out-of-school setting in mind. Teachers like the VEX platform for its affordability, sustainability, flexibility, accessibility to educational materials that assist them as facilitators of learning experiences, and for its opportunity for their students to “play” in multiple events. Also, students like VEX for the video game-like environment (controlling a robot with a joystick), its competitive nature similar to high school sports, and “because it’s fun” (T. Norman, 2011, p. 2; see also R. T. Johnson & Londt, 2010). As presented by Robinson and Stewardson (2012), in VRC the learning occurs not only at the competition events but it also spans throughout the entire robotics season and covering many math, science, and technology benchmarks. Students working in small teams experience the scientific method and the design process by researching, generating ideas, exploring possibilities, and building and testing robot prototypes.

Robinson (2014) detailed multiple student outcomes from participation in VRC derived from math, science, technology, and 21st-century skills. For example, particularly mathematics, students need to calculate ratios for simple and compound drive trains that will propel the robot by means of gears, sprockets, wheels, and chains; utilize geometry concepts to design a stable robot's structure and chassis; employ optimization algorithms and dynamics system theory to design lift mechanisms; and other math-related topics (Coxon, Dohrman, & Nadler, 2018; Robinson, 2014)

Conceptual Framework

According to Grant and Osanloo (2014), the primary purpose of the conceptual framework in a research study is to guide the researcher in assembling a guiding structure, which the researcher judges as appropriate to best explain the natural progression of the phenomena being studied (Camp, 2001; Grant & Osanloo, 2014). The conceptual theories for this study were grounded in D. A. Kolb's (1984) experiential learning theory (KELT), Kolb's experiential learning cycle, and Kolb's learning styles. When combined, these theories provided a framework with meaningful pedagogical implications for students involved in out-of-school educational robotics competitions, their academic performance in mathematics, and their participation's influence to pursue a STEM college degree.

Kolb's Experiential Learning Theory (KELT)

According to D. A. Kolb (1984), learning is a holistic continuous process of adaptation. Kolb's cycle of experiential learning guides the learning process where knowledge is created through the transformation of experience (D. A. Kolb, 1984). Action is at the core of experiential learning. It proposes that learning is action. It is an active process in which most of what a student learns and understands is generated by continuous learning grounded in concrete experiences. Learning occurs in small groups, and teachers are facilitators of learning experiences (Baker & Robinson, 2016; Barker & Ansorge, 2007; Barrows, 1996). Students involved in experiential learning are in charge of their own learning, look for new knowledge based on their own interest, and are better equipped to understand and simplify abstract concepts (Pressley, Hogan, Wharton-McDonald, Misretta, & Ettenberger, 1996). The outcomes of this approach include better long-term retention, development of critical thinking, problem-solving skills, and an increase in student motivation (Baker & Robinson, 2016; G. R. Norman & Schmidt, 1992).

According to Beaudin (1995), one of the most notorious advocates for experiential learning was John Dewey in the 1930s. Dewey emphasized the importance between experience and education. Dewey stressed the importance of having connections with the events of life and knowing the interpretation of such events through academia. Fifty years later, D. A. Kolb (1984) reignited the conversation on the importance placed on translating abstract ideas with practical and concrete real-world applications. D. A. Kolb argued that the exposure to practical learning experiences in schools was necessary to better prepare students for the real workforce (see also Beaudin, 1995). Additionally, research indicates that experiential learning improves both academic and social development in students generated by the required social interactions and cooperative learning (Baker & Robinson, 2016; Bergsteiner, Avery, & Neumann, 2010; Slavich & Zimbardo, 2012).

Experiential Learning and Mathematics Achievement

Mathematics is a mental activity perceived as a culture of formal thinking (Prediger, 2001). Regarding mathematics achievement, Prediger (2001) insisted in the importance of developing the ability to grasp abstract concepts. A. Y. Kolb and Kolb (2012) formulated the cycle of experiential learning based on the experiential learning theory (ELT) developed by D. A. Kolb (1984), which helps distill and assimilate abstract concepts. The cycle is based on four modes of transforming experience into knowledge: concrete experience, abstract conceptualization, reflective observation, and active experimentation (A. Y. Kolb & Kolb, 2012). Kablan (2016) reported that based on Kolb’s learning styles derived from the ELT, concrete learners showed higher performance in mathematics when exposed to manipulatives (Kablan, 2016). Similarly, Shih, Chang, Chen, Chen, and Liang (2012) found that through the implementation of Kolb’s learning cycle students can increase their mathematical achievement levels along with the stimulation of collaboration between them (Shih et al., 2012). Would experiential learning be helpful in promoting an interest in STEM programs among students who are underrepresented in these fields? Consequently, would experiential learning affect student achievement in STEM courses, such as mathematics?

Statement of the Research Problem

Multiple studies report the growing concern of industry leaders and policy makers regarding the shortage of a quality U.S. STEM workforce. This concern originates from statements from different studies that indicate that the prosperity, economic stability, global competitiveness, and national security of this country depends on the capacity to satisfy the growing demand of the U.S. STEM labor market (Ball et al., 2017; Hom, 2014; Lembo, 2016). To illustrate, the U.S. Bureau of Labor Statistics (2015) reported that there were about 8.6 million STEM jobs. From 2009 to 2015 the demand grew 10.5%. Although the gap between the growing demand for STEM workers and the condition of the current pipeline to produce them keep increasing, as presented by the Smithsonian Science Education Center, current estimates suggest a deficit of 2.4 million workers to satisfy the U.S. STEM workforce by 2018 (“The STEM Imperative,” 2018). Furthermore, females and minorities keep falling behind in representation in STEM fields, an opportunity niche which has not yet been fully explored or tapped to strengthen the U.S. STEM workforce (Doerschuk et al., 2016; Kotok, 2017).

The world is changing rapidly, and the need to increase the pipeline for these jobs is critical. It can begin in secondary schools. In order to attract high school students to high-level math courses that include Pre-Calculus and calculus, creativity and innovation in teaching and learning are necessary. Thus, the use of robotics in education is relevant, exciting, and fun for students (Cerge, 2014; Nugent, Barker, Grandgenett, & Welch, 2016). Recent studies indicate the potential of robotics to impact students’ cognitive, metacognitive, and social skills (Afari & Khine, 2017; Eguchi, 2016). Furthermore, several studies have demonstrated that the utilization of robotics in education can intensify the engagement and interest in STEM fields and careers (Kim et al., 2015; Mohr-Schroeder et al., 2014).

The implementation of robotics in education may offer the innovation that could be helpful in both attracting students’ attention and interest in STEM fields and improving their academic achievement. Most research involving robotics in education provides results related to teacher or student perceptions. There is a clear lack of research studies based on the use of educational robotics and student achievement data (Barker & Ansorge, 2007; Benitti, 2012; Mac Iver & Mac Iver, 2013). More information is needed on the direct impact of robotics on students' learning and personal development (Alimisis, 2013; Barker & Ansorge, 2007; J. Johnson, 2003). If student achievement is impacted by participation in out-of-school robotics competitions, this information could be utilized by schools to impact or influence the implementation of programs like these in schools.

Purpose Statement

The purpose of this mixed-methods ex post facto study was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino/a students in Southern California who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and high school Latino/a students who did not participate in out-of-school high school educational robotics competitions. A secondary purpose was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino (male) and Latina (female) students that participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions in Southern California. A third and final purpose was to describe the experiences of Latino/a college students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and how these experiences influenced their interest in enrolling in college courses leading to a STEM college degree.

Research Questions

Central Research Question

Do Latino/a students who participate in out-of-school high school educational robotics competitions perform better in mathematics courses in high school, and are these students influenced to pursue college STEM degrees?

Quantitative Research Questions

1. Do Latino/a students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latino/a students who do not participate?
2. Do Latino (male) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latina (female) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years?

Qualitative Research Questions

3. How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?
4. How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?

Significance of the Problem

The unvarnished contrast between the demographic segments of the U.S. population as a whole and that of science, technology, engineering, and mathematics (STEM) career and college professionals has created anxieties in economic and educational policy circles for the past decades (Doerschuk et al., 2016; Means et al., 2017). The shortage of females and minorities in these fields in school breeds uncertainty in the capacity to produce a high quality and adequate pipeline of STEM professionals to sustain this country’s economic prowess and leadership in the world (Ball et al., 2017; U.S. Department of Labor, 2017). Although females comprise almost half of the population (U.S. Census Bureau, 2016), they remain underrepresented in STEM fields (U.S. Department of Labor, 2017). Further, Latinos/as represent the largest ethnic minority and continue to grow in numbers but languish in participation in the STEM labor market (Hanson, 2013; Hinojosa et al., 2016; U.S. Department of Labor, 2017). Certainly female and Latino/a students represent an opportunity niche that has not yet been fully explored or tapped to strengthen the U.S. STEM workforce (Doerschuk et al., 2016; Kotok, 2017).

There is no specific solution to increase the number of students in STEM fields and careers, but focusing on academic achievement, particularly in mathematics performance, will open access to more college STEM options that currently are taken away because of the lack of math competency (Bright, 2017). Likewise, educational robotics represents a powerful, engaging tool for education because students can touch and manipulate hardware and software in an experiential-based environment resulting in mind and hands-on and self-directed learning. Moreover, participation in educational robotics promotes STEM career interest among students (Eguchi, 2016; Nugent, Barker, Grandgenett, & Welch, 2016). However, there is a gap in the literature regarding the lack of rigorous quantitative research on the role of educational robotics in student learning (Afari & Khine, 2017; Alimisis, 2013; Benitti, 2012; Nugent et al., 2016).

The findings of this study will provide valuable information on how participation in out-of-school high school educational robotics competitions can impact the academic performance in mathematics of Latino/a students. The results from this study will aid educational policy makers and school and district administrators in making decisions about innovative programming and corresponding investment in out-of-school robotics programs or comparable programs to benefit students. Similarly, the role of robotics in education should be considered as a tool to develop not only essential cognitive skills but also social and emotional skills (Alimisis, 2013).

Particularly, the discoveries of this research will help educators determine appropriate academic processes to engage Latino/a youth in school to attain academic success and build a pathway to careers in a field that is desperately in need of a workforce to serve the needs of this country. In addition, the results from this study will add insight to current literature in new innovative ways to educate and motivate students, particularly female and minority students maximizing their academic potential through the use of educational robotic activities.

Definitions

Latino/a or Hispanic. The U.S. Office of Management and Budget (OMB) identifies Latino or Hispanic as a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race.

Mathematics academic performance. Mathematics educational attainment that represents the student's ability to master the curricular material of a math course based on the grades recorded in the student’s high school transcripts.

Out-of-school educational robotics competition. A sports-like competition that includes a team approach to compete in a collaborative environment with a robot to sort out specific challenges within a determined timeframe and a common kit of parts. Each team’s robot needs to comply with specific rules, design guidelines, and construction constraints.

STEM. STEM is an acronym for science, technology, engineering, and mathematics.

STEM fields. As defined by the National Science Foundation (NSF), STEM fields include mathematics, natural sciences, engineering, computer and information sciences, and the social and behavioral sciences–psychology, economics, sociology, and political science.

Delimitations

This study was delimited to Latino/a high school students in Southern California that participated in VEX Robotics League Competitions (VRC) for a minimum of 2 consecutive years. Additionally, it was also delimited to Latino/a college students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions in Southern California.

Organization of the Study

Chapter I presented the background to the problem, conceptual framework, the statement of the research problem, purpose statement, research questions, significance of the problem, and the delimitations of the study. The remainder of the study contains four chapters, references, and appendices. Chapter II explores the literature on STEM education, the role of mathematics in STEM education, females and Latinos/as in STEM, educational robotics including out-of-school high school educational robotics competitions, and a review of the theoretical framework. Chapter III explains the research design and methodology of the study. This chapter also includes a description of the population, the sample, data gathering procedures, and procedures used to analyze the data collected. Chapter IV presents the results of the data analysis, the study's major findings, and provides a discussion of such findings. Chapter V offers a summary of the study's conclusions, implications of the study, and recommendations for action and future research.

CHAPTER II: REVIEW OF THE LITERATURE

This chapter provides an in-depth review of research and literature related to the variables of this study. This literature review is divided into six major sections. The first section covers relevant information related to science, technology, engineering, and mathematics (STEM) education, including a brief history of STEM education, importance of STEM education, the U.S. STEM workforce, and the status of the high school pipeline into STEM careers. The second section addresses females and their participation in the STEM workforce. The third section reviews Latinos/as in the United States, including an explanation about the differences between Latinos/as and Hispanics, academic achievement of Latinos/as, and concludes with Latinos/as and their participation in STEM education and careers. The fourth section of this review presents a summary of the role of mathematics in STEM education, covering the importance and significance of mathematics in STEM. The fifth section details studies related to educational robotics, including a brief history of educational robotics, the impact of educational robotics in STEM education, and educational robotics competitions and mathematics. The last section of this review includes a summary of the experiential learning theory (ELT), including Kolb’s experiential learning theory (KELT), Kolb’s experiential learning cycle, experiential learning styles, and experiential learning and its impact on mathematics achievement.

Several methods were used to retrieve literature related to this study. Books, e-books, academic journals, peer-reviewed journals, articles, doctoral dissertations, and organizational websites provided the greatest amount of essential information. ProQuest, ERIC (EBSCO Information Services), SAGE Knowledge, and Web of Science, were some of the databases used. Individual terms searched in the literature included science, technology, engineering, and mathematics (STEM), STEM education, STEM workforce, Hispanics, Latinos/as, females and STEM, Latinos and STEM, educational robotics, robotics competitions, mathematics achievement, mathematics and STEM, and experiential learning. Appendix A shows the synthesis matrix used to compile research resources used to undergird the literature review presented in this chapter.

STEM Education

In recent years, the term *STEM* has emerged in schools as a synonym of innovation, although its meaning continues to be a topic for debate (Brown, Brown, Reardon, & Merrill, 2011; Vilorio, 2014). Breiner, Harkness, Johnson, and Koehler (2012) argued that the definition of STEM education varies greatly as it relates to instruction dependent on educational grade levels, especially in mathematics and science (see also Bybee, 2010). At the elementary grade levels, STEM education is provided in curriculum specifically for mathematics and science instruction by scope and sequence and aligned with a specific grade level and the standards required. The content is embedded in the general class curriculum. At the secondary grade level, the curriculum is more specialized and progressively becomes more complex to include several strand courses derived from mathematics and science such as Algebra, Geometry, Calculus, Biology, Chemistry, and Physics. Similarly, at these secondary educational grade levels, there are also specific STEM-related elective courses like computer science and career technical education pathways that students can select (Xie, Fang, & Shauman, 2015). At the undergraduate and graduate grade levels in college, STEM education is designed in courses of study that develop specific sequences in very explicit career fields such as Mechanical Engineering and Environmental Science (Xie & Killewald, 2012).

In a study related to describe the characteristics of STEM, Breiner et al. (2012) reported that there is no shared concept or definition of STEM. A survey conducted by Keefe (2010), with professionals in STEM-related fields, revealed that the majority of educators do not have a clear understanding of the acronym. Further, most survey respondents associated the acronym to plants or stem cell research (Keefe, 2010). Similarly, Brown et al. (2011) questioned faculty and students of a graduate program in STEM Education and Leadership at the University of Illinois and found that the concept of STEM education is not clearly defined or understood. According to Bybee (2010), STEM is understood frequently as a term related only to mathematics and science. Equally important, Bybee (2010) noted that there was a concern that needs to be addressed to the importance of the “T” and the “E” in STEM, which stand for technology and engineering. In general terms, technology and engineering are often times forgotten in the STEM educational community (Bybee, 2010).

With the understanding that technology and engineering play a crucial role in the well-being of this nation, there has been a transition in the educational community related to STEM fields from a focus on mathematics and science to an integrative concept of STEM and STEM education (Sanders, 2008). Chesky and Wolfmeyer (2015) stated that mathematics and science alone are not enough to acquire the knowledge required by current world citizens. Technology and engineering need to interweave with mathematics and science (Chesky & Wolfmeyer, 2015). Further, an authentic STEM education is expected to build students’ conceptual knowledge of the interrelated nature of science and mathematics, in order to allow students to develop their understanding of engineering and technology (Hernandez et al., 2014).

STEM education should be considered as a discipline that emphasizes logical, conceptual connections through the various fields of STEM and the integration of their multiple fields as a whole (Xie et al., 2015). Rather than teaching the four disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications (Hom, 2014). Similarly, Bybee (2010) asserted that educators in the STEM community need to come together to define the term STEM to provide clarity in programs, practices, and policy implementations.

A Congressional Research Service (CRS) report prepared for members and committees of Congress defined STEM education as the activity to teach and learn in the fields of science, technology, engineering, and mathematics (STEM). The report alludes to the possibility that such teaching and learning activities occur across multiple educational levels, ranging from preschool to postdoctorate. In schools at all grade levels, these activities can be found in formal settings during the school day or during informal settings in after-school programs such as robotics (Granovskiy, 2018). Similarly, Hom (2014) defined STEM education as a curriculum-based concept of educating students in science, technology, engineering and mathematics in an interdisciplinary approach and also through applied approaches.

Brief History of STEM

The origins of STEM, or the formal idea of STEM education as a concept in the United States, can be traced back to the early 1900s (Bybee, 2010; Kelley & Knowles, 2016; Sanders, 2008). STEM education took place primarily in specialized schools for the gifted and talented students. However, the first specialized schools that were designed to meet the need of a technically trained workforce were created as early as 1922 (Rabenberg, 2013). Moreover, schools specifically designed for mathematics and science studies were developed as early as 1938, but it was not until the Soviet satellite Sputnik was launched in 1957 that the face of STEM education changed in the United States (Woodruff, 2013). Cold War anxieties provided the rationale for an increased emphasis in science and technology (Thomas & Williams, 2009). The Soviet satellite amplified America's Cold War fears that stimulated a public and political response. The Sputnik era is a symbol of significant reform in STEM education in the United States (Bybee, 2007).

Although there were multiple initiatives to concentrate on science and technology education, in 1989 the National Science Foundation (NSF) coined the term "SMET" for science, mathematics, engineering, and technology (Sahin & Mohr-Schroeder, 2015). Sanders (2009) declared that the first acronym adopted by the NSF combined all elements of STEM into a multidisciplinary approach. However, Chute (2009) described that in 2001, Judith Ramaley, then assistant director of education and human resources at NSF, reordered the letters of the SMET acronym to form the term STEM that we all know today. According to Chute, Ramaley explained that the new term showed a more meaningful connection by having *science* as the leading term and *mathematics* as the closing term, both foundational learning for technology and engineering. In addition, the new term (STEM) "had a much better ring to it" (Christenson, 2011, para. 4). Nevertheless, according to Bybee (2010), STEM education had its origins in the 1990s at the NSF and has been used as a generic label for any event, policy, program, or practice that involves one or several of the STEM disciplines.

Importance of STEM Education

America has been known as a global leader mainly for its STEM impact in the world. However, this leadership has been threatened by the lack of students pursuing expertise and careers in STEM fields (Allen-Ramdial & Campbell, 2014; Granovskiy, 2018; Hinojosa et al., 2016). America's economic global competitiveness depends on an adequate supply of high-quality innovative workers in STEM fields (National Science Board, 2014). As an example, there is no agreement on precise numbers, but China and India may be threatening America's economic competitive superiority (Gereffi, Wadhwa, Rissing, & Ong, 2008). While the United States is producing fewer STEM majors than China or India, there is also an underrepresentation of STEM degrees earned by minority students (Byars-Winston, Estrada, & Howard, 2008; Chen & Weko, 2009). According to Colvin (2005), the United States produced roughly 70,000 undergraduate engineers in 2004, while China graduated 600,000 and India 350,000 (Gereffi et al., 2008). More recently, McCarthy (2017) stated that China produced 4.7 million STEM graduates in 2016, and when compared with all of China's college graduates, this represents 6% of its graduates. If this number of graduates is compared with China's general population, this accounts for approximately 0.33%. Conversely, the United States produced in the same year 568,000 STEM graduates, which translates to 0.84% of all U.S. college graduates and only 0.17% compared to the country's general population (McCarthy, 2017).

U.S. STEM Workforce

Over the past decade, there has been a growing concern among policy makers, practitioners, and researchers that America is falling short in producing the next generation of talent to fill STEM jobs in the United States (President's Council of Advisors on Science and Technology 2010; Reider et al., 2016; Ybarra, 2016). Noonan (2017) indicated that the STEM workforce helps drive U.S. innovation and competitiveness by generating new ideas and new companies. It has an enormous impact on this nation's competitiveness, economic growth, and overall standard of living. Noonan expanded this idea, indicating that STEM workers drive innovation (as measured by patents), and they have the flexible skills needed for the modern economy. At a time when firms across the nation cite difficulty matching skilled workers to job openings, the ability of STEM workers to adapt to new circumstances and processes makes them highly sought after (Noonan, 2017).

According to research by the U.S. Department of Commerce, the U.S. STEM workforce is crucial to America's innovative capacity and global competitiveness (Beede et al., 2011). The American Immigration Council (2017) pointed out that the number of STEM workers available in the U.S. workforce increased only 1.8% by 1990 and 5.2% by 2000. Between 2000 and 2015, America experienced a slight decline of 5%. Conversely, as indicated by Fayer, Lacey, and Watson (2017), the U.S. Bureau of Statistics reported about 8.6 million job offerings related to STEM occupations, which represented 6.2% of total U.S. employment. All STEM occupations are projected to grow at an average rate of 6.5% from 2014 to 2024. Between the same years, the STEM field with the highest growth projection of 28.2% is in the mathematical science occupations such as mathematicians and statisticians (Fayer et al., 2017). Similarly, a research report by the Department for Professional Employees (DPE, 2016), indicated that computer and mathematical-related occupations increased significantly from 2005 to 2015, accounting for 79.5% of all STEM occupational growth with 1,123,000 jobs added in this timeframe. During the same period, 161,000 jobs were added in the occupations of architecture and engineering, 129,000 jobs were added in the physical, life and social science occupations. In addition, the rates for unemployment for STEM workers continue to be under the national unemployment average (DPE, 2016).

The President's Council of Advisors on Science and Technology (PCAST) advised the president in a 2012 report that based on the current production rate for STEM professionals, America requires the production of one million more STEM professionals within the present decade. Likewise, PCAST emphasized the urgency of incrementing the number of undergraduate students in STEM majors by about a 34% rate annually compared to current rates, increasing student retention in STEM majors, and inclusion of female and minority students such as Latinos/as (Olson & Riordan, 2012).

STEM Occupations

Similar to educational professionals at various levels in careers, the American Immigration Council (2017) reported that there is no clear definition of a STEM occupation (Fayer et al., 2017; Vilorio, 2014). According to Landivar (2013), all federal statistical agencies use STEM definitions based on the Standard Occupational Classification (SOC) Manual. This manual was developed by the Standard Occupational Classification Policy Committee (SOCPC), and its purpose is to collect, calculate, and disseminate data related to occupations (American Immigration Council, 2017). The

SOC mainly organizes workers on the kind of work they perform and occasionally on the skills, education, or training needed to perform such type of work (Landivar, 2013).

For example, and based on the *SOC Manual*, Vilorio (2014), in a quarterly outlook report of the U.S. Bureau of Labor Statistics (BLS), identified 96 STEM occupations in six different groups: (a) management; (b) computer and mathematics; (c) architecture and engineering; (d) life, physical, and social sciences; (e) education, training, and library; and (f) sales and related. Similarly, Fayer et al., (2017), in a BLS report regarding the past, present, and future of STEM occupations, classified STEM occupations based on data from Occupational Employment Statistics and Employment Projections. The data included 100 STEM occupations divided in 11 different types: (a) mathematical science; (b) architects, surveyors, and cartographers; (c) STEM-related postsecondary teachers; (d) physical scientists; (e) life scientists; (f) life and physical technicians; (g) STEM-related sales; (h) STEM-related management; (i) drafters, engineering technicians, and mapping technicians; (j) engineers; and (k) computer occupations (Fayer et al., 2017).

Moreover, in a fact sheet developed by the American Immigration Council (2017), STEM occupations were classified into sets: (a) a narrow STEM definition with 46 STEM occupations and (b) a STEM plus health and social sciences definition with 87 STEM occupations. The STEM plus health and social sciences definition excluded STEM occupations in higher education but included occupations in health care such as physicians, therapists, nurses, and technicians. It also included STEM occupations in social science such as psychologists, economists, and social scientists and researchers. The two definitions were based on the lists of STEM occupations from the U.S.

Department of Commerce (DOC) and the U.S. Bureau of Labor Statistics (BLS). The lists from DOC and BLS used the *SOC Manual* (American Immigration Council, 2017). Regardless of the STEM occupations' classification, Vilorio (2014) asserted that the BLS projected a 13% growth in STEM employment between 2012 and 2022. This represents a faster growth rate over all occupations in more than 10 years. A significant number of STEM occupations require a bachelor's degree, but others require at least a high school diploma and specialized training. Above all, in order to increase participation in STEM occupations, it is important to take advantage of the variety of STEM classes offered in high school, including mathematics, science, computer science, career technical education, and advanced placement (AP) courses (Vilorio, 2014).

High School Pipeline Into STEM Careers

The STEM workforce relies on the STEM pipeline to produce qualified and talented STEM professionals. This pipeline starts in early pre-K days and runs through kindergarten, elementary, secondary, postsecondary, college, and graduate-level schools (Lyon, Jafri, & St. Louis, 2012). The metaphor of a "pipeline" is frequently used to describe the "flow" of students through the educational system to culminate into a STEM career (Allen-Ramdial & Campbell, 2014). The "leaks" in the pipeline are referred to when the students do not continue in the STEM flow (Ball et al., 2017). In a recent study by Doerschuk et al. (2016), it was affirmed that the production of students majoring in STEM fields is not keeping pace with the increasing demand of STEM professionals. Likewise, a report by the National Science Board (NSB, 2010) announced tendencies for students to have a lack of interest in pursuing STEM majors, particularly females and underrepresented minority students (NSB, 2010).

In addition, a report by the College Board affirmed that students are not entering college equipped to succeed in STEM majors (Smith et al., 2018). This includes high school students who proclaimed interest in STEM (Smith et al., 2018). Conversely, Le and Robbins (2016) argued that it is not just a matter of academic ability but also the proper STEM interest fit. However, ability is more stable over time than interest fit as an indicator to determine selection, retention, and success in a STEM major (Le & Robbins, 2016). Hinojosa et al. (2016) identified several factors that can predict success in STEM majors that start at the high school level: (a) academic rigor, which includes enrollment in high-level mathematics and science classes such as AP courses, (b) students' interest or confidence in STEM, (c) students' satisfactions with their teachers, and (d) levels of parent participation. Above all, very few students pursue a STEM degree and an even smaller group of students is able to attain it. Comparing the United States with the rest of the world, America has one of the lowest ratios between non-STEM and STEM majors' completers (NSF, 2014). Many issues need to be addressed at each joint of the STEM pipeline, particularly at the secondary level (Doerschuk et al., 2016). As the demand for STEM professionals continues to grow, it is necessary to find ways to increase and maintain a steady flow of students in the STEM pipeline (Ball et al., 2017).

Females in STEM

A report by the U.S. Census Bureau (2018b) exhibited that there are almost 326 million Americans at the time of this study. The report also showed that 50.8% are females (U.S. Census Bureau, 2018b). Another trend, according to a report by the BLS in 2015, was that females tallied more than half of the total workforce of the country (BLS, 2017). The female workforce surpassed the 50% representation mark of all workers in the following industry sectors: education and health services with 75%, financial activities with 53%, leisure and hospitality with 51%, and other services with 52%. The female workforce peaked in employment participation in 1990 with 60% participation (BLS, 2017).

Moreover, in 2015, according to the BLS (2017), 41% of females actively engaged in the workforce and those ages 25 to 64 had at least a bachelor's degree. Fifty years ago, only 11% of females in the workforce had a bachelor's degree (BLS, 2017). In a recent report by the Pew Research Center (Graf, Fry, & Funk, 2018), based on data from the U.S. Census Bureau, in 2016, the STEM workforce accounted for 13% of the total U.S. workforce with 17.3 million workers. Since 1990, STEM occupations have increased by 79%. Computer occupations alone increased by 338% from 1990 to 2016, making it the STEM occupation with the greatest increase (Graf et al., 2018). Regardless of the high percentage of female participation in the U.S. workforce, the high educational attainment level of females involved in the workforce, and the increasing demand in the STEM workforce, females continue to be underrepresented overall in STEM occupations (Graf et al., 2018; Landivar, 2013; Sassler, Glass, Levitte, & Michelmore, 2017; Ybarra 2016). Equally noted and as reported by the National Science Board (2018), Hispanic females (Latinas) account for only 6.2% of all females involved in science and engineering fields.

Possible Causes for Female Underrepresentation in STEM

Female participation in the STEM workforce varies broadly per occupation ranging in 2017 from 7% in sales engineering or 8% in mechanical engineering to 96% in speech language pathologists or 95% in dental hygienists fields (Graf et al., 2018).

According to the U.S. Census Bureau, since 1970, the participation of females in STEM occupations has shown uneven growth (Landivar, 2013). In 1970, females in STEM had only 3% participation in engineering, 14% in life and physical science, 15% in mathematics and computers, and 17% in social science research (Landivar, 2013). Likewise, the NSF (2017) reported that female participation in the science and engineering workforce fluctuates widely by occupation. For example, females are more likely to be employed in life science occupations such as technicians, technologists, or psychologists. However, females employed in health-related occupations are less likely to be employed as physicians, surgeons, or dentists (NSF, 2017). Equally important, in recent decades the participation in STEM employment for young females showed limited growth since 1990 (Landivar, 2013).

A study from Ybarra (2016) asserted that many of the issues related to female underrepresentation in STEM are consequences from the past. A combination of societal barriers, institutional hurdles, and inadequate government policies have obstructed the advancement of females in STEM (Ybarra, 2016). Sassler et al. (2017) declared that the shortage of female representation in STEM can be attributed to this nation’s historical legacy. Simply put, females have not been motivated to aspire to become STEM professionals (Sassler et al., 2017). Moreover, a research analysis study conducted by Wang and Degol (2017), which included multiple studies in the fields of sociology, education, economics, and psychology over the past 30 years, summarized in six main points the possible reasons for female underrepresentation in STEM fields, particularly for math-intensive fields such as engineering and computer science. These reasons include gender biases and stereotypes, lifestyle preferences, ability beliefs per specific field, personal and occupational interests, cognitive ability, and relative cognitive strengths (Wang & Degol, 2017).

In a separate study, Sassler et al. (2017) posed historical gender inequality and discrimination as the main causes for female underrepresentation in STEM. The study found that females and males have not benefited equally from their family's upbringing. Family expectations and transition into STEM careers are different for females and males. For example, married males who transition into STEM probably will receive spousal support and have less family responsibilities. Conversely, married females who transition into STEM careers may be treated differently. Females are expected to adhere to more conventional gender ideologies such as less spousal support and considerably more family responsibilities (Sassler et al., 2017).

Diekman, Weisgram, and Belanger (2015) presented a more novel reason to explain the underrepresentation of females in STEM and to justify their overrepresentation in specific STEM fields such as healthcare occupations and social research. Diekman et al. suggested that females certainly have the ability to pursue and succeed at STEM careers, but most STEM fields discourage female participation due to the very nature of those careers. STEM fields are believed to hinder communal goals such as altruism or collaboration (Diekman et al., 2015). Females are concerned with helping others. They are more people oriented (Diekman et al., 2015; Su & Rounds, 2015). Regardless of the hypotheses related to causes for female underrepresentation in STEM fields, females provide an abundance of human capital and potential to encourage recruitment of their skills and talents in order to increase the quantity and quality of

STEM professionals in America (Diekman et al., 2015; Su & Rounds, 2015; White & Massiha, 2016).

Latinos/as in the United States

According to a recent U.S. Census Bureau's population projection report (Colby & Ortman, 2015), America will reach 400 million people by 2051 and 417 million by 2060. The annual average growth rate is estimated at 2.1 million people. Between the years 2014 and 2060, the projection indicated an increase of 98.1 million people (Colby & Ortman, 2015). In a similar report by the U.S. Census Bureau, Colby and Ortman (2014) pointed out that by the year 2030, the non-Hispanic White population will decrease to be 55% of the nation's population and only 43% by 2060. This phenomenon has been referred to as a "majority minority" nation, which means that the non-Hispanic White population will be less than 50% of the total population (Colby & Ortman, 2015; National Science Foundation, 2017). Moreover, between 2014 and 2060, according to a report by the National Science Foundation (2017) and based on data from the U.S. Census Bureau, Hispanics, Asians, and people of various races will account for the largest group growth (NSF, 2017).

The Latino/a population is predicted to increase 115% between 2014 and 2060. It accounted for 55 million in 2014, which represented 17.4% of the U.S. population, and it will grow to 119 million by 2060 with a 28.6% representation in the populace (Colby & Ortman, 2015; Gonzalez-Barrera & Lopez, 2015). A report by Gonzalez-Barrera and Lopez (2015) indicated that the Latino/a population grew faster than any other ethnic group between 1990 and 2013. In addition, Vela and Gutierrez (2017) asserted that in 2013, Latinos/as comprised almost half of the population under the age of 18 in three states: New Mexico with 59%, California with 52%, and Texas with 49%. In 2013, Latinos/as between the ages of 18 and 34, also known as millennials, were the biggest ethnic minority group in America (Vela & Gutierrez, 2017). Conversely, Flores (2017) indicated that in 2015, California had 15.2 million Latinos/as, which represented an increase of 39% from 2000 when there were only 10.9 million, turning California into the state with the largest Latino/a population in the nation, followed by Texas with 10.7 million in 2015.

Latinos or Hispanics

The U.S. Office of Management and Budget (OMB) requires all federal agencies including the U.S. Census Bureau to utilize either Hispanic or Latino or Not Hispanic or Latino terminology when collecting or reporting data about ethnicities. OMB identifies Hispanic or Latino as a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race. In addition, these terms do not reflect anthropological, genetic, or biological information but a social self-classification (U.S. Census Bureau, 2018a).

According to Telles (2018), both Latino and Hispanic are terms that originated in the United States. However, the term *Latino* might have its origins in the core name of Latin America, which was generated in the 18th century and was associated with a call by Simon Bolivar for a unified Latin America. This idea of uniting Latin America was also used in the 1950s and 1960s by Che Guevara. Later in the 1970s, it was used in literature and music. The Latin American term was also used in the 1960s by Mexican Americans in Texas as an ethnic identification, apparently to evade their identification as *Mexicans*, which was a term extremely stigmatized (Telles, 2018).

In 1977, the U.S. Congress approved Directive 15, which was presented by the OMB. This directive considered that Latinos/Hispanics were not a racial group but an ethnicity to be used in the U.S. Census. However, in social practice and publications by the U.S. Census Bureau, both terms are oftentimes used as separate categories. Before 1980, the U.S. Census utilized categories such as Mexican, Cuban, or Puerto Rican to refer to Latinos/Hispanics, which were the primary nations for individuals from Latin America in the United States (Telles, 2018). As noted by Mora (2014), in the 1970s, Mexicans, Cubans, and Puerto Ricans were segregated and discriminated against. For this reason and driven by the census and a coalition of interests groups formed by media and businesses, the *Hispanic* ethnic category was created (Mora, 2014). According to Garcia-Navarro (2015), the term Hispanic groups people from Latin America's origins who speak Spanish. However, this term excludes several groups of people. For example, individuals from Brazil speak Portuguese, and individuals from the French Guyana speak French. Further, people from Spain also speak Spanish but are not geographically from Latin America. *Latino/a* (*Latino* for males and *Latina* for females) or *Latinx* (gender-neutral individuals) is a more inclusive term that groups people from any Latin American descent regardless of their race or language (Garcia-Navarro, 2015). As described by McKeown (2017), the term *Latin America* describes a group of 21 countries located in the American continent south of the United States-Mexico border including countries like Argentina, Haiti, and Brazil. Latin American countries share elements of culture and historical experiences, and their official languages were originated from Latin, hence the term *Latin* America. These languages include Spanish, Portuguese, and French and are part of the legacy of the colonization process that started in the 16th century by Europeans (McKeown, 2017).

Racial self-identification varies significantly per Latin American country. For example, 20% of respondents who are of Mexican descent are confused or do not know how to respond when asked about their race. This could be attributed to the fact that Latin America has a rich history of race mixing. For instance, most Argentinians have a European (White) phenotype and dark-black skin. Brazilians are descendants from Africa while some Mexicans, Guatemalans, and Bolivians among others have an indigenous descent and consider themselves as "mestizos." With this in mind, the two questions about ethnicity and race used by the U.S. Census since 1980 might adequately capture the ethnicity of the Latino/Hispanic group but fails at capturing the group members' race by not acknowledging and understanding their racial diversity (Telles, 2018).

Latinos/as in STEM

As reported by the BLS, in 2017, Latinos/as accounted for 17% of the U.S. labor force. Moreover, among adult men age 20 years and older, Latinos were more likely to participate in the labor force than other ethnic groups (BLS, 2018). Despite Latinos/as' increasing representation in the U.S. population, they still lag behind other groups in obtaining a 4-year degree. As of 2014, among Latinos/as aged 25 to 29, just 15% had a bachelor's degree or higher. By comparison, among the same age group, about 41% of Whites had a bachelor's degree or higher, followed by Asians with 63% and Blacks with 22%. This gap is due in part to the fact that Latinos/as are less likely than some other groups to enroll in a 4-year college, attend an academically selective college, and enroll full time (Krogstad, 2016a).

Latinos/as are substantially underrepresented in STEM education and occupations (Business-Higher Education Forum, 2011; Hanson, 2013). Since 1970, Latinos/as have been consistently underrepresented in STEM occupations. Although the Latinos/as' share of the workforce has increased significantly, from 3% in 1970 to 15% in 2011, Latinos/as make up only 7% of the STEM workforce. The Latino/as' share of STEM occupations has not kept pace with the increase in the Latinos/as' share of the workforce (U.S. Census Bureau, 2013). Latinos/as' participation in STEM education and consequently in STEM careers is a concern both in terms of sustainability of the STEM workforce and in terms of equitable opportunities (Hinojosa et al., 2016). The growing shortage of STEM specialists, well-trained technical workers, scientists, and engineers, and the need for competitiveness in STEM fields is at odds with the underrepresentation of one of this nation's largest future talent bases–Latinos/as (Hanson, 2013).

The Role of Mathematics in STEM Education

Regardless of the college major, mathematics competence is one of the gateway skills that students need to possess for entry into college (Conley, 2008). As described by Conley (2008), successful college students display the following mathematical skills:

- Think conceptually, not just procedurally, about mathematics.
- Use logical reasoning and common sense to find mathematical solutions.
- Think experimentally and exhibit inquisitiveness and willingness to investigate the steps used to reach a solution.

- Take risks and embrace failure as part of the learning process.
- Be able to use formulas and algorithms of computation. (p. 190)

The development of mathematical reasoning is considered a gatekeeper that strongly influences students' future decisions about college and careers. Consequently, inadequate mathematical preparation may negate students' access to many careers, particularly STEM majors that require mathematical competency (McDonald, 2016). As denoted by Coxon et al. (2018), mathematics is indeed a gatekeeper for STEM majors particularly for careers such as engineering and computer science.

One of the most predominant hypotheses regarding student enrollment, retention, attainment, and success in STEM can be attributed to the student's academic ability, particularly in mathematics (Ayebo, Ukkelberg, & Assuah, 2017; Bright 2017; Green & Sanderson, 2018). Bright (2017) discussed that the student's ability to successfully complete high-level math courses, like calculus, in high school is a common denominator for admission into the majority of STEM majors. The lack of mathematics competency at the secondary level limits students' options for college majors especially for STEM-related degrees (Bright, 2017). Moreover, Ayebo et al. (2017) argued that although there are numerous factors that assess students' college readiness, one of the most important factors is the uppermost level of mathematics taken by the student in high school. Enrollment in secondary mathematics courses above Algebra II have a significant effect on students completing a college degree. This factor has a greater impact on students' college completion compared to other factors like parents' educational background, family socioeconomics, and even ethnicity (Ayebo et al., 2017). As reported by Riegle-Crumb and King (2010), students interested in pursuing and attaining a STEM college degree need to successfully follow a mathematics course sequence in high school that starts with Algebra or Geometry and concludes with higher level math courses such as Trigonometry, Pre-Calculus, and Calculus. Even for students who do not show interest in STEM college degrees, if they take Pre-Calculus and Calculus in high school, it is more likely to help them switch to a STEM major when enrolled in college (Green & Sanderson, 2018).

Moreover, a study by Redmond-Sanogo, Angle, and Davis (2016) found that a conclusive determining factor of successful completion of STEM college gatekeeper courses such as Calculus, Physics, and Chemistry can be traced back to the student's performance in secondary Pre-Calculus and Calculus courses regardless of ethnicity or gender. A longitudinal study by Ma and Johnson (2008) on mathematics coursework and its effect on gender career choices identified Algebra II as a critical filter for male students' choices of college and career. However, Calculus was found to be a critical filter for female students who steered away from STEM majors (Ma & Johnson, 2008).

Although mathematics is considered as one of the most abstract, complex, and complicated subjects by a majority of people, it is the most accessible to students (Papert, 1980). Interestingly, according to Miller and Kimmel (2012), when mathematics courses are compared with science courses as a factor to influence students to enter a STEM career, science courses show a minimal positive effect at every educational level while mathematics courses demonstrate a much higher impact. Additionally, Green and Sanderson (2018) claimed that even for students not interested in STEM, positive high school mathematics experiences have a greater influence on their possibility of pursuing STEM majors. At the college entry level, incoming non-STEM majors that took higher level math courses in high school such as calculus have a 29% probability of switching into STEM (Green & Sanderson, 2018). In addition, incoming nondeclared college major students who took at least Pre-Calculus in high school have a 20% probability of declaring their major to be in STEM (Green & Sanderson, 2018). Thus, increasing the number of high school students who take high-level math courses will drive an increase in the number of students pursuing a STEM college degree (Green & Sanderson, 2018). Interest in STEM combined with secondary mathematics preparedness will increase the number of students entering the college STEM pipeline and consequently strengthen the STEM workforce (Redmond-Sanogo et al., 2016).

National and International Mathematics Achievement at the Secondary Level

According to a recent report by the U.S. Department of Labor (2017) on the condition of education and through the evaluation of the National Assessment of Educational Progress (NAEP), it was found that 25% of 12th-grade American students performed at or above proficient level in 2015, which was not significantly different from the previous assessment conducted in 2005. The NAEP measures student performance in mathematics in Grades 4, 8, and 12 in private and public schools in the United States. Particularly for 12th-grade mathematics results, the students’ scores range from 0 to 300. The average score for Asian/Pacific Islander students was 170, White students was 160, Latino/a students was 139, American Indian/Alaska Native students was 138, and African American students was 130. Mathematics scores for White students have been higher than scores for Latino/a, American Indian/Alaska Native, and African American in 2009, 2013, and 2015. The 2015 average mathematics scores for 12th-grade male students was 153 and for 12th-grade female students was 150. These scores were lower than the scores in 2013, which were 155 for male students and 152 for female students (McFarland et al., 2017).

At the international level, the Organization for Economic Cooperation and Development (OECD) organizes the Program for International Student Assessment (PISA). The OECD has evaluated math, reading, and the science performance of 15-year-old students every 3 years since 2000. In 2015, PISA results for mathematics were presented by an average scale ranging from 0 to 1,000. All 35 OECD member countries participated plus 696 additional countries. The U.S. average mathematics score was 470, which was lower than the OECD average score of 490. Singapore led the scoreboard in mathematics with an average score of 564. The United States was 36 countries below Singapore including China, Japan, Korea, Denmark, Germany, France, Spain, and Hungary among others. Regarding mathematics literacy, PISA manages six proficiency levels, with Level 6 being the highest and Level 1 the lowest. Students with scores above Level 5 demonstrated proficiency in mathematical reasoning skills and advanced mathematical thinking. The United States had 6% of students who scored at or higher than Level 5, which was lower that the OECD average of 11%. Singapore led with 35% of their students at Level 5 or higher. The United States was 38 nations lower than Singapore’s level scores (McFarland et al., 2017). Regardless of ethnicity or gender, student mathematics proficiency is a predictive indicator of academic success for students pursuing college degrees, particularly STEM-related degrees. Consequently, educators and policy makers in this country should be encouraged to implement effective interventions to improve students’ mathematics competency throughout the K-12 educational system (Redmond-Sanogo et al., 2016).

Robotics

As denoted by Emeagwali (2015), in the last 2 decades, America has experienced multiple technology advancements that involve robotics, artificial intelligence (AI), computer science, and a combination in between. Movies, television shows, books, magazines, and the Internet have helped spread interest, curiosity, and wonder at the possibilities of the future (Emeagwali, 2015). From the 1960s through the 1980s, people in America enjoyed watching a television show called *The Jetsons*. No one at the time ever imagined that a robot cartoon character named Rosie could ever become a reality (Eguchi, 2014). Recently, the collaboration between Softbank Robotics, a Japanese company, and Aldebaran Robotics, a French company, released a family of humanoid robots that were designed to interact with humans—NAO, Romeo, and Pepper. These robots are used in different industries such as retail, tourism, finance, healthcare, and education helping with different tasks (Eguchi 2014; SoftBank Robotics, 2018). This is a miniscule example of the robotics revolution that this nation is experiencing. Robots are everywhere: in automobiles, in home appliances, on land, underwater, in the air, in operating rooms, on production lines, in search and rescue, and in military applications. And the demand for robotics keeps increasing (Dang, 2018).

Friedman (2006) stated that in the last decades, the world has become "flat" (p. 5), referring to its interconnectivity and the flow of information. This can be attributed to the fast-paced technological advancements that we experience in all human endeavors and the inter-multi-connections across the world through the Internet with multiple technologies of mobile phones and social media (Eguchi, 2014; Friedman, 2006). Frey and Osborne (2013) declared that within 2 decades, about half of the current jobs in

America are projected to be replaced by robotics systems or computer programs. The new employment market will require people who are capable of designing, repairing, or maintaining robots (Coxon et al., 2018).

Educational Robotics

The current technology publicity generated by traditional media and the Internet provides the perfect venue for students to be exposed to and explore STEM fields and careers (Eguchi, 2016). Moreover, with the acknowledgement that the world is changing precipitously because of the pacing of technology innovations, robotics plays a strategic role in utilizing and maximizing its benefits in education (Afari & Khine, 2017). Nugent, Barker, Grandgenett, and Welch (2016) noted that the use of robotics in education represents an attractive mechanism for students because they can use their hands to touch and manipulate the robots, which becomes a memorable learning experience that engages students' minds. This hands-minds-on experience results in the development of self-directed learners driven by their curiosity (Nugent, Barker, Grandgenett, &Welch, 2016). Druin and Hendler (2000) asserted that robots and dinosaurs top the list of attention grabbers when engaging school-age students. Robots are also very effective at attracting the attention of students toward career pathways related to STEM (Druin & Hendler, 2000; Emeagwali, 2015; Merdan, 2017). Robotics challenges students in a multidisciplinary STEM context, addressing real-life societal needs, and promoting the development of 21st-century skills such as critical thinking, teamwork, collaboration, communication, creativity, and entrepreneurial abilities (Merdan, 2017).

Atmatzidou and Demetriadis (2016) reported that robotics in education (RIE), also known as educational robotics (ER), can be traced back to Seymour Papert's (1980) work in the late 1970s. Papert created a programming language called Logo to program a mechanical turtle (robot) that assisted children in learning mathematics, primarily geometry. According to Papert, effective learning occurs when students discover and experience knowledge by themselves. Papert's work was based on Jean Piaget's studies on children's learning experiences. Coincidentally, Papert was a mathematician that became Piaget's protégé while working together at the University of Geneva from 1958 to 1963. The current trends in educational technology including robotics can be connected directly to Piaget through Papert's work (Blikstein, 2013). Papert (1980) discovered that robotics used in education has untapped potential to increase and improve teaching and learning.

Impact of Educational Robotics in STEM Education

A recent literature review study conducted by Bascou and Menekse (2016) analyzed 119 significant studies related to the implementation of robotics in K-12 formal and informal education settings between the years 2000 and 2015. All of these studies assessed cognitive factors related to teaching STEM education through robotics. Bascou and Menekse discovered that robotics has an immense potential as a learning tool specifically for creating associations and connections with abstract concepts found in diverse areas ranging from engineering to mathematics and physics. Their findings also include the use of robotics as a mechanism to support learning for students who might not be initially interested in STEM academic areas. Furthermore, they emphasized the importance of incorporating cognitive, sociological, and affective methodologies in robotics to optimize the learning process and to motivate students (Bascou, & Menekse, 2016).

Moreover, the results from a study by Kandlhofer and Steinbauer (2016) suggested that the impact of robotics in education should be considered through a holistic-integrative approach. Robotics involves different areas and fields and is not an isolated activity (Kandlhofer & Steinbauer, 2016). Robotics in education have developed, improved, or increased several students' skills and abilities including enhancement of higher order thinking skills such as abstraction, critical thinking, and solving complex problems (Afari & Khine, 2017; Merdan, 2017). In addition, students involved in robotics also demonstrate engineering, computational, and entrepreneurial skills (Kandlhofer & Steinbauer, 2016; Merdan, 2017). Equally important, robotics has also shown the development and increase of social skills in students such as cooperative learning, teamwork, collaboration, and communication (Eguchi, 2014). Robotics develops motivation, self-confidence, and perseverance in students (Atmatzidou & Demetriadis, 2016). According to some researchers, robotics in education has proven its impact at increasing students' interest in STEM fields and careers (Afari & Khine, 2017; Eguchi, 2016; Merdan, 2017).

Eguchi (2014) described robotics as an integral learning tool for educational transformation. It is noteworthy to state that robotics in education also introduces students to new and innovative technology movements such as coding, engineering practices, and the maker movement. The coding movement looks for the integration of computational thinking across all levels of K-12 education. Engineering practices have been recently incorporated in K-12 science coursework to increase technological literacy of students. The maker movement integrates all elements of coding, engineering practices and STEM education (Eguchi, 2014). Studies have indicated that both genders can equally benefit from participation in robotics (Atmatzidou & Demetriadis, 2016). Melchior, Burack, Hoover, and Marcus (2017) found that although females involved in robotics initially show less confidence than males, eventually their confidence level surpasses the male students' confidence. Both females and males have the same competency in robotics activities (Melchior et al., 2017).

Educational robotics and mathematics. As denoted by Barger and Boyette (2015), robotics activities involve a wide array of uses and applications of mathematics including algebra, geometry, and trigonometry. Concepts from these core areas of mathematics are necessary to successfully program a robot. Likewise, robotics can provide support to students in remedial-math courses with hands-on activities that make learning abstract concepts accessible. On the other hand, gifted and talented students involved in robotics engage in high-level thinking and reasoning. Both groups benefit from participation in robotics through enjoyable, fun, but challenging activities (Barger & Boyette, 2015).

In a similar study, Alfieri, Higashi, Shoop, and Schunn (2015) utilized the term "robot-math" to describe the cross-disciplinary integration of STEM to teach mathematics through robotics. They argued that in robot-math instruction, the intention is to first use math-related skills in robotics-related challenges through exploration. Later, these activities will help students transfer and extend those mathematics skills into academic skills (Alfieri et al., 2015). The literature review indicates that there is a lack of high-quality quantitative studies related to the use of robotics in education, particularly its effectiveness in mathematics performance (Afari & Khine, 2017; Alimisis, 2013; Benitti, 2012; Nugent, Barker, Grandgenett, & Welch, 2016).

Out-of-school robotics competitions. In the last decade, robotics in education has been used in formal and informal settings, within the school day in traditional teaching-learning structures and after-school environments, also referred to as out-of-school activities (Bascou & Menekse, 2016; Eguchi 2016; Melchior et al., 2017; Mubin & Ahmad, 2016; Nugent, Barker, Grandgenett, &Welch, 2016). Robinson (2014) reported that robotics competitions started to receive attention in the 1980s, initially involving only college and some precollege students and educators. However, since early 2000, educational robotics competitions have gained momentum in K-12 school-age students around the world (Eguchi, 2016). Robinson (2014) reported that in the last 3 decades, the number of educational robotics competitions has steadily increased. Schools have been using educational robotics competitions mainly to foster students' interest in STEM (Barger & Boyette, 2015; Robison, 2014). Most of the educational robotics competitions engage students in a collaborative process to address a specific challenge within a determined timeframe and specific (limited) resources (Eguchi, 2016; Menekse, Higashi, Schunn, & Baehr, 2017).

Several of the most popular K-12 educational robotics competitions include the robotics competitions developed by For Inspiration and Recognition of Science & Technology (FIRST): FIRST Lego League Jr., FIRST Lego League, FIRST Tech Challenge, and FIRST Robotics Competition; BotBall robotics, organized by the KISS Institute for Practical Robotics; World Robot Olympiad, run by the World Robot Olympiad Association; RoboCupJunior and RoboChallenge, promoted by the RoboCup Federation (Eguchi, 2016). Another popular educational robotics competition platform is VEX Robotics. VEX is organized by the Robotics Education & Competition Foundation

(REC), and it includes VEX IQ Challenge, VEX Robotics Competition (VRC), and VEX U (Robinson, 2014). Emeagwali (2015) indicated that VEX Robotics touches 500,000 students around the world. In 2015, VRC alone had 15,000 student participants from 29 different countries and 45 in the United States (Emeagwali, 2015).

According to Stephenson (2018), VEX Robotics is the largest educational robotics competition at a single international event called VEX Worlds, with a record of 1,075 teams, 10,000 participants, and 30,000 people involved in a week-long event in Louisville, Kentucky. VEX Worlds robotics has held this record since 2016 (Stephenson, 2018). As reported by the REC Foundation (2018a), VEX Robotics is the biggest and fastest growing robotics competition platform for K-12 students including VEX IQ for elementary and middle school-age students, VRC for middle and high school students, and VEX U for college students. In the world, there are more than 20,000 teams in 50 different countries participating in over 1,700 competitions (REC Foundation, 2018a).

As indicated by an independent VEX event partner, the heart of the VEX program revolves around student involvement and participation; robots are student designed, student built, student programmed, and student driven/controlled (J. Amaro, personal communication, November 15, 2018). In the high school level robotics competition, the REC Foundation offers robotics teams the opportunity to participate in VRC tournaments and/or VRC leagues. J. Amaro (personal communication, November 15, 2018) explained that a VRC tournament is a single, one-day competition compared with a VRC league that involves the students' participation in multiple competitions (events) of usually three to four events. The main advantage of a VRC league is that students participate in more events, consequently more matches allowing for more learning due to iteration (J. Amaro, personal communication, November 15, 2018). A study conducted in 2011 by the Center of Education Integrating Science, Math and Technology at the Georgia Institute of Technology reported positive student outcomes from participating in VEX robotics competitions that included interest in STEM, self-efficacy, sportsmanship, and 21st-century skills such as goal setting, project management, communication, collaboration, self-direction, and accepting and proving critical feedback (T. Norman, 2011).

Certainly, participation in VEX robotics competitions involves preparation and conducting several activities prior to the actual competition. As briefed by T. Norman (2011), these preparation activities include the "very visceral experience" of making connections with what students learn in school. Moreover, the "build" season starts as the new competition challenge is revealed each year in April at the VEX Worlds Competition event (Hendricks, Alemdar, & Ogeltree, 2012). Experienced robotics teachers (coaches) start working with their students as early as the challenge is announced, although other teachers can decide to start activities at the beginning of the new school year, which varies per school district ranging from July to September. Before participation on their first robotics competition, teams of students will spend from 2 to 8 or more hours a week, depending on their level of enthusiasm or resource availability. Prior to actually building a robot, students should be thoroughly familiar with the current game manual and all of the rules of the challenge. This includes the rules for building the robot and the scoring of a match (J. Amaro, personal communication, November 15, 2018).

To illustrate, a VRC game challenge at the 2017 VEX robotics presented "In the Zone" robotics challenge for 2017-2018 season. In the Zone was played on a 12 by 12 foot foam-mat arena surrounded by a perimeter of sheet metal. Matches were played between two alliances (red and blue) with two randomly selected teams per alliance. There were 80 plastic cones that could be staked in different goals and zones to score points. The object of the challenge (game) for each team alliance was to use their robot to stack cones in different locations to obtain a higher score than the opposing alliance (VEX Robotics Inc. 2017). For this particular challenge, the teams were to design a mechanism that was able to collect and stack cones along with a strong enough lift mechanism to carry those elements. These tasks were crucial for a team to be successful in the season (J. Amaro, personal communication, November 15, 2018). The math topics related to this particular design feat included geometry concepts, dynamics system theory, optimization algorithms, and mathematical computation employed in the robot's programming, among others (Coxon et al., 2018).

As indicated by Menekse et al. (2017), a narrow number of studies have examined educational robotics competitions and their impact on students, but most of them tend to be survey based instead of performance based (see also Robinson, 2014). Additionally, Robinson (2014) noted that there have not been studies that compare students to themselves before and after participation in educational robotics competitions. Are students acquiring specific content knowledge such as in mathematics from participation in educational robotics competitions? Are students pursuing STEM majors based on their experience gained after their participation in educational robotics competitions? Few studies have explored these questions related to the outcomes of students' participation in educational robotics competitions (Robinson, 2014).

Conceptual Framework

Experiential Learning Theory (ELT)

Haury and Rillero (1994) proclaimed that if students are exposed to concrete hands-on learning experiences, like manipulatives, and if they also have the opportunity to handle such object in an exploratory manner, they may learn mathematics more effectively. The hands-on approach allows students to learn mathematics even before being exposed to traditional-formal instruction (Haury & Rillero, 1994). A more recent study by Ekwueme, Ekon, and Ezenwa-Nebife (2015) showed that the hands-on methodology increased not only students' mathematical knowledge and critical thinking but also their creativity, attitude, perception, logic development, and language development.

A. Y. Kolb and Kolb (2012) claimed that ELT presents a student-centered constructivist theory of learning that diverges from the traditional *transmission* teaching-learning model where concepts and ideas are transmitted to the learner. In ELT, the learner creates and recreates social knowledge in his/her personal knowledge (A. Y. Kolb & Kolb 2012). Further, ELT defines learning as "the process whereby knowledge is created through the transformation of experience" (p. 41). Knowledge is not an autonomous-isolated entity that can be transmitted or acquired. It is a continuous process of creation and recreation of knowledge through the transformation of experience (D. A. Kolb, 1984).

Twentieth-century scholars who decided learning was based on experiences have contributed to what is known as experiential learning (EL) theory. John Dewey, experiential education; Kurt Lewin, action research & the T-group; Jean Piaget, constructivism; Paulo Freire, naming experience in dialogue; William James, radical empiricism; Lev Vygotsky, proximal zone of development; Carl Jung, development from specialization to integration; and Carl Rogers, self-actualization through the process of experiencing, among others (A. Y. Kolb & Kolb, 2012; D. A. Kolb, 1984, 2013), are noted in this field of EL.

In order to unify all research-based insights and contributions of these and other scholars, in 1971, David Kolb (1984) created a coherent and explicit framework that addressed similarities and distinctive contributions in the area of experiential learning. Kolb named it ELT, and it is also referred to as KELT (Kablan, 2016). The ELT framework incorporates six common propositions among EL proponents: (a) learning is best conceived as a process and not in terms of outcomes, (b) all learning is relearning, (c) learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world, (d) learning is a holistic process of adaptation, (e) learning results from synergetic transactions between the person and the environment, and (f) learning is the process of creating knowledge (D. A. Kolb, 1984, 2013).

Kolb's Experiential Learning Framework

According to Kablan (2016) and D. A. Kolb (1984), KELT is one of the most prominent frameworks that describes and clarifies the connections between academic achievement and learning styles. D. A. Kolb professed that curiosity about the here, the now, and possible future outcomes drives learning. Moreover, D. A. Kolb (2013) described KELT as a dynamic-holistic theory that involves the whole individual in a transformational process of adaptation. In addition, KELT was also based on Kurt Lewin’s plan for the generation of scientific knowledge, which allows researchers to conceptualize phenomena by permitting the treatment of both quantitative and qualitative traits of the phenomena in a single study. It adequately presents the causal characteristics of the phenomena, facilitates the assessment of the phenomena's characteristics, and permits generalization of the phenomena (D. A. Kolb, 2013). Since the early 1970s and based on KELT's holistic approach, many research studies have used its framework in diverse fields such as psychology, medicine, nursing, management, accounting, law, and education at different levels and fields (A. Y. Kolb & Kolb, 2012; D. A. Kolb, 2013). Healey and Jenkins (2000) commended the KELT framework for its well-developed conception that has received careful analysis and testing in the educational research community.

Experiential Learning Cycle

D. A. Kolb (1984) asserted that optimal learning is a cyclical process (see Figure 1) that is reached when students follow a cycle of four stages: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). This is also known as Kolb's experiential learning cycle (Abdulwahed & Nagy, 2013). However, the cycle has neither a predetermined entry point nor is it a recipe to be followed; it is a continuous learning spiral that enriches and generates knowledge through the transformation of concrete experiences (A. Y. Kolb & Kolb, 2009). This process is depicted as an ideal learning spiral in which the student touches all the bases of experiencing, reflecting, thinking, and acting. This process is flexible and sensitive to the learning situation. However, concrete experiences are the foundation for the next stages in the process. Based on the concrete experience, students can observe and reflect about their experiences to distill abstract concepts from which inferences for actions are drawn

(A. Y. Kolb & Kolb, 2012). When a concrete experience is heightened by reflection, offering meaning by thinking, and transformed by action the experience and the knowledge drawn from it become deeper, broader, richer, meaningful, and last longer (A. Y. Kolb & Kolb, 2009).

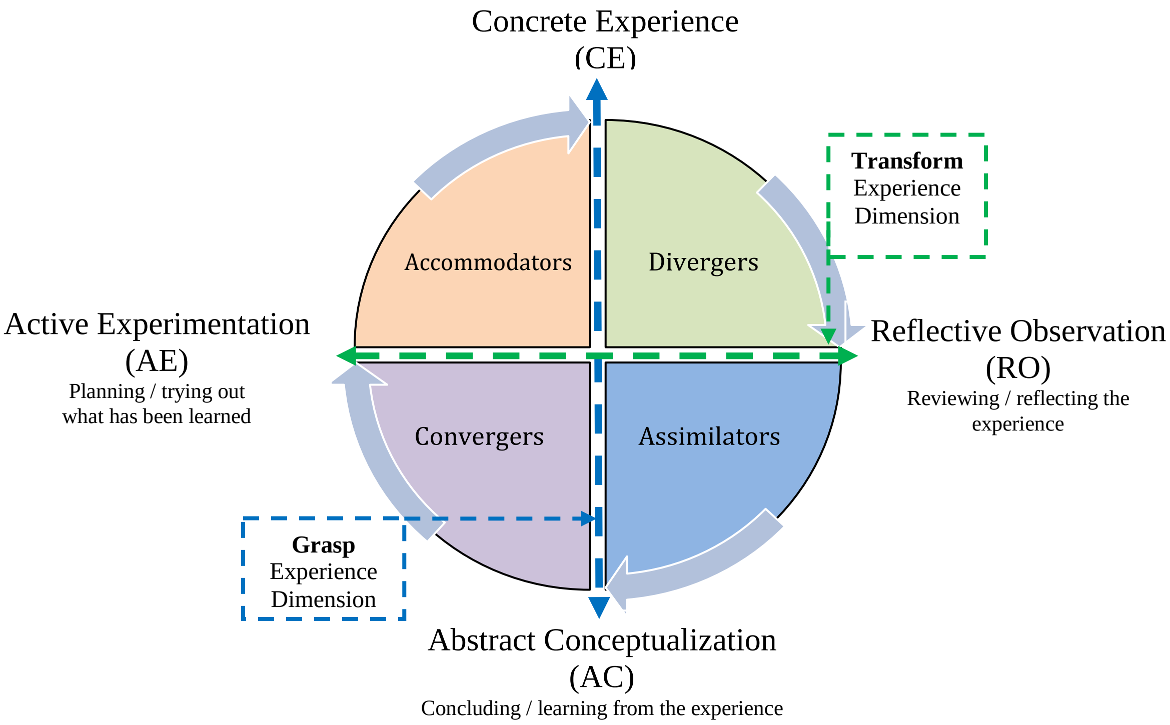

Figure 1. Kolb’s experiential learning cycle including Kolb’s basic learning styles. Adapted from “Experiential learning: Experience as the Source of Learning and Development,” by D. A. Kolb, 1984, Englewood Cliffs, NJ: Prentice-Hall.

In D. A. Kolb’s experiential learning cycle, the first dimension (AC-CE) referred to as the abstract-concrete dimension is separated by the *transform* experience axis. It is used to describe how some students perceive and comprehend new information. Some students have a preference for concrete methods that involve hands-on senses and feelings. Other students align with abstract methods that require thinking and analyzing. The second dimension (AE-RO), known as the active-reflective dimension, is divided by the *grasping* experience axis. It involves how students process new information. Some students prefer to process information by engaging in reflection while observing, making sense of the situation. Others prefer to have an active role in the process. Based on these premises, D. A. Kolb presented the basic learning modes and learning styles as shown in Figure 2 (Kablan, 2016; D. A. Kolb, 1984; Morel-Baker, 2017).

Experiential Learning Styles

Kolb’s learning styles refer to the unique learners’ characteristics that follow or *spiral* through the experiential learning cycle—CE, AC, AE, and RO (Kolb 2013; Morel-Baker, 2017). Each learning style is not a psychological attribute but rather a dynamic state that changes based on genetics, unique life experiences, the environment, and past and present incidents (D. A. Kolb, 2013). D. A. Kolb (1984) and Healey and Jenkins (2000) proposed that learners have a preference for a particular learning style, but they also suggested that students need to develop *adaptive flexibility*, which is the learner’s ability to respond to each learning opportunity accordingly and to adapt to different learning situations throughout the learner’s life.

According to Healey and Jenkins (2000), there are four basic learning styles associated with the way learners solve problems (as referenced in Figure 2): divergers enjoy brainstorming and generation of multiple ideas, observe situations from many points of view; assimilators have the capacity to create theoretical models and prefer inductive reasoning; convergers trust the hypothetical-deductive process; accommodators adapt quickly to any situation and like to experiment and carry out plans. Figure 2 shows the characteristics per learning style.

Can carry out plans	Imaginative, good at generating ideas
Interested in action and results	Can view situation from different angles
Adapts to immediate circumstances	Open to experience
Trial and error style	Recognizes problems
Sets objectives	Investigates
Sets schedules	Senses opportunities
Accommodator	**Diverger**
Converger	**Assimilator**
Good at practical applications	Ability to create theoretical models
Makes decisions	Compares alternatives
Focuses efforts	Defines problems
Does well when there is one answer	Establishes criteria
Evaluates plans	Formulates hypotheses
Selects from alternatives	

Figure 2. Characteristics of Kolb's learning styles. Adapted from "Experiential learning: Experience as the Source of Learning and Development," by D. A. Kolb, 1984, Englewood Cliffs, NJ: Prentice-Hall.

Furthermore, Wyrick and Hilsen (2002) summarized the following findings by utilizing Kolb's cycle of EL as a framework: students were able to recall details over a longer period of time, students' perceptions were that they did not learn much when in fact they demonstrated mastery and application of knowledge, the learning environment was a more enjoyable experience for both students and teacher, and finally teachers became *facilitators of learning* rather than *teachers*.

Similarly, Shih et al. (2012) found that through the implementation of Kolb's experiential learning cycle, students can increase their mathematical achievement levels along with the stimulation of collaboration between them. In brief, KELT and the utilization of Kolb's experiential learning cycle including EL styles present a dynamic and innovative view of learning driven by concrete experiences and the resolution of dual dialectics—experience-abstraction and action-reflection (A. Y. Kolb & Kolb, 2012).

Robotics provides the perfect hands-on vehicle to increase students' mathematics knowledge by exposing them to concrete-learning experiences through exploration and manipulation of tangible objects (Barker & Ansorge, 2007; Haury & Rillero, 1994). Similarly, ELT guides the concrete-learning experience of students involved in robotics through the spiral of the continuous EL cycle based on each individual student's EL style (A. Y. Kolb & Kolb, 2012; Nugent, Barker, Grandgenett, &Welch, 2016). Consequently, both robotics and EL may demonstrate to become the perfect combination to increase students' mathematics competency (Barker & Ansorge, 2007), ultimately, increasing the number of students pursuing and attaining STEM college degrees (Ball et al., 2017; Green & Sanderson, 2018).

Figure 3 presents the interrelation between the main elements of this study's conceptual framework. These elements are intertwined in a continuous spiral-cycle based on KELT and its adaptability to the activities related to out-of-school high school educational robotics competitions. Robinson (2014) identified several outcomes of student participation in robotics competitions: design outcomes such as maintaining an engineering design notebook; mechanical outcomes like constructing structurally sound mechanisms; programming outcomes including programming using logical operators and the use of automated routines; and 21st-century skills such as teamwork, collaboration, persistence, positive work ethic, commitment, punctuality, and professional behavior. These student outcomes that aligned with KELT may provide the learning experiences to develop what Conley (2008) posed as the set of math skills of successful college students. therefore increasing the number of students that successfully pursue and attain a STEM college degree.

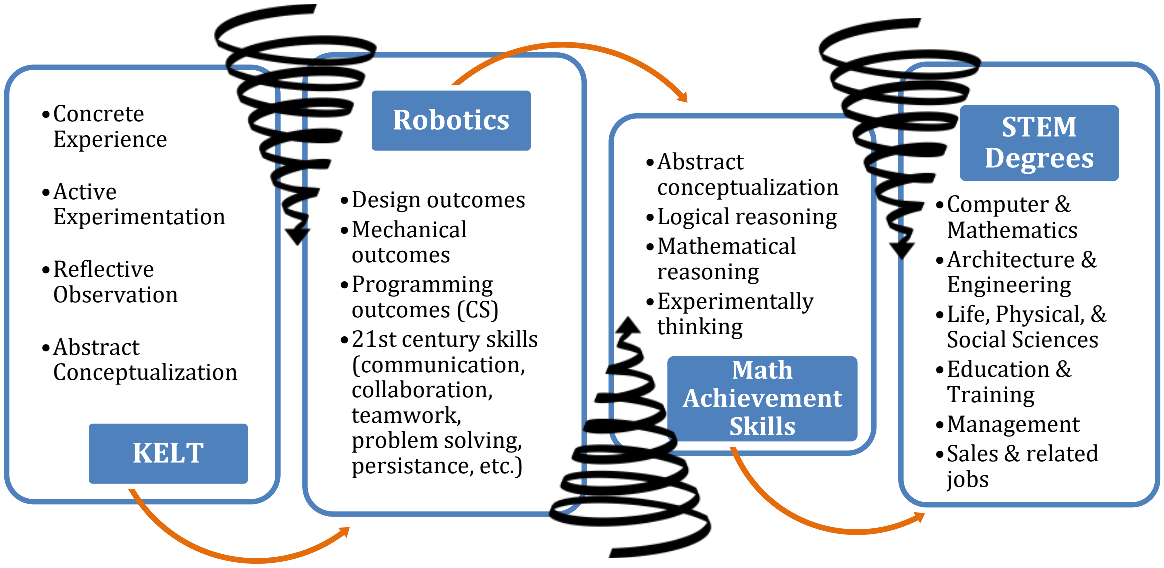

Figure 3. Conceptual framework relationships. Adapted from D. A. Kolb (1984), Robinson (2014), Conley (2008), and Vilorio (2014).

Summary

This chapter has been about the importance of STEM and STEM education. It provided a review of the origins of STEM education, STEM occupations, the U.S. STEM workforce, and the high school pipeline into STEM careers. In addition, this literature review explored the participation of females and Latinos/as in STEM and the untapped human capital potential that both groups represent to increase the STEM pipeline. In addition, the review included an exploration of the importance of mathematics as the entry point into most STEM professions. Next, in the literature review, the opportunity that educational robotics, particularly out-of-school robotics competitions, presents to motivate students to follow STEM postsecondary careers was analyzed. The researcher also presented a summary of the possible connection between robotics learning experiences and improving mathematics skills among students who participate in these activities. With this in mind, this chapter also presented KELT including D. A. Kolb's learning cycle and learning styles as the theoretical framework providing the structure for students involved in experiential out-of-school robotics activities to develop mathematics competence and the possibility of translating these concrete experiences into STEM career aspirations.

CHAPTER III: METHODOLOGY

Overview

This chapter reviews the methodology used to conduct this study, which examined the difference in academic performance in mathematics between high school Latino/a students who participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years and high school Latino/a students who did not participate in such activities in Southern California. In addition, this study described the experiences of Latino/a college students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and how these experiences influenced their interest in enrolling in courses leading to a STEM college degree. The chapter begins with the purpose statement, followed by the research questions, research design, population and sample, instrumentation used to collect data, data collection, data analysis, and the limitations of the study. The chapter closes with a brief summary.

Purpose Statement

The purpose of this mixed-methods ex post facto study was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino/a students in Southern California who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and high school Latino/a students who did not participate in out-of-school high school educational robotics competitions. A secondary purpose was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino (male) and Latina (female) students that participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions in Southern California. A third and final purpose was to describe the experiences of Latino/a college students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and how these experiences influenced their interest in enrolling in college courses leading to a STEM college degree.

Research Questions

Central Research Question

Do Latino/a students who participate in out-of-school high school educational robotics competitions perform better in mathematics courses in high school, and are these students influenced to pursue college STEM degrees?

Quantitative Research Questions

1. Do Latino/a students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latino/a students who do not participate?
2. Do Latino (male) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latina (female) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years?

Qualitative Research Questions

3. How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?

4. How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?

Research Design

This study used a mixed-methods ex post facto design to capture both quantitative and qualitative data. According to Patton (2015), mixed methods generate a more comprehensive study that includes multiple mechanisms from both quantitative and qualitative methodologies. As compared with one methodology, mixed-research methods provide a wider scope, deeper insight, and a better understanding of the research problem studied (Creswell 2014; Greene, 2007; Patton, 2015). Mixed-methods research is unique in producing better results when either qualitative or quantitative methods by themselves fall short or are inadequate in clarifying the research problem (McMillan & Schumacher, 2010). Additionally, Creswell and Plano Clark (2011) identified three critical decisions to consider when selecting the mixed-methods design to use: the order in which data are collected and used, the emphasis on each type of data, and the relationship between the two sets of data.

According to Ellis and Levy (2008), the fundamental rule to plan any research study is to abide by the research questions, and that should guide the selection of the research design. Since this study sought to examine the difference in academic performance in mathematics between high school Latino/a students in Southern California who participated in out-of-school high school educational robotics competitions and Latino/a high school students who did not participate in such activities and to examine if participation in out-of-school robotics competitions led to interest in pursuing a STEM college degree, it was determined that a mixed-methods design was best suited for this study because the quantitative data collected as the first step in the research supported the identification of rich descriptive data through the qualitative inquiry process that followed.

Moreover, this ex post facto mixed-methods design study examined the difference in academic performance in mathematics as measured by class grades between high school Latino/a students who participated in out-of-school high school educational robotics competitions and high school Latino/a students who did not participate in such activities in Southern California. These data supported the quantitative analysis for this research. An ex post facto design, also referred to as causal-comparative design, was selected due to the preexisting condition of the independent variable (participation in out-of-school high school educational robotics competitions). This condition was not and could not be manipulated by the researcher (McMillan & Schumacher, 2010).

Further, in ex post facto design there is frequently an *intervention* group and a *control* group. As indicated by McMillan and Schumacher (2010), both groups need to be as homogenous as possible in characteristics that form each group but opposite in the independent variable. This study involved examining the data from two independent groups: an intervention group composed of high school Latino/a students who participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years (2016-2017 and 2017-2018) and a control group composed of high school Latino/a students who did not participate in out-of-school high school educational robotics competitions during the same period of time (2016-2017 and 2017-2018).

For the qualitative portion of the research design, seven Latino/a college students who participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive school years (2016-2017 and 2017-2018) and were also part of the intervention group's quantitative data set were interviewed face to face to gather their perceptions about their performance in mathematics courses in high school and if their participation in out-of-school high school educational robotics competitions influenced their decision to pursue a STEM college degree.

As defined by R. B. Johnson and Christensen (2008), ex post facto research explores phenomena that have already happened. It investigates the world as it naturally occurs. Ex post facto design tests relationships between variables; however, it does not provide adequate safeguards to infer causal relationships. Despite this limitation, ex post facto research contributes valuable information to the field of education and other social sciences (Ary, Jacobs, & Sorensen, 2010).

Population

As proposed by McMillan and Schumacher (2010), population is a group of elements that share specific characteristics and that the researcher is interested in studying to withdraw discoveries and to generalize findings as much as possible (see also Patten 2012). As reported by Emeagwali (2015), VEX robotics touches 500,000 students around the world. In 2015, VEX Robotics Competition (VRC) alone had 15,000 student participants from 29 different countries and 45 states in the United States. The population of this study included all high school students who participated in 2016-2017 and 2017-2018 school years in VEX robotics high school leagues in Southern California. According to the California director of regional operations for Robotics Education &

Competition Foundation, in each year (2016-2017 and 2017-2018), about 408 high school VEX Robotics Competition (VRC) robotics teams participated with approximately 4,000 student participants in four high school VRC robotics leagues in Southern California (T. Shraibati, personal communication, July 13, 2018). Southern California boundaries are usually defined by eight counties: Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Santa Barbara ("Southern California," n.d.).

Target Population

The target population of this study was narrowed to all Latino/a 10th- and 11th-grade high school students who participated in the 2016-2017 San Diego VRC High School Robotics League and also participated the following year in 2017-2018 when they were enrolled as 11th- and 12th-grade high school students. In the 2016-2017 San Diego VRC High School Robotics League, there were 161 student participants from 11 different public high schools of which 43 were Latino (male) and 21 were Latina (female) 10th- and 11th-grade student participants. In the 2017-2018 San Diego VRC High School Robotics League, there were 195 student participants from 12 different public high schools of which 45 were Latino (male) and 35 were Latina (female) 11th- and 12th-grade student participants. From both high school robotics leagues, there were 30 students who participated in both consecutive school years, 18 Latino (male) and 12 Latina (female) students.

The 30 students were from eight high schools within the Sweetwater Union High School District (SUHSD): Castle Park, Hilltop, Montgomery, Olympian, Otay Ranch, San Ysidro, Southwest, and Sweetwater. Since many of the San Diego VRC High

School Robotics League competitions were hosted by its VEX-REC independent partner in Sweetwater Union High School District's schools, the San Diego VRC High School Robotics League changed its name in 2017-2018 to Sweetwater VRC High School Robotics League. In an effort to avoid confusion and add consistency, the league's original name, San Diego VRC High School Robotics League, was used throughout the study. Table 1 shows the distribution per grade and gender of the student participants as of the 2017-2018 school year for both 2016-2017 and 2017-2018 San Diego VEX Robotics High School League.

Table 1

High School Latino/a Student Participants for Both 2016-2017 and 2017-2018 San Diego VEX Robotics High School League

Grade	# Latino (male) high school participants	# Latina (female) high school participants
Grade 12 in 2017-2018	7	8
Grade 11 in 2017-2018	11	4
Subtotals	18	12
Total Latino/a students	30	

Note. Data retrieved from Sweetwater Union High School District, College and Career Readiness Office: Science, Technology, Engineering, Arts, and Math Department.

Quantitative Target Population

The quantitative target population selected for this study included the group of students that participated in 2 consecutive San Diego VRC high school robotics leagues (2016-2017 and 2017-2018) with the following characteristics:

- Year 1 participation—Latino/a 10th and 11th-grade high school students who participated in the 2016-2017 San Diego VRC high school robotics league.

- Year 2 participation—Latino/a 11th and 12th-grade high school students who participated in the 2017-2018 San Diego VRC high school robotics league and also participated in the previous 2016-2017 year.

Students were identified by their identification numbers (ID), and all quantitative data were provided by SUHSD's Office of Research and Evaluation Department per permission granted and provided in Appendix B. Since data did not disclose students' personal information, it was not necessary to request BUIRB permission to obtain them. Table 1 shows the student participants' distribution per grade and gender as of 2017-2018.

Qualitative Target Population

The qualitative target population selected for this study included all Latino/a 12th-grade high school students as of 2017-2018, seven Latino (male) and eight Latina (female) for a total of 15 students. These students met the following criteria:

- Two consecutive years of participation in San Diego VRC high school robotics leagues in 2016-2017 as 11th-grade students and in 2017-2018 as 12th-grade students.
- At least age 18 years and enrolled in college in 2018-2019.

Sample

Patten (2012) explained that researchers draw a sample from the population they are interested in studying. According to Patten, "The quality of the sample affects the quality of the inferences made from a sample to the population" (p. 45). As described by McMillan and Schumacher (2010), in quantitative studies, the sample is the group from which data are extracted. Conversely, in qualitative studies, the sample is composed of "information-rich" elements (p. 326).

Quantitative Sample

In quantitative research studies and as proposed by McMillan and Schumacher (2010), the larger the sample the better it is to determine statistical significance between variables. In fact, as the sample size increases to infinity, the sample mean approximates to the normal distribution of the population even if it is unknown (Sang Gyu & Jong Hae, 2017). With this in mind and as denoted by Sang Gyu and Jong Hae (2017), the central limit theorem (CLT) indicates that if the sample size is sufficiently large, regardless of the population distribution, the mean of the sample and the mean of the population will be distributed normally. A sample size of 30 will be distributed normally making it an optimum size for a minor quantitative study (Sang Gyu & Jong Hae, 2017). Further, McMillan and Schumacher (2010) defined as a *rule of thumb* for estimating an adequate sample size for quantitative studies, a size of at least 30 elements.

The quantitative sample for this study included two sets of data: one for the intervention group and one for the control group. The intervention group was comprised of all elements identified in the target population, which consisted of the group of students who participated in 2 consecutive San Diego VRC high school robotics leagues (2016-2017 & 2017-2018). The quantitative sample included 30 ($N = 30$) students, 18 Latino (male) and 12 Latina (female) students (as referenced in Table 1).

The control group of this study was also comprised of 30 ($N = 30$) randomly selected students, 18 Latino (male) and 12 Latina (female) students. Control group students were randomly selected matching all the characteristics of the intervention group but opposite in the independent variable, which was participation in out-of-school high school educational robotics competitions in 2 consecutive school years (2016-2017 and

2017-2018). This means that none of the members of the control group participated in out-of-school educational robotics. Table 2 shows a comparison between intervention and control groups. High school mathematics course information was gathered for both groups that included school year, name of the school, name of the class, period of the class, name of the teacher, and final mathematics class grade.

Table 2

Breakdown of Intervention and Control Sample Groups by Grade and Gender

	Intervention group participation in 2016-17 & 2017-18 robotics leagues				Control group nonparticipation in robotics leagues			
	Grade 12		Grade 11		Grade 12		Grade 11	
	Male	Female	Male	Female	Male	Female	Male	Female
	7	8	11	4	7	8	11	4
Total	30				30			

Note. Data retrieved from Sweetwater Union High School District, College and Career Readiness Office: Science, Technology, Engineering, Arts, and Math Department.

Quantitative Sample Selection Process

Selection process for intervention group. For the intervention group (high school Latino/a students who participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years), the researcher used purposeful sampling composed of the group of students that participated in 2 consecutive (2016-2017 and 2017-2018) San Diego VRC high school robotics leagues (*N* = 30). The following are the mathematics classes that one or more of these students from each of the control or intervention groups were enrolled in during their junior or senior year: Integrated Mathematics II, Integrated Mathematics III, Pre-Calculus, Pre-Calculus Honors, AP Calculus AB, AP Calculus BC, or AP Statistics. The following are the mathematics classes that one or more students were enrolled in during their sophomore or freshman year: Integrated Mathematics I, Integrated Mathematics II, Pre-Calculus, and Pre-Calculus Honors.

Selection process for control group. According to McMillan and Schumacher (2010), in ex post facto studies, once the variables are determined, both intervention and control groups need to be similar to each other and share the same characteristics as possible but be different with respect to the independent variable. In this study, the independent variable tested was participation a minimum of 2 consecutive years in out-of-school high school educational robotics competitions: 2016-2017 and 2017-2018 school years. The control group was composed of Latino/a students who did not volunteer to participate in out-of-school high school educational robotics competitions nor were they involved in a formal in-school STEM track. The researcher chose to use simple random sampling as the selection process for the control group members. Simple random sampling is an unbiased process to select population elements with the same opportunity of inclusion (Patten, 2012).

In order to keep both groups (intervention and control) to similar experiences as much as possible, the researcher randomly selected Latino/a high school student who neither participated in out-of-school high school educational robotics competitions in 2016-2017 and 2017-2018 nor were they enrolled in a formal in-school STEM track. Each control group identified *post*-mathematics-class Latino/a students who participated in out-of-school high school educational robotics competitions. Each control group student was randomly selected from each of the mathematics classes in which other Latino/a students voluntarily participated in out-of-school high school educational robotics. Patten (2012) contended that by means of random selection, all potential participants have an equal opportunity of being selected. Further, Patten referred to this sample as a rich and unbiased sample that will produce realistic inferences matching the characteristics of the population. The random selection process of the control group followed these next steps:

1. From the quantitative data set of the sample intervention group (*N* = 30), intervention group students were listed and ordered per mathematics class taken in 2017-2018 school year. The mathematics classes included Integrated Mathematics II, Integrated Mathematics III, Financial Algebra, Pre-Calculus, Pre-Calculus Honors, AP Calculus AB, AP Calculus BC, and AP Statistics. These data consisted of school name, mathematics class name, mathematics class period number, mathematics teacher's name, students' identification (ID) numbers, students' grade level, students' gender, and students' ethnicity.
2. From the previous list, the researcher secured the class roster of each identified mathematics class per intervention group member. Each roster data included school name, mathematics class name, mathematics class period number, mathematics teacher's name, students' ID numbers, students' grade level, students' gender, and students' ethnicity.
3. From each identified mathematics class where an intervention group's student was included, the researcher created a list of all Latino/a students who did not participate in out-of-school high school educational robotics competitions. These students were candidates to become members of the control group.

4. All candidates on the control group per class roster were sorted by their student ID number from smallest to largest, and a sequential number was assigned to each one of them.
5. Lastly, all the information was organized in Microsoft Excel, and by means of using the random generation function (=randbetween [*bottom, top*]) a Latino/a student who did not participate in out-of-school high school educational robotics competitions was randomly selected to match each identified Latino/a student who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions. The matching characteristics included ethnicity (Latino/a), gender, grade level, mathematics class, mathematics teacher, mathematics class period, and high school. The control group had the same number of members as the intervention group (N = 30).

Qualitative Sample

As defined by Patton (2015), in qualitative inquiry, there are no specific guidelines to define sample size. However, when determining the sample size, it must be put within the context of the study. It needs to be specified in order to accomplish reasonable coverage of the research. Above all, to ease concerns about sample size in qualitative studies, it is suggested to use in-depth, purposeful sampling (Patton, 2015). The logic and power of purposeful sampling lies in selecting information-rich cases for in-depth study. Studying information-rich cases yields insights and in-depth understanding rather than empirical generalizations (Patton, 2015).

To support the qualitative research design of this study, nonprobability sampling techniques of purposive and convenience sampling were used. From the 15 potential

Latino/a college participants identified as the qualitative target population (referenced in Table 1), 10 were located and contacted but only seven volunteered to participate based on known elements conducive to the study's purpose and availability of study participants. These students participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years (2016-2017 and 2017-2018) and were also part of the intervention group data set. The qualitative data of this research study were collected using voluntary participants who were age 18 years or older and graduated from eight high schools located within SUHSD: Castle Park, Hilltop, Montgomery, Olympian, Otay Ranch, San Ysidro, Southwest, and Sweetwater. These seven participants, once notified and informed of their rights, took part in the interview process for this study voluntarily.

Qualitative Sample Selection Process. The purposive sample strategy used by the researcher was convenience sampling. Purposive convenience sampling, a type of nonprobability sampling, utilizes study participants who are available or who meet predetermined characteristics or criteria (McMillan & Schumacher, 2010). The researcher decided to conduct seven face-to-face interviews with Latino/a college students who participated a minimum of 2 consecutive school years (2016-2017 and 2017-2018) in out-of-school high school educational robotics competitions. The seven Latino/a college students were also part of the quantitative intervention group sample. The following qualitative purposeful-random sampling process was conducted to select the participants:

1. From quantitative control group data, all Latino/a 11th-grade students who participated in 2016-2017 San Diego VRC High School Robotics League were

identified by students’ ID numbers. This group of students was identified as 2016-2017 potential.

2. From quantitative control group data, all Latino/a 12th-grade students who participated in 2017-2018 Sweetwater VRC High School Robotics League were identified by students’ ID numbers. This group of students was identified as 2017-2018 potential.
3. From both potential groups, 2016-2017 and 2017-2018, all students who were part of both groups were identified. This group of students was identified as potential qualitative target population. All of these students were 18 years of age or older at the time this research was conducted.
4. Robotics advisors (teachers) and school counselors from all eight different high schools were contacted to identify the students from the potential qualitative-target population who were enrolled in college. Students’ contact information was gathered including e-mail, phone number, and college or university at which they were enrolled as students. This final group of students was identified as qualitative-target population.
5. From the qualitative target population (15), 10 Latino/a college student were located and contacted via e-mail or phone calls to invite them to volunteer to participate in the study. Seven college students volunteered to participate in the study. Interviews were conducted face-to-face based on participants’ availability. Appendix C shows the e-mail with the invitation to participate.

Instrumentation

Creswell (2014) denoted the importance of the use of instruments by researchers to gather data during the course of their research study. Patten (2012) further defined instrumentation as a synonym for measurement. Measure or measurements are generic terms for any type of measurement device (Patten, 2012). This section describes the quantitative and qualitative instruments employed in this study.

Quantitative Instrument

The quantitative data were provided by SUHSD's Office of Research and Evaluation Department. Appendix B presents the school district's approval. The data were compiled for both intervention and control groups. The quantitative data were separated into two major blocks—preparticipation (2015-2016 school year) and postparticipation (2017-2018 school year)—in out-of-school high school educational robotics competitions (San Diego VRC high school robotics league). Each block of quantitative data included school name, students' ID numbers, students' gender, students' ethnicity, students' mathematics class name, students' mathematics teacher's name, and students' mathematics class final grades.

Qualitative Instrument

Patton (2015) asserted that in qualitative studies, the researcher is the principal instrument of inquiry. For the qualitative purposes of this study, the researcher was the primary instrument of qualitative data collection. The foundations of the findings rely on the researcher's experience, skills, competence, and his engagement in the fieldwork (Patton, 2015). Additionally, this study employed the use of interviews as a source of qualitative data. Interviews allow researchers to enter interviewees' perspectives. Such perspectives can be meaningful and provide insights into the phenomena. Interviews are used to obtain other people's stories as they relate to the study (Patton, 2015). Moreover, Patton (2015) defined four variations in interview instrumentation: closed fixed-response interviews, interview-guide approach, informal-conversational interviews, and standardized open-ended interviews.

Similarly, Patten (2012) attested that semistructured interviews are the most widely used in qualitative research for its flexibility. In semistructured interviews, the researcher does not need to ask only the predetermined questions. If the interviewee does not seem to understand the question, the interviewer can reword it, or use probing questions to elicit rich data. Additionally, if the answer to a question is too brief, the interviewer can ask additional questions, such as "Can you tell me more about it?" (Patten, 2012, p. 153). For the purposes of this study, the qualitative instrument to gather data used was in the form of face-to-face, semistructured, probing, open-ended, and conversational interviews. The interviews started with an interview protocol outline located in Appendix D, followed by the interview questions in Appendix E. The interview questions were guided by the research literature. Moreover, the interview questions were designed to align with the study's research purpose and research questions as well as the conceptual framework for this study.

During this study, the researcher was employed as the STEAM programs coordinator for SUHSD. Based on the researcher's professional background and experience, there was potential for researcher bias during the interview process. To reduce and minimize researcher bias during the interview process; first, the researcher was aware of the potential bias; second, the researcher utilized an interview protocol outline (Appendix D); and third the researcher was careful not to have any prior connections or relationships with the interviewees.

Validity, Reliability, and Ethics

Patten (2012) denoted that validity is the indication that an instrument that was designed to measure a particular phenomenon performs its function accurately and effectively. Patten argued that the instrument is reliable if it produces consistent results. According to Patten, when assessing measures "validity is more important than reliability" (p. 73).

Validity

A strategy to ensure validity is the use of field experts during the development process of the qualitative instrument. A qualitative instrument's validity relies not only on the richness of the data source but also on the analytical abilities of the researcher implementing the instrument. In the same way, the instrument's content validity often relies on the judgment of experts in the field (Patton, 2015). To validate the qualitative instrument used in this study, the researcher probed the measure with an expert panel of two doctoral graduates with experience in qualitative research. The qualitative instrument was adjusted based on the panel's feedback. A secondary strategy used in this study to ensure validity was the participants' reviews. McMillan and Schumacher (2010) proclaimed that a method to increase validity and accuracy is to ask participants to review and modify appropriately the researcher's transcripts or synthesis of the data obtained from them including interview transcripts. The interviewed participants or seven Latino/a college students were informed of this strategy as part of the informed consent form located in Appendix F. After the interview was transcribed, the participants had an opportunity to review the transcripts and add any corrections. Interview transcripts were modified based on interviewees' feedback. Additionally, the researcher followed the interview protocol outline described in Appendix D.

Another strategy used to secure validity was the aid of a researcher/observer, also referred to as an informant researcher. McMillan and Schumacher (2010) reported that by means of the support of informants, the researcher can corroborate the consistency of the implementation of the instrument, including interviewer's tone of voice, physical stand, and posture. For the purpose of this study, the researcher asked a graduate of Brandman University from the doctoral program in Organizational Leadership with experience in the field of qualitative research to corroborate the fidelity of the implementation of the qualitative instrument by observing and taking notes at one of the face-to-face interviews (field test). After the interview, the researcher/observer provided feedback to the researcher on the application of the instrument. The application of the instrument was modified accordingly based on the feedback provided.

Reliability

Patten (2012) defined reliability as the consistency of results produced by the instrument. Similarly, McMillan and Schumacher (2010) explained that reliability consists of the quality, stability, and consistency of the instrument producing similar results during the process of data gathering. In order to support the reliability of the qualitative instrument, the researcher conducted a field test. It is important to reduce possible errors during the instrument development process. By pretesting the instrument, the researcher is able to identify potential sources of measurement error (Kimberlin & Winterstein, 2008). With this in mind, the researcher conducted a field-test interview with a participant that met the criteria of the subjects under study. During the field test, an expert qualitative researcher/observer was invited to monitor the process and identify any aspect that could imply bias toward any response. Both the expert qualitative researcher/observer and the field-test participant provided feedback on the clarity of the questions and potential for bias of the researcher while conducting the interviews. The instrument was revised and calibrated based on the field-test participant's and researcher/observer's suggestions. The field-test participant was not used in the study's data analysis.

Ethics

McMillan and Schumacher (2010) contended that the researcher is responsible for the ethical ramifications of educational research that includes human beings. Likewise, Patten (2012) added that the research community has developed a series of basic ethical values to protect humans in social research; participants need to be protected from any harm including physical and psychological harm, participants have a right to privacy and confidentiality, and the participants have a right to know the purpose of the research prior to participation. A fundamental element in adding ethical values to a research study is the use of informed consent (Patten, 2012). Prior to conducting any interviews, all participants signed an informed consent statement (Appendix F). The participants were also provided a standard introduction about the researcher, general information about the research, and the researcher's contact information. Equally important, the researcher was trained in the protection of human subjects as evidenced by the certification from the National Institutes of Health Office of Extramural Research "Protecting Human Research

Participants" as found in Appendix G and by meeting the requirements of the Brandman University Institutional Review Board (BUIRB) as found in Appendix H.

Data Collection

Prior to collecting any data, the researcher received approval from the BUIRB. The researcher also obtained approval from Sweetwater Union High School District to access its schools' archival data (Appendix B). Additionally, the Participant's Bill of Rights and Confidentiality forms (Appendix I) protected the participant's rights and privacy throughout the study.

Quantitative Data Collection

The quantitative data were provided by SUHSD's Office of Research and Evaluation Department. The archival data were from 2015-2016 through 2017-2018 school years. The data included school name, mathematics class name, mathematics class period number, mathematics teacher's name, students' ID numbers, students' grade level, students' gender, students' ethnicity, and students' mathematics final class grade. In order to protect the privacy and confidentiality of students' information, their names were not used. Students were identified by ID numbers.

Qualitative Data Collection

Qualitative data were obtained by conducting face-to-face semistructured, probing, and conversational interviews with seven Latino/a college students who participated 2 consecutive years in out-of-school high school educational robotics competitions and were also part of the quantitative data. The interview questions used are located in Appendix E. The questions were addressed in a conversational style. Patton (2015) contended that a combined strategy of interviewing offers flexibility to explore the subjects deeper, and in return, participants respond naturally to the questioning and expand on their personal experiences. In the same way, the researcher followed the interview protocol outline described in Appendix D. The benefit of using an interview protocol, also known as interview guide, is that it provides direction and consistency when it is necessary to interview multiple people (Patton, 2015).

Data Analysis

This study used a mixed-methods approach to analyze quantitative and qualitative data. The quantitative data were collected first from SUHSD's archival student data system. The qualitative data were obtained through face-to-face interviews with Latino/a college students that were also part of the quantitative data set. Upon completion of both methods of data collection, the researcher examined the data to synthesize the findings of this study.

Quantitative Data Analysis

Data analysis in ex post facto studies are very similar to the analysis conducted in experimental and quasi-experimental studies. The comparison between groups based on a variable of interest drives the analysis (McMillan & Schumacher, 2010). Upon completion of data collection, the researcher captured all quantitative data into a Microsoft Excel spreadsheet for both intervention and control groups. The categories included on the spreadsheets were grade level, gender, mathematics class name, and final mathematics class grade per school year and status (participant in out-of-school high school educational robotics competitions/nonparticipant).

Next, the researcher conducted a descriptive statistical analysis to summarize the information and to bring meaning to the quantitative data. The inferential statistical tool used to evaluate the difference between the intervention and control groups was a two-sample *t* test with independent groups, also known as independent samples *t* test. As asserted by McMillan and Schumacher (2010), the purpose of a two-sample *t* test with independent groups is to identify if there is a statistical significant difference between the groups being compared. Moreover, McMillan and Schumacher explained that this statistical procedure produces the *t* statistic, “which is the difference between the sample means divided by the standard error of the mean” (p. 300).

The researcher used Microsoft Excel MegaStat to analyze the data. MegaStat is an add-in for Microsoft Excel that performs several statistical analyses and procedures such as descriptive statistics, frequency distributions, and probability calculations.

Qualitative Data Analysis

The qualitative data gathered from the face-to-face interviews were digitally captured and transcribed. Then, the researcher reviewed each interviewee’s transcription document manually to identify possible patterns and themes. The identified codes were listed and cross-referenced between the interviews. Some codes with low incidence were grouped and renamed with other themes. According to Patten (2012), in this stage the transcripts of the interviews are examined for distinct, separate segments (such as the ideas or experiences of the participants), which are identified by type and coded with individual names.

After the first manual code identification was conducted, the researcher exported the Word documents containing the interview transcriptions to NVivo (http://www.qsrinternational.com/what-is-nvivo), a coding software used for qualitative data analysis. Using NVivo, the researcher examined again each interview transcription and created codes using specific key terms. In this second revision, the interview transcripts were independently coded by the researcher considering the first sets of themes recognized. Final codes were consolidated, and interrelated themes between interviews were identified. The use of NVivo helped in organizing data-rich information from multiple interviews to identify patterns and themes for analysis. In addition, the researcher used Microsoft Excel to list and prioritize the themes that emerged from the analysis.

Interrater Reliability

In order to increase data reliability, an expert in qualitative research with a degree of Doctor of Education in Organizational Leadership and with experience in the utilization of NVivo coded one of the initial interview transcriptions. A comparison between the expert and the researcher of this study determined the interrater reliability. An accuracy rating of 91% between the interrater and researcher exceeded the requirement for interrater reliability of no less than 80%.

Limitations

This study has several limitations. The quantitative data were limited to high school students' final grades in mathematics courses. Purposeful sampling was used for the qualitative part of the study, which is conducive to produce results dependent on the sample's unique characteristics and is difficult to generalize to other subjects (Patton, 2015). In addition, this study followed an ex post facto research design, which requires the identification of a control group to be as homogeneous as possible to the intervention group. The selection of the control group may limit the study's results (McMillan & Schumacher, 2010).

Summary

The purpose of this mixed-methods ex post facto study was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino/a students in Southern California that participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and high school Latino/a students who did not participate in out-of-school high school educational robotics competitions. A secondary purpose was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino (male) and Latina (female) students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions in Southern California. A third and final purpose was to describe the experiences of Latino/a college students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and how these experiences influenced their interest in enrolling in college courses leading to a STEM college degree.

This study employed an ex post facto mixed-methods design. The purposeful sample size was 30 Latino/a high school students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions for the intervention group and 30 Latino/a high school students who did not participate in out-of-school high school educational robotics competitions. The quantitative data gathered were in the form of final mathematics class grades for students of the intervention and control groups. The inferential statistical tool used to evaluate the difference between the intervention and control groups was a two-sample *t* test for these two independent groups. The researcher used Microsoft Excel MegaStat to analyze the quantitative data. The qualitative data were obtained by conducting face-to-face semistructured, probing, and conversational interviews with seven Latino/a college students who participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years and were also part of the intervention group's data set. The researcher used NVivo to analyze the qualitative data. Chapter IV presents the results of the data analysis. Chapter V provides a summary of findings, conclusions, implications for action, and recommendation for research.

CHAPTER IV: RESEARCH, DATA COLLECTION, AND FINDINGS

Chapter IV begins with a reiteration of the purpose of the study, research questions, research methods, data collection, population, study samples, demographic data, and presentation and analysis of data per research question. This chapter describes the analysis of both quantitative and qualitative data collected to respond to the stated research questions. For the quantitative portion of the study (RQ1 and RQ2), descriptive and inferential statistics that include box plot graphs and *t*-test analyses are presented. For the qualitative portion of the study (RQ3 and RQ4), a comprehensive analysis of the qualitative data collected from seven interviews with Latino/a college students is presented and analyzed per participant. Each participant's data were analyzed based on research questions and their connection to the study's conceptual framework of experiential learning and the following concepts: concrete experience, active experimentation, abstract conceptualization, and reflective observation. The data were then collectively analyzed to identify common themes. The data are presented using narrative descriptions followed by tables. Finally, this chapter concludes with a summary.

Purpose Statement

The purpose of this mixed-methods ex post facto study was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino/a students in Southern California who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and high school Latino/a students who did not participate in out-of-school high school educational robotics competitions. A secondary purpose was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino (male) and Latina (female) students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions in Southern California. A third and final purpose was to describe the experiences of Latino/a college students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and how these experiences influenced their interest in enrolling in college courses leading to a STEM college degree.

Research Questions

Central Research Question

Do Latino/a students who participate in out-of-school high school educational robotics competitions perform better in mathematics courses in high school and are these students influenced to pursue college STEM degrees?

Quantitative Research Questions

1. Do Latino/a students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latino/a students who do not participate?
2. Do Latino (male) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latina (female) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years?

Qualitative Research Question

3. How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?
4. How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?

Research Methods and Data Collection Procedures

This study used a mixed-methods ex post facto design to capture both quantitative and qualitative data. The quantitative data collected as the first step in the research supported the identification of rich descriptive data through the qualitative inquiry process that followed. For the quantitative portion of the research design, archival data in the form of mathematics courses grades for 2015-2016 and 2017-2018 school years were gathered for 30 10th- and 11th-grade high school Latino/a students who participated in the 2016-2017 San Diego VRC High School Robotics League and also participated the following year in the same robotics league (in 2017-2018) when they were enrolled as 11th- and 12th-grade high school students (intervention group). Additionally and for comparison reasons, archival data were also gathered to form two control groups of 30 high school Latino/a students each; a 2015-2016 control group (30) and a 2017-2018 control group (30). Control groups of students were randomly selected matching all of the characteristics of the intervention group but whose characteristics did not include the independent variable, which was voluntary participation in out-of-school high school educational robotics competitions in 2 consecutive school years (2016-2017 and 2017-

2018). None of the members of the control groups participated in out-of-school high school educational robotics competitions.

For the qualitative portion of the research design, seven Latino/a college students who participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive school years (2016-2017 and 2017-2018) and were also part of the intervention group's quantitative data set volunteered to participate in a face-to-face interview. The interviews the researcher conducted were intended to gather these participants' perceptions about their performance in mathematics courses in high school and to determine whether their participation in out-of-school high school educational robotics competitions influenced their decision to pursue a STEM college degree. All interviews lasted between 45 and 60 minutes and were an average of 48 minutes in length. Two portable digital audio-recording devices were used to capture the interactions during the interviews. All of the participants responded to the same 10 semistructured, open-ended interview questions (Appendix E). The interview questions were designed to align with the study's research purpose and research questions as well as with the conceptual framework for this study.

Population/Target Population

The population for this research study was Latino/a high school students who participated voluntarily in out-of-school high school educational robotics competitions a minimum of 2 consecutive years. In addition, the population of this study included Latino/a college students who participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years and were also part of the intervention group. The target population was comprised of all 11th- and 12th-grade

Latino/a students (30) for the 2017-2018 school year who participated in 2016-2017 and 2017-18 San Diego VEX VRC high school robotics league.

Sample

The purposeful sample for the quantitative portion of the study was composed of 30 high school Latino/a students who voluntarily participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years. In addition, to support the qualitative research design of this study, nonprobability sampling techniques of purposive and convenience sampling were used. From the 15 potential Latino/a college participants identified as the qualitative target population (referenced in Table 1), 10 were located, and they were contacted through e-mail or phone calls with an invitation to participate in the study. Seven students agreed to volunteer to participate in the interviews based on their availability. The seven students were already in college and graduated from one of the following Sweetwater Union High School District (SUHSD) high schools: Montgomery High School, San Ysidro High School, Southwest High School, or Sweetwater High School. In addition, these college Latino/a students participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years (2016-2017 and 2017-2018) and were also part of the quantitative data set.

Quantitative Demographic Data

This section presents quantitative demographic data first, then the data are analyzed by research question. The quantitative data were separated in two main blocks: before participation in out-of-school high school educational robotics competitions (2015-2016 school year) and after participation in out-of-school high school educational robotics competitions (2017-2018 school year). Further, each block of quantitative data was divided in two sets: intervention group and control group. Both intervention and control groups had the same characteristics (gender, grade level, math class, math class period, math class teacher, and high school) but were different with respect to the independent variable. In this study, the independent variable tested was participation a minimum of 2 consecutive years in out-of-school high school educational robotics competitions. Each group (intervention and control) had the same number of elements (30): 18 Latino (male) and 12 Latina (female) students.

Before Participation in Robotics

In order to identify significant differences between samples, the researcher analyzed both groups' data (intervention and control) before the intervention group engaged in out-of-school high school educational robotics competitions (hereafter known as robotics competitions). It was in the interest of this study to identify whether there were significant statistical differences between both groups (intervention and control) prior to engagement in robotics competitions. Each group (intervention and control) before participation in robotics competitions had 15 freshmen (ninth grade) students and 15 sophomore (10th grade) students. Table 3 displays before participation in robotics competitions' student breakdown for both groups (intervention and control) by grade and gender.

Students who belonged to either an intervention or a control group were enrolled in one of the following mathematics courses: Integrated Math I, Integrated Math II, Integrated Math III, Compacted Integrated Math III, or Pre-Calculus. According to the 2017-2018 SUHSD's curriculum guide for students' placement, students who were enrolled in Integrated Math II or higher during their ninth grade and students who were enrolled in either Integrated Math III or Compacted Integrated Math III/Pre-Calculus or higher during their 10th grade were considered to be on a high-level mathematics track because before they complete high school, they will have taken at least one higher level math course. Appendix J presents the SUHSD mathematics course sequence for the 2017-2018 school year. Quantitative data before participation show that six of the 15 ninth-grade students were enrolled in a high-level mathematics track. In addition, 10 of the 15 10th-grade students were enrolled in a high-level mathematics track.

Table 3

Before Participation in Robotics Competitions—Student Breakdown (2015-2016 School Year)

	Intervention group			Control group		
	Latina (female)	Latino (male)	Total	Latina (female)	Latino (male)	Total
9th grade	4	11	15	4	11	15
10th grade	8	7	15	8	7	15
Total	12	18	30	12	18	30

Based on SUHSD mathematics course sequence for the 2017-2018 school year, two ninth-grade Latina (female) students were on track to complete a high-level math class before completion of high school compared with four ninth-grade Latino (male) students. Conversely, only two ninth-grade Latina (female) students were off track compared with seven ninth-grade Latino (male) students. In addition, both Latina (female) and Latino (male) 10th-grade students had five students each on track to complete a high-level math class before completion of high school. There were three 10th-grade Latina (female) students off track compared with two 10th-grade Latino (male) students. Table 4 displays before-participation student breakdown by math course, grade, and gender.

Table 4

Before Participation in Robotics Competitions (2015-2016 School Year) Breakdown of Each Group (Intervention and Control) by Math Course, Grade, and Gender

	9th Grade		10th Grade	
Math course	Latina (female)	Latino (male)	Latina (female)	Latino (male)
Integrated Math I	2	7	0	0
Integrated Math II	2	4	3	2
Integrated Math III	0	0	3	4
Compacted Int Math III	0	0	1	1
Pre-Calculus	0	0	1	0
Total	4	11	8	7

After Participation in Robotics

Similar to before participation, each after-participation group (intervention and control) had a total number of 30 elements: 18 Latino (male) students and 12 Latina (female) students. Each after-participation group (intervention and control) had 15 junior (11th grade) students and 15 senior (12th grade) students. Table 5 displays after participation in robotics competitions student breakdowns for both intervention and control groups by grade and gender.

Table 5

After Participation in Robotics Competitions—Student Breakdown (2017-2018 School)

	Intervention group			Control group		
	Latina (female)	Latino (male)	Total	Latina (female)	Latino (male)	Total
11th grade	4	11	15	4	11	15
12th grade	8	7	15	8	7	15
Total	12	18	30	12	18	30

Students who were a part of the after-participation groups (intervention and control) were enrolled in one of the following mathematics courses: Integrated Math II, Integrated Math III, Pre-Calculus, Discrete Math, Pre-Calculus Honors, AP Statistics, AP Calculus AB, or AP Calculus BC. As described by the 2017-2018 SUHSD's mathematics course sequence, students enrolled in Integrated Math III or higher during their junior year (11th graders) are considered to be on a high-level mathematics track because before they complete high school they will have taken at least one higher level math course.

Per SUHSD's 2017-2018 mathematics course sequence, the following courses are considered high-level math courses: Pre-Calculus, Pre-Calculus Honors, AP Statistics, Calculus Concepts, AP Calculus AB, and AP Calculus BC. Appendix J presents SUHSD mathematics course sequence for the 2017-2018 school year. Quantitative data for after participation show that 14 of the 15 11th-grade students were enrolled in a high-level mathematics track. In addition, 14 of the 15 12th-grade students were enrolled in a high-level mathematics class. Based on SUHSD mathematics course sequence for the 2017-2018 school year, four 11th-grade Latina (female) students were on track to complete a high-level math class before completion of high school compared with 10 11th-grade Latino (male) students. Eleventh-grade Latino (male) students had one student off track compared with no students off track for 11th-grade Latina (female) students. In addition, both Latina (female) and Latino (male) 12th-grade students had seven students each, enrolled in a high-level math class. Although, there was one 12th-grade Latina (female) student who completed high school without exposure to a high-level math class, there were no Latino (male) 12th-grade students. All 12th-grade Latino (male) students were enrolled in a higher level math class. Table 6 displays the student breakdown by math course, grade, and gender for after participation in robotics competition groups.

Table 6

After Participation in Robotics Competitions (2017-2018 School Year) Student Breakdown of Each Group (Intervention and Control) by Math Course, Grade, and Gender

	11th Grade		12th Grade	
Math course	Latina (female)	Latino (male)	Latina (female)	Latino (male)
Integrated Math II	0	1	0	0
Integrated Math III	2	7	1	0
Pre-Calculus	0	0	0	2
Discrete Math	0	0	0	1
Pre-Calculus Honors	0	3	0	0
AP Statistics	0	0	1	0
AP Calculus AB	2	0	5	3
AP Calculus BC	0	0	1	1
Total	4	11	8	7

Qualitative Demographic Data

This section presents qualitative demographic data first then the data are analyzed by research question. To guarantee confidentiality, data were reported without direct reference to any participants (Latino/a college student) and their associated institutions (high school or college name). The participants were each assigned alphabetic designations based on the sequential order in which they were interviewed. Table 7 presents a summary of the selection criteria for inclusion in the study. At the time of the interview, all participants were enrolled in one of the following colleges: San Diego City Community College, Southwestern Community College, San Diego State University, University of California San Diego, or University of California Berkeley. The participants enrolled in a 4-year university declared one of the following college majors: electrical engineering or mechanical engineering. The participants attending community colleges expressed interest in transferring to a 4-year university and declared one of the following majors: mechanical engineering or civil engineering. In the Table 7, the selection criteria for the participants are provided.

Table 7

Selection Criteria for College Students

Participant (College Student)	1	2	3	4	5	6	7
Participation in 2 consecutive school years (2016-2017 and 2017-2018) in out-of-school high school educational robotics competitions	✓	✓	✓	✓	✓	✓	✓
STEM college student during 2018-2019	✓	✓	✓	✓	✓	✓	✓
At least 18 years of age	✓	✓	✓	✓	✓	✓	✓
Voluntary participation in the study	✓	✓	✓	✓	✓	✓	✓

All participants participated a minimum of 2 consecutive years (2016-2017 and 2017-2018) in robotics competitions and graduated from one of the following Southern California high schools: Montgomery High School, San Ysidro High School, Southwest High School, or Sweetwater High School. Table 8 presents the gender and the number of years students were involved in robotics competitions per college student.

Moreover, at the time of the interview, all participants were enrolled in a math college class. The highest mathematics course taken by the participants during high school included Pre-Calculus, AP Calculus AB, or AP Calculus BC. Based on SUHSD's

Table 8

Number of Years of Voluntary Participation in Out-of-School High School Educational Robotics Competitions per College Student

College student	Gender	Number of years of participation
College Student A	Male	4 years
College Student B	Female	3 years
College Student C	Male	4 years
College Student D	Female	2 years
College Student E	Female	3 years
College Student F	Female	6 years
College Student G	Female	2 years

2017-2018 mathematics course sequence, all college students were enrolled in a high-level math class during their 12th-grade senior year in high school. Table 9 presents the seven participants who were interviewed, the highest math course they took during high school, and the college math course the participants were enrolled in at the time of the interview.

Table 9

Highest Mathematics Course in High School and College per College Student

College student	Highest math class in high school	Highest math class in college
College Student A	AP Calculus BC	Math IB
College Student B	AP Calculus AB	Math 38
College Student C	AP Calculus AB	Calculus BC
College Student D	AP Calculus AB	Math IB
College Student E	AP Calculus BC	Calculus I
College Student F	Pre-Calculus	Math 105
College Student G	AP Calculus AB	Math 141

Presentation and Analysis of the Data

Quantitative Research Data

The researcher elicited archival student data from Sweetwater Union High School District for 30 Latino/a students who participated in the San Diego VRC robotics league for 2 consecutive school years (2016-2017 and 2017-2018). Appendix B contains the Sweetwater School District's approval for the researcher to collect archival student data. The first batch of data included information about Sweetwater Union High School District's mathematics course enrollment and its mathematics grades for both semesters for the school year before participation in robotics competitions (2015-2016). Similarly, the quantitative data for 2015-2016 included all of the mathematics class rosters and students' mathematics class grades for each of the 30 Latino/a students of the intervention group. The rosters were used to randomly select the control group for 2015-2016, referred to as the 2015-2016 before-participation control group. The first step in creating the 2015-2016 before-participation control group included elimination of non-Latino/a students and students who might have participated in robotics competitions. Appendix K contains 2015-2016 quantitative data for intervention and control groups before participation in robotics competitions.

The second batch of data included information about mathematics course enrollment and mathematics grades for both semesters for the school year after participation in robotics competitions for the intervention group (2017-2018). Likewise, the quantitative data for 2017-2018 included all the mathematics class rosters and students' mathematics class grades for each of the 30 Latino/a students of the intervention group. The rosters were used to randomly select the control group for 2017-

2018, referred to as the 2017-2018 after participation control group. Prior to the random selection of students for the 2017-2018 control group, non-Latino/a students and students who might have participated in out-of-school high school educational robotics competitions were eliminated. Appendix K contains 2017-2018 quantitative data for intervention and control groups after participation in robotics competitions.

In order to manipulate letter grades from the quantitative dataset, the researcher used a standard letter grade scale to convert letter grades into numerical information. In addition, the researcher averaged both semester grades per class to have a final numerical grade per student, per mathematics class, per year. Appendix L contains the standard letter scale used to convert letter grades into numerical grades. The quantitative data addressed two of the four research questions: Research Question 1 and Research Question 2.

Findings for Research Question 1. Research Question 1 was, "Do Latino/a students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latino/a students who do not participate?" To analyze whether there was a significant statistical difference between Latino/a students who participated in robotics competitions and Latino/a students who did not participate in such activities, the researcher used an inferential statistical tool. The inferential statistical tool used to evaluate the difference between the intervention and control groups was a two-sample *t* test with independent groups, also known as an independent samples *t* test. The *p*-value is used to determine statistical significance and to reject or fail to reject the null hypothesis. To reject the null hypothesis means that there is a statistical difference between the samples. A *p*-value of less than .05 ($p < .05$) indicates statistical significance and rejection of the null hypothesis. Fail to reject means that the *p*-value is greater than .05 and it is not possible to accept the null hypothesis; consequently, this implies that there are not enough data to validate a significant statistical difference between samples (Patten, 2012). The purpose in using null hypotheses in inferential statistics is that researchers “never prove something to be true” (McMillan & Schumacher, 2010, p. 297), but they fail to disprove it—null hypothesis.

The first step into the analysis of Research Question 1 included revising the quantitative data before participation to find out if there was a significant statistical difference between intervention and control groups regarding their grade achievement in mathematics classes before the participants engaged in robotics competitions.

Findings for Research Question 1: Before participation in robotics competitions (2015-2016). Through the descriptive statistical analysis of 2015-2016 data (refer to Appendix K), it was discovered that Latino/a students from the before-participation intervention group presented a mean of 87.51with a standard deviation of 10.43 compared with a mean of 78.86 and a standard deviation of 11.07 for the control group. Prior to the inferential statistical analysis, these results indicated that Latino/a students of the intervention group had higher grading average results in their two semesters of mathematics classes compared with control group students before intervention group students engaged in robotics competitions. Table 10 shows the descriptive statistics for 2015-2016 before participation in robotics competitions for intervention and control groups.

Table 10

Descriptive Statistics for 2015-2016 Before Participation in Robotics Competitions for Intervention and Control Groups

Intervention group		Control group	
Mean	87.52	Mean	78.87
Standard error	1.90	Standard error	2.022
Median	90	Median	81
Mode	96	Mode	86
Standard deviation	10.43	Standard deviation	11.08
Sample variance	108.82	Sample variance	122.70
Kurtosis	0.02	Kurtosis	-0.76
Skewness	-0.84	Skewness	-0.06
Range	38	Range	40
Minimum	62	Minimum	60
Maximum	100	Maximum	100
Sum	2625.5	Sum	2366
Count	30	Count	30

The next step into the analysis was to identify any anomalies or outliers in the data set. As noted by McMillan and Schumacher (2010), outliers are data points that land far from the main data distribution and can alter statistical analyses. Researchers rely on data visual representations, such as box-and-whisker plots, to identify outmost data points (McMillan & Schumacher, 2010). With this in mind, there were no outliers in the 2015-2016 data as assessed by inspection of boxplot graphs. Figure 4 presents the boxplot graphs of the data.

The results of the *t* test before participation in robotics competitions for both groups demonstrated what the descriptive analysis showed: There was a significant statistical difference in mathematics performance between the intervention and control groups before the intervention group engaged in robotics competitions, *t*(57) = 3.11, *p* = .05. These results suggest that the intervention group (*M* = 87.51, *SD* = 10.43, *n* = 30) students had a higher mathematics performance compared with the control group students

(*M* = 78.86, *SD* = 11.07, *n* = 30) prior to their engagement in robotics competitions. Table 11 presents the generated *t*-test results.

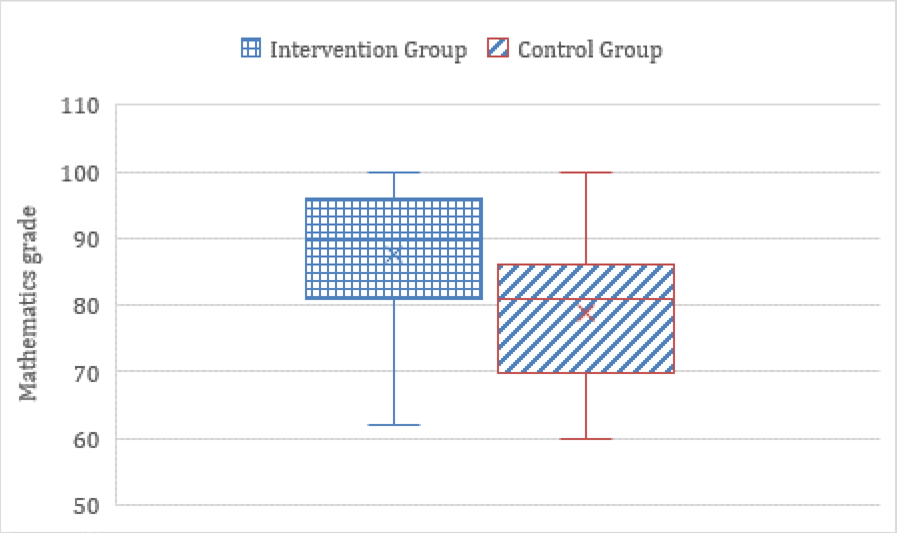

Figure 4. Boxplot graphs for intervention and control groups before participation in robotics competitions (2015-2016).

Table 11

Results Comparing Mathematics Performance of Intervention and Control Groups Before Participation in Robotics Competitions (2015-16 School Year)

Group	*N*	*M*	*SD*	*t*	*df*	*p*	95% Confidence interval
Intervention	30	87.51	10.43	-	-	-	-
Control	30	78.86	11.07	-	-	-	-
Total	60	83.19		3.11	57	.0014	3.08 - 14.21

**p*<.05

Findings for Research Question 1: After participation in robotics competitions (2017-2018). The second step into the analysis of Research Question 1 was to revise the quantitative data after participation (2017-2018) in robotics competitions to find out if there was a significant statistical difference between intervention and control groups regarding their grade average achievement in mathematics classes after the intervention group engaged in robotics competitions. Through the descriptive statistical analysis, it was discovered that Latino/a students from after-participation intervention group (2017-2018) presented a mean of 85.21 with a standard deviation of 10.23 compared with a mean of 83.58 and a standard deviation of 8.73 for the control group. The intervention group mean was slightly higher than the control group mean. Table 12 shows the descriptive statistics for 2017-2018 after participation in robotics competitions for both intervention and control groups. Additionally, there were no outliers in the 2017-2018 data, as assessed by inspection of boxplot graphs. Although the descriptive statistical analysis showed a slightly higher academic performance for the intervention group compared with the control group, the results of the inferential statistical analysis indicated that both groups differences were not statistical different. Figure 5 presents boxplot graphs of the data.

Table 12

Descriptive Statistics for 2017-2018: After Participation in Robotics Competitions for Intervention and Control Groups

Intervention group		Control group	
Mean	85.22	Mean	83.58
Standard error	1.98	Standard error	1.59
Median	90	Median	85.5
Mode	96	Mode	86
Standard deviation	10.84	Standard deviation	8.73
Sample variance	117.53	Sample variance	76.26
Kurtosis	-0.80	Kurtosis	0.51
Skewness	-0.65	Skewness	-0.83
Range	38	Range	36
Minimum	60	Minimum	60
Maximum	98	Maximum	96
Sum	2556.5	Sum	2507.5
Count	30	Count	30

The *t*-test analysis after participation in robotics competitions for both groups indicates that there was not enough evidence to reject the null hypothesis, *t*(57) = 0.64, *p* = .05. The results reveal that there is a nonsignificant statistical difference in mathematics performance for both after-participation groups (intervention and control). Table 13 presents the generated *t*-test results.

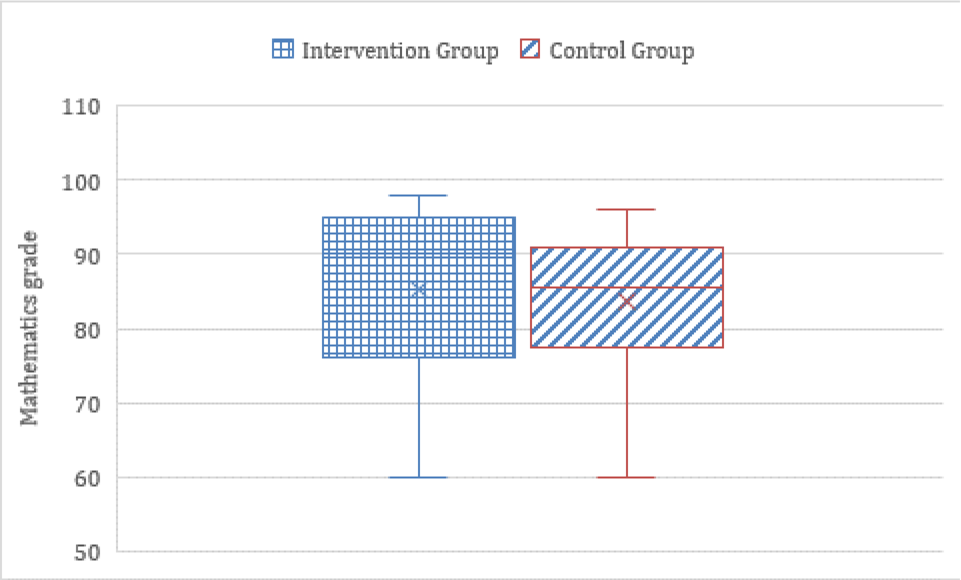

Figure 5. Boxplot graphs for intervention and control groups after participation in robotics competitions (2017-2018).

Table 13

Results Comparing Mathematics Performance of Intervention and Control Groups After Participation in Robotics Competitions (2017-18 School Year)

Group	*N*	*M*	*SD*	*t*	*df*	*p*	95% Confidence interval
Intervention	30	85.21	10.84	-	-	-	-
Control	30	83.58	8.73	-	-	-	-
Total	60	84.40		0.64	57	.2615	-3.46 - 6.72

Findings for Research Question 2. Research Question 2 was, “Do Latino (male) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latina (female) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years?" To analyze if there was a significant statistical difference between Latino (male) students and Latina (female) students who participated in robotics competitions regarding their academic performance, the researcher used an inferential statistical tool.

The inferential statistical tool used to evaluate the difference between the Latino (male) and Latina (female) groups was a two-sample *t* test with independent groups, also known as an independent samples *t* test. Eighteen of the 30 students who participated in robotics competitions were Latinos (male). From the 18 Latino (male) students, 11 were juniors (11th grade) and seven were seniors (12th grade). All 11 Latino (male) juniors but one were on track to take a high-level math class before completing high school as described by the 2017-2018 SUHSD's mathematics course sequence. Appendix J presents SUHSD mathematics course sequence for 2017-2018 school year. All seven Latino (male) students were enrolled in a higher level math class as presented by 2017-2018 SUHSD's mathematics course sequence. Four Latino (male) students were enrolled in an Advanced Placement mathematics class. Table 14 presents the mathematics courses, student grade level, and class grade of after-participation Latino (male) students.

The descriptive statistical analysis revealed that Latino (male) students had a median of 91.5, a mode of 96, mean of 85.55 and a standard deviation of 11.45 with a maximum score of 98 and a minimum of 60 in their average mathematics grade-level results two semesters after participation in robotics competitions. Table 15 presents the

Table 14

Mathematics Classes and Grades for Latino (male) Students After Participation (2017-2018) in Robotics Competitions

Student	Class	Grade level	Class grade
Latino 1	AP Calculus BC	12	92
Latino 2	AP Calculus AB	12	94.5
Latino 3	AP Calculus AB	12	94
Latino 4	AP Calculus AB	12	96
Latino 5	Pre-Calculus Honors	11	92
Latino 6	Pre-Calculus Honors	11	92
Latino 7	Pre-Calculus Honors	11	74
Latino 8	Pre-Calculus	12	79
Latino 9	Pre-Calculus	12	98
Latino 10	Integrated Math III	11	81
Latino 11	Integrated Math III	11	96
Latino 12	Integrated Math III	11	96
Latino 13	Integrated Math III	11	60
Latino 14	Integrated Math III	11	69
Latino 15	Integrated Math III	11	91
Latino 16	Integrated Math III	11	87
Latino 17	Discrete Mathematics	12	69
Latino 18	Integrated Math II	11	79

Table 15

Descriptive Statistics for Latino (Male) Students After Participation in Robotics Competitions

	Latino (male)
Category	Statistic
Mean	85.53
Standard error	2.70
Median	91.5
Mode	96
Standard deviation	11.46
Sample variance	131.25
Kurtosis	-0.33
Skewness	-0.88
Range	38
Minimum	60
Maximum	98
Sum	1539.5
Count	18

descriptive statistical analysis for Latino (male) students after participation (2017-2018) in robotics competitions.

Twelve of the 30 students who participated in robotics competitions were Latina (female) students. From the 12 Latina (female) students, four were juniors (11th grade) and eight were seniors (12th grade). All 11th-grade Latina (female) students were on track to take a high-level math class before completing high school as described by SUHSD's 2017-2018 mathematics course sequence.

Two 11th-grade Latina (female) students were already enrolled in an Advanced Placement mathematics class. Seven out of eight 12th-grade Latina (female) students were enrolled in an Advanced Placement mathematics class. One12th-grade Latina (female) student was enrolled in Integrated Mathematics III, which means that she completed high school without exposure to a high-level mathematics class. Table 16 presents the mathematics courses, student grade level, and class grade of after-participation Latina (female) students.

Table 16

Mathematics Classes and Grades for Latina (Female) Students After Participation (2017-2018) in Robotics Competitions

Student	Class	Grade level	Class grade
Latina 1	AP Calculus BC	12	89
Latina 2	AP Calculus AB	12	69.5
Latina 3	AP Calculus AB	11	91
Latina 4	AP Calculus AB	11	94
Latina 5	AP Calculus AB	12	96
Latina 6	AP Calculus AB	12	77
Latina 7	AP Calculus AB	12	76
Latina 8	AP Calculus AB	12	96
Latina 9	AP Statistics	12	86
Latina 10	Integrated Math III	11	96
Latina 11	Integrated Math III	12	70.5
Latina 12	Integrated Math III	11	76

The descriptive statistical analysis revealed that Latina (female) students had a mean of 84.75, which was slightly lower than Latino (male) students at 85.52. Latina (female) students' standard deviation was 10.32 compared with Latino (male) students of 11.45. This indicates that the average grades for two semesters of Latina (female) students after participation in robotics were slightly more concentrated at the mean value compared with Latino (male) students. Table 17 presents the descriptive statistical analysis for Latina (female) students after participation (2017-2018) in robotics competitions.

Table 17

Descriptive Statistics for Latina (Female) Students After-Participation in Robotics Competitions

	Latina (female)
Category	Statistic
Mean	84.75
Standard error	2.98
Median	87.5
Mode	96
Standard deviation	10.32
Sample variance	106.61
Kurtosis	-1.70
Skewness	-0.28
Range	26.5
Minimum	69.5
Maximum	96
Sum	1017
Count	12

The null hypothesis for Research Question 2 was, "Latino (male) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a lower academic performance in mathematics than Latina (female) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years."

Although, the descriptive statistical analysis revealed that Latina (female) students had a slightly lower academic performance than Latino (male) students did, the results of the inferential statistical analysis indicated that there was not a statistically significant difference between both Latina (female) and Latino (male) students as it pertained to their academic average grade-level performance in the two semesters after robotics competition participation by these students. The results of the *t* test after participation in robotics competitions between Latino (male) and Latina (female) high school students, $t(25) = 0.19$, $p = .05$, regarding their mathematics performance indicated that there was no statistically significant difference between them. Table 18 presents the generated *t*-test results.

Table 18

Results Comparing Mathematics Performance Between Latino (Male) and Latina (Female) Students Who Participated in Robotics Competitions (2017-2018 School Year)

Group	*n*	*M*	*SD*	*t*	*df*	*p*	95% Confidence interval
Latina (female)	12	84.75	10.32	-	-	-	-
Latino (male)	18	85.55	11.45	-	-	-	-
Total	30	85.15		0.19	25	.4241	-7.50 - 9.06

Qualitative Research Data

Two methods were used to analyze the qualitative data collected for this study. Each participant's data were analyzed based on the two qualitative research questions (RQ3 and RQ4) and their connection to the study's conceptual framework of experiential learning as in concrete experience, active experimentation, abstract conceptualization, and reflective observation (Kolb, 1984). The data were then collectively analyzed to develop common themes and patterns. The researcher uploaded into NVivo software the seven interview transcripts. The researcher used NVivo to identify themes in the participant responses to the interview questions. Based on the researcher's familiarity with the data, initial themes were identified and codes assigned to emerging themes. Of the themes identified, the researcher found 27 themes and 409 frequencies. A criterion for theme identification that the researcher chose was that a response had to be mentioned two or more times. Of the seven college students interviewed, four identified 11 themes in common in their responses related to Research Question 3 and six themes in common in their responses related to Research Question 4. After reviewing codes, grouping and eliminating redundant codes, an analysis and interpretation of the findings were conducted based on the frequency count of each code. The use of an Excel spreadsheet helped the researcher to further organize themes, counts, and frequencies. Further analysis of the themes generated 11 key study findings in relation to Research Question 3 and six key study findings in relation to Research Question 4. Common themes represented greater than 50%, or at least in four, of the participants' responses while themes not commonly shared represented less than 50% or no more than three participants' responses.

Qualitative data analysis per college student. The first step in the qualitative analysis was the examination of each participant's data (college student). Each college student's data were analyzed based on Research Questions 3 and 4 including their connection to the study's conceptual framework of experiential learning.

College Student A—Research Question 3. Research Question 3 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?"

College Student A was a Latino (male) student who participated in high school educational robotics competitions during his entire high school program (4 years of participation). He attended a University of California (UC System) college and his major was electrical engineering. His highest mathematics class in high school was AP Calculus BC, and at the time of the interview, he was enrolled in Math IB in college, which according to College Student A, is similar to Calculus BC. He noted that his current college class was similar to AP Calculus BC, but he indicated that in comparing the topics of both classes he realized that there were many topics that he did not cover in his high school class and decided to take it again in college. In addition, College Student A started a nonprofit organization to teach computer science and robotics to high school students in Tijuana, Baja California, Mexico. Equally important, College Student A participated in VEX and FIRST robotics and other extracurricular STEM activities during high school.

College Student A's responses identified with 12 of the 16 themes that related to Research Question 3. Table 19 presents College Student A's responses as themes for Research Question 3. College Student A expressed that his overall mathematics ability in high school was high, it was high for his ninth and 10th grades, and it was also high for his 11th and 12th grades. College Student A, made six references to "robotics helps grasp math concepts." In particular, he described how his participation in robotics, taking Calculus class, and working with an accelerometer helped him understand the concept from a mathematical perspective:

> In Calculus we reviewed the relationships between acceleration, velocity, and displacement and how you can go from one to the other. So knowing this

information, I became much more interested in the class and knowing exactly how it works mathematically.

Table 19

College Student A: Themes in Responses to Research Question 3

Research question (RQ)	Theme	Frequency by reference
RQ3: How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?	● Robotics helps grasp math concepts	6
	● Concrete experience	6
	● Robotics helps improve in math	5
	● Active experimentation	5
	● Robotics influences to take higher level math courses	2
	● High overall math ability in HS	2
	● Teacher-mentor-robotics peers influence to pursue higher level math	2
	● High math performance 11th & 12th	1
	● High math performance 9th & 10th	1
	● Follow predetermined sequence of math courses-program	1
	● Abstract conceptualization	1
	● Reflective observation	1

During the interview, College Student A, made reference five times to the theme of "robotics helps grasp math concepts." Robotics was "a real-world application" that allowed him to "apply mathematics . . . and become more excited in the subject." "Robotics influence to take higher level math" was referenced two times by College Student A. He indicated that he was not sure why he decided to take AP Calculus AB, "but what filled that interest might've been robotics," although, he also made one reference to "follow predetermined sequence of math courses-program" when describing the sequence of math courses that he took during high school. In addition, College Student A also indicated that his math teacher during his freshman year pointed out that he was good at math: "I do remember the decision was because my math teacher from my first year, he said that I seemed to be good at math—and he suggested for me to take that course."

Regarding experiential learning, during the interview, College Student A made six references to "concrete experiences," five references to "active experimentation," one reference to "reflective observation," and one reference to "abstract conceptualization." College Student A described how a "concrete experience" can bring all STEM concepts together.

> Then you say, "Well, I didn't do any equation. . . . I didn't do any of that." But like, "No, that's science! It's way more than science. And so, especially when students are—I think, that they didn't like and that they're not good in any of the STEM subjects and you put them in a program where they enjoy, where they're able to, uh—without them knowing—you know, bringing all these STEM concepts together to make it work in a robot.

On the theme of "active experimentation," College Student A described a particular experience when the students experimented with a sensor: "We had to use an accelerometer . . . make a program that allows [the robot] to know exactly where it is."

College Student A—Research Question 4. Research Question 4 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?" College Student A's responses identified with eight of the 11 themes related to Research Question 4. Table 20 presents College Student A's responses as themes for Research Question 4.

Table 20

College Student A: Themes in Responses to Research Question 4

Research Question (RQ)	Theme	Frequency by reference
RQ#4: How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?	● Robotics increases interest in STEM	13
	● Robotics develops 21st century skills	11
	● Robotics influenced my career-major	10
	● Robotics develops passion for STEM	4
	● Other Activities that influence to pursue STEM	4
	● Career pathway after college—private sector	3
	● Broaden participation in robotics	2
	● Robotics creates a sense of community	2

College Student A made 13 references to “robotics increases interest in STEM.” He narrated an interaction with one of his mentors that showed him programming, focused only on how to program VEX robots. College Student A thought he knew it all related to programming, but then he realized that it was the beginning of his journey into STEM: “I thought I had learned everything, but I really had no idea . . . there’s so much more!”

College Student A made 10 references to “robotics influenced my career-major.” He noted that since he was a little kid, he knew he wanted to do engineering, but he was not sure what type of engineering: “I had feelings as a kid—whenever I fixed stuff, uh, satisfaction of doing something I didn’t know how to solve and finding, you know, to do that it was incredible!” He added,

> By participating in robotics throughout my high school years it allowed me—to confirm it—that is something that I enjoy doing and that I see myself improving on a daily basis, which, in the long term, it can become a career.

During the interview, “robotics develops 21st century skills” was referenced 11 times by College Student A. During his senior year, College Student A was the team leader of his school robotics club. This gave him an opportunity to develop leadership and communication skills. He also noted that in his experience, robotics programs integrate three elements, which he called “pillars”: inspiration, collaboration, and innovation. College Student A also made reference to “Robotics develops a passion for STEM” four times during his interview. He described how he started a programming club at his high school during his senior year “because I became really passionate about robotics and there wasn’t really anyone who was teaching programming in my school . . . I started making programming classes during lunch.”

College Student A was involved in other STEM extracurricular activities during his high school years. He made four references to “other activities that influence to pursue STEM”; he described his involvement in For Inspiration and Recognition of Science and Technology (FIRST) Robotics (FRC), a STEM extracurricular program that combined 3D printing technology and Unmanned Airborne Systems (UAS), also known as Drones, and the relationships he formed with mentors in those activities. Similarly, during the interview, College Student A made two references to the following theme: “robotics creates a sense of community.” Particularly, he described his experience in leadership “it taught me that’s there much more, uh, I mean, it just taught me the importance of community.”

In addition, he made reference two times to the theme “broaden participation in robotics.” He indicated that many high school students “especially in communities low-income” do not realize all of the opportunities that robotics offer. He recommended to "get the interest of the students and let them know that there are resources available." He added that "robotics is a place where they can apply their creativity." College Student A plans to work in the private sector, "probably in Silicon Valley," for several years and then try to come back to San Diego and continue working in engineering.

College Student B—Research Question 3. Research Question 3 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?" College Student B was a Latina (female) student who participated in high school educational robotics competitions for 3 years during high school (3 years of participation). She attended a community college in Southern California and her intended major was civil engineering. Her highest mathematics class in high school was AP Calculus AB and at the time of the interview, she was enrolled in Math 38 in college. College Student B's responses identified with nine of the 16 themes that related to Research Question 3. Table 21 presents College Student B's responses as themes for Research Question 3.

College Student B considered that her overall mathematics ability in high school was high. During her high school freshman year (ninth grade), she was enrolled in Integrated Mathematics I bilingual (Spanish) and in her sophomore year (10th grade), she took Integrated Mathematics II; she scored As in both courses and during the interview, she indicated that she considered that her performance was high in both years. In her high school junior year (11th grade), she was enrolled in Compacted Integrated Mathematics III (Pre-Calculus), and she scored an A- during the first semester and a B+ during the second semester. During her senior year, she took AP Calculus AB, and she scored a C- during first semester and a B- in the second semester. During the interview, she indicated that her performance during her 11th- and 12th-grade years was below average.

Table 21

College Student B: Themes in Responses to Research Question 3

Research question (RQ)	Theme	Frequency by reference
RQ3: How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?	● Robotics helps grasp math concepts	6
	● Concrete experience	5
	● Teacher-mentor-robotics peers influence to pursue higher level math	3
	● Active experimentation	3
	● Robotics helps improve in math	3
	● Abstract conceptualization	2
	● High math performance 9th & 10th	1
	● High overall math ability in HS	1
	● Reflective observation	1
	● Below average—math performance 11th & 12th	1

During the interview, College Student B made reference six times to the theme of "robotics helps grasp math concepts." She described a situation where in the robotics class, students were working with gear ratios and in her Pre-Calculus class, they were reviewing information about the "Unit Circle," and she understood the connection between both. She said,

> In the robot was the ratio about the gears and how it goes clockwise and in the pre-calculus class, they were like talking about the unit circle . . . and that helped us a lot of for the programming, so it was like connected to it.

"Concrete experience" was referenced five times by College Student B. She summarized a situation in which by using math, she and her robotics teammates were able to resolve a problem:

> We needed to figure out how the brain robot controller was going to be connected to the all the motors, and all the pieces and their dimensions. And it was kind of difficult, but we kind of figured it out using math.

College Student B made three references to "teacher-mentor-robotics peers influence to pursue higher level math," an experience where in her first 2 years of high school she was classified as an English Language Development (ELD) student. She noticed that none of her ELD peers were involved in robotics. At that time, she was the only ELD student in her robotics club at school. She narrated how ELD students were talking about taking easy math classes while her robotics teammates were telling her to challenge herself to take higher level math classes to go to college: "In robotics they were talking about AP Cal or AP Stats and they were like: 'No, we need to take risks and everything to figure out how to go to college."

"Active experimentation" was referenced three times by College Student B. She mentioned that, on many occasions, the first step in solving a problem related to the robot's design, including the robot's coding, was to try out different approaches. She described an experience where, based on trial and error, the students tried to solve a programing issue, but eventually they realized that there was a pattern that was able to be replicated by using an equation in the program of the robot. In reference to "reflective observation," she said, "So, I can relate like, oh, when I was in class: 'Oh that was like, it connects to the gears and we solved some problems from the robot through the class.'"

College Student B—Research Question 4. Research Question 4 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?" College Student B's responses identified with five of the 11 themes related to Research Question 4. Table 22 presents College Student B's responses as themes for Research Question 4.

Table 22

College Student B: Themes in Responses to Research Question 4

Research question (RQ)	Theme	Frequency by reference
RQ4: In what ways do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?	● Other activities that influence to pursue STEM	4
	● Robotics influenced my career-major	2
	● Broaden participation in robotics	2
	● Career pathway after college—own business	1
	● Career pathway after college—undecided	1

College Student B made two references to "robotics influenced my career-major." She narrated that in her freshman year in high school, she thought that she wanted to become an accountant because she liked math, but through her involvement in robotics she realized that math is also applied in other careers, specifically in engineering.

> In my freshman year I was going to choose accounting, like just an idea and then when I got to robotics, I found out, like, there's another way to apply math, like choosing a career, because I was only thinking "ok math connects to accounting and that's it." And then, when I got to robotics, I was like "Oh my gosh, there's a lot of type of engineering, and there's a lot of different paths."

In addition, College Student B made four references to "other activities that influence to pursue STEM." During high school, she was involved in VEX and FIRST robotics competitions; in addition, she was part of the ACE mentoring program. ACE stands for Architecture, Construction, and Engineering. Through her involvement in the ACE program, she was able to interact with mentors who were architects, civil engineers, and professionals related to the construction field. She indicated that through her participation in robotics, she discovered her interest in engineering, but through her participation in ACE and her interactions with ACE mentors, she found her intended major "civil engineering."

When College Student B was asked about her career pathway after college, she made a reference to "career pathway after college—undecided" but also indicated that she would like to build a hotel in Mexico and make it her own business. "Broaden participation in robotics" was referenced two times by College Student B. She noted that she was the only ELD student in robotics: "The majority of my teammates were like AP students, honor students, they know, they figure out what they want. . . . But there were no ELD students . . . they didn't try to join."

College Student C—Research Question 3. Research Question 3 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?" College Student C was a Latino (male) student who participated in high school educational robotics competitions during his entire high school program (4 years of participation). He attends a University of California (UC system) college and his major is mechanical engineering. His highest mathematics class in high school was AP Calculus AB, and at the time of the interview, he was enrolled in Calculus BC in college. College Student C's responses identified with nine of the 16 themes that related to

Research Question 3. Table 23 presents College Student C's themes per Research Question 3.

Table 23

College Student C: Themes in Responses to Research Question 3

Research question (RQ)	Theme	Frequency by reference
RQ3: How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?	● Robotics helps grasp math concepts	6
	● Robotics helps improve in math	5
	● Concrete experience	5
	● Abstract conceptualization	3
	● Active experimentation	3
	● Teacher-mentor-robotics peers influence to pursue higher level math	2
	● High math performance 9th & 10th	1
	● High overall math ability in HS	1
	● Reflective observation	1
	● High math performance 11th & 12th	1

College Student C considered that his overall mathematics ability in high school was high. In ninth grade, College Student C was enrolled in Integrated Mathematics II. In 10th grade, he was enrolled in Integrated Mathematics III. In 11th grade, he was enrolled in Pre-Calculus Honors. In 12th grade, he was enrolled in AP Calculus AB. College Student C scored As in all of his high school math classes both semesters. During the interview, College Student C, made reference six times to the theme of "robotics helps grasp math concepts." He summarized how robotics provides a way to visualize math concepts.

> I guess 'cause robotics taught how to visualize the ideas, in the sense of like, for example, volume or area or like washers inside of space, the empty space in between. I was able to understand, like, why such math for— no formulas, applied and would work in that sense.

College Student C made five references to the theme of “robotics helps improve in math.” He expressed the importance of learning through applied math concepts in real-world activities.

> I’d say yes because it’s more you can apply the mathematics you learn through actual . . . relational, I guess I can say, ‘cause math it’s kind of hypothetical, or the questions are kind of hypothetical like in some you don’t even need experience in life, but like with robotics you can actually apply mathematics into the robot.

The theme “teacher-mentor-robotics peers influence to pursue higher level math” was referenced twice during the interview: “Well my team, in robotics when I was a freshman were all seniors, they were very intelligent seniors. So they kinda pushed me to, like, challenge myself and take on harder classes.” Regarding experiential learning, “concrete experience” was referenced five times, “abstract conceptualization” three times, “active experimentation” three times, and “reflective observation” one time. Particularly, College Student C described how the robotics experiences were not just the competitions but everything related to the robotics team: “Every practice was the experience . . . working on the robot, trying to fix it up, make it ready and just to be able to work on the robot.”

College Student C—Research Question 4. Research Question 4 was, “How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?” College Student C’s responses identified with seven of the 11 themes related to Research Question 4. Table 24 presents College Student C’s responses as themes for Research Question 4.

Table 24

College Student C: Themes in Responses to Research Question 4

Research question (RQ)	Theme	Frequency by reference
RQ4: How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?	● Robotics influenced my career-major	8
	● Robotics increase interest in STEM	6
	● Other activities that influence to pursue STEM	3
	● Robotics develops 21st century skills	3
	● Robotics increase a sense of community	3
	● Broaden participation in robotics	1
	● Career pathway after college—undecided	1

College Student C made eight references to "robotics influenced my career-major." He expressed that he had an interest in STEM before participating in robotics, but his participation influenced his career and major selection. He said,

> I always kinda—before, uh, joining robotics I had my view I'd become a scientist or a doctor, but then after joining robotics I kinda, it grew, I realized I had more interest in building, like designing and well, see my project come to life, which was shown through robotics.

"Robotics increase interest in STEM" emerged six times during the interview with College Student C. He described how most students take "theoretical" classes, "but robotics, it shows you more, it opens up more branches or areas that people didn't really consider." The themes of "robotics develops 21st skills," "robotics increase a sense of community," and "other activities that influence to pursue STEM" were referenced three times each. He described his involvement in a class named "Technical Theater" as follows:

> It was also another hands-on type of class they offered and which, personally I'm not a big fan of spotlighting theater, but technical theater are how the backstage works. So like, we were able to apply like mathematics that would apply that in theaters 'cause all the measuring, building, the constructing, you know, the designing from the script or like just the design theatrical—producing it.

College Student C made one reference to "broaden participation in robotics." He expressed concern on how other students are not benefiting from robotics "with robotics they [students] are able to finally see that or they're given a chance to see and explore, what else the world awaits." College Student C has not identified a specific career pathway after college: "I have really no preferences to what career pathway . . . as long as I continue working . . . with the programming and designing."

College Student D—Research Question 3. Research Question 3 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?" College Student D was a Latina (female) student who participated in high school educational robotics competitions for 2 years during high school. She attended a University of California (UC System) college and her major was electrical engineering. Her highest mathematics class in high school was AP Calculus AB, and at the time of the interview, she was enrolled in Math IB in college. College Student D's responses identified with nine of the 16 themes that related to Research Question 3. Table 25 presents College Student D's responses as themes for Research Question 3.

Table 25

College Student D: Themes in Responses to Research Question 3

Research question (RQ)	Theme	Frequency by reference
RQ#3: How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?	● Robotics helps improve in math	4
	● Robotics influences to take higher level math courses	3
	● Robotics helps grasp math concepts	3
	● Concrete experience	3
	● Active experimentation	2
	● High math performance 9th & 10th	1
	● High overall math ability in HS	1
	● High math performance 11th & 12th	1
	● Robotics has no direct math-class connection	1

College Student D considered that she had a high mathematics performance in all her high school years (ninth grade–12th grade). She was enrolled in Integrated Mathematics II in her freshman year, Integrated Mathematics III in her sophomore year, Pre-Calculus Honors in her junior year, and AP Calculus AB in her senior year. She received scores of As in all her high school mathematics classes.

During the interview, College Student D, made reference three times to the theme of “robotics helps improve in math.” In one of her references, she noted that maybe there was an indirect connection between robotics and improving in math classes:

> I think . . . like maybe not directly but, like, in the sense if you do wanna follow an engineering path, you know, you have to do well in school, in like you too need to do well, in like, those math classes.

College Student D, made reference three times to the theme of “robotics helps grasp math concepts.” She described how specific concepts were related to robotics:

> There were like math concepts that you had to keep in mind for robotics, like gear ratios and like making, like ‘cause based on the gear ratios you would know how much torque you had or how much speed you had to work with and compound gear ratios along with that.

Conversely, College Student D made one reference to the theme “robotics has no direct-math class connection.” She pointed out that “at least for what we did in robotics, it didn’t like directly connect to what I was learning at the same time.” The theme “robotics influences to take higher level math courses” was referenced three times by College Student D. She noted that since robotics influenced her major, she knew that she needed to take higher level math classes both in high school and college: “I would say yes because robotics did influence me in my major with which it also influenced which classes I took.” Regarding experiential learning, College Student D made three references to “concrete experience” and two references to “active experimentation.” She described a situation that involved gear ratios: “Based on the gear ratios, you would know how much torque you had or how much speed you had to work with.”

College Student D—Research Question 4. Research Question 4 was, “How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?” College Student D’s responses identified with five of the 11 themes related to Research Question 4. Table 26 presents College Student D’s responses as themes for Research Question 4.

Table 26

College Student D: Themes in Responses to Research Question 4

Research question (RQ)	Theme	Frequency by reference
RQ4: How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?	● Robotics influenced my career-major ● Robotics develops 21st century skills ● Robotics develops passion for STEM ● Robotics creates a sense of community ● Career pathway after college—undecided	8 6 5 3 1

During the interview, College Student D made eight references to “robotics influenced my career-major.” In one of her references, she stated, “Yes! Robotics did influence me in my major,” and she continued with, “I do think it [robotics] does have an influence to what you wanna do after high school.” Then, she shared how her career interest changed throughout her high school years in relation to her participation in robotics.

> I think it did have a great influence because when I started off in high school, before I participated in robotics, I was going through the medical pathway so I wanted to be a pediatrician and then, like, around sophomore year I kind of transitioned into biomedical engineering and then, uh, junior and senior year I was in robotics. And I realized, like, I didn’t really wanna keep on following, like, the medical pathway, but I was more interested, like in working with robots or like cybersecurity and stuff like that.

The theme of “robotics develops 21st century skills” was referenced six times, “robotics develops a passion for STEM” was referenced five times, and “robotics creates a sense of community" was referenced three times. She described the team interactions during build or practice sessions and how her robotics peers collaborate and work together to get ready for the robotics competitions. She noted that those experiences "build a passion not just for robotics but to do well in school and stay in like, STEM pathway." At the time of the interview, College Student D was undecided about her career pathway after college, although she mentioned that, "as of right now, I was thinking of either going the cyber security route or artificial intelligence route or if not because I'm still, like, interested in the biomedical aspect." She attributed her interest in the biomedical or bio-engineering from her exposure to a medical pathway she was enrolled in during her freshman year in high school, "I was going through the medical pathway so I wanted to be a pediatrician and then, like, around sophomore year I kind of transitioned into biomedical engineering."

College Student E—Research Question 3. Research Question 3 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?" College Student E was a Latina (female) student who participated in high school educational robotics competitions for 3 years during high school. She attended a community college in Southern California and her intended major was mechanical engineering. Her highest mathematics class in high school was AP Calculus BC, and at the time of the interview, she was enrolled in Calculus I in college. College Student E's responses identified with 10 of the 16 themes that relate to Research Question 3. Table 27 presents College Student E's responses as themes for Research Question 3.

Table 27

College Student E: Themes in Responses to Research Question 3

Research question (RQ)	Theme	Frequency by reference
RQ3: How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?	● Concrete experience	6
	● Active experimentation	5
	● Robotics helps improve in math	3
	● Robotics helps grasp math concepts	3
	● Robotics influences to take higher level math courses	3
	● Robotics has no direct math-class connection	2
	● Reflective observation	2
	● Good math performance 9th & 10th	2
	● High math performance 11th & 12th	1
	● Good overall math ability in HS	1
	● Abstract conceptualization	1

College Student E considered that her overall mathematics ability in high school was good. She indicated that her math performance in ninth and 10th grade was good. She noted that in her sophomore year, she started to receive help from a private tutor, and consequently, right after receiving help from the tutor, there was improvement in her mathematics grades. College Student E was enrolled in Integrated Math III during ninth grade; she scored Cs in both semesters. In 10th grade, she was enrolled in Pre-Calculus and scored a C- first semester and a B- second semester. In 11th grade, she was enrolled in AP Calculus AB and scored a B the first semester and an A the second semester. In 12th grade, she was enrolled in AP Calculus BC and scored an A- the first semester and a B the second semester. When she referred to her AP Calculus AB class, she said, “I don’t think I was qualified to be in that class,” and when she was asked about her reasoning for that statement, she replied, “Because I didn’t pass the AP calculus AB test,” referring to the College Board AP test. Although, she passed the class and was placed in

AP Calculus BC the following year, at which point she added, “I did struggle in that class a lot, but I enjoyed it and I worked hard for the grade.”

During the interview, College Student E, three times in her responses referenced the following themes: “robotics helps improve in math,” “robotics helps grasp math concepts,” and “robotics influences to take higher level math courses.” She described an experience when she was confronted with working with gear ratios to decide between speed or torque, she noted, “Oh, all this is mathematics and that made me see. Oh, there’s much more to see in mathematics and that opened my mind and I think that can help other students.” When referring to the theme of “robotics influences to take higher level math courses,” she described how the year she joined robotics and discovered that she was interested in engineering influenced her decision to take higher level math courses.

> Going back to my sophomore year, in Pre-calculus, I wasn’t really like—I did have a problem with math. But that’s the year I joined robotics and I knew that I had to take higher math classes. I didn’t even know what was calculus, I just wanted to take that class, I wanted to learn more about math. So yeah, I think robotics influenced my major and the classes I’m taking now and I will be taking.

However, the theme, “robotics has no direct math-class connection,” was referenced twice during the interview. College Student E indicated that most of the mathematics involved in robotics was related to coding, and she added, “Uh, for robotics, I don’t think I remember doing hard math, what is considered hard.” Regarding experiential learning themes, College Student E referenced “concrete experience” six times, “active experimentation” five times, “reflective observation” two times, and “abstract conceptualization” one time. When she was referring to “abstract conceptualization,” she described how she made the connections between math concepts (ratios) and physical objects (gears).

> For example, in robotics, I had to study gears, and I knew that gears were related to the ratios and those had to do with mathematics and knowing that—oh, these numbers have to do with this and like, that you get torque or speed or just the way to make it work, and that opened my mind.

College Student E—Research Question 4. Research Question 4 was, “How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?” College Student E’s responses identified with five of the 11 themes related to Research Question 4. Table 28 presents College Student E’s responses as themes for Research Question 4.

During the interview, College Student E, referenced the theme, “robotics influenced my career-major,” eight times in her responses. She noted that she knew that she was interested in engineering prior to her involvement in robotics. Initially, she thought about chemical engineering because she was taking chemistry, but later she joined robotics and her decision changed: “I was between mechanical or aerospace engineering and through robotics I got to learn more stuff about engineering.” She concluded, “but right now I’m going to stay in mechanical engineering because of robotics.”

Table 28

College Student E: Themes in Responses to Research Question 4

Research question (RQ)	Theme	Frequency by reference
RQ4: How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?	● Robotics influenced my career-major ● Robotics increase interest in STEM ● Other activities that influence to pursue STEM ● Broaden participation in robotics ● Career pathway after college—government	8 5 4 2 1

Five times College Student E, in her responses referenced the theme "robotics increase interest of STEM." College Student E alluded to the importance of robotics, its impact in the near future, and its connection with STEM.

> I see robotics as the future, eventually many things will become robots and that's where the money will be, where the future will be. If students see that, they will be more interested in STEM and I feel like a lot of students don't really see that, no, and especially girls.

College Student E made four references to "other activities that influence to pursue STEM." During her senior year in high school, she was involved in another STEM extracurricular program that involved drones and 3D printers. Through her exposure to mentorship from aerospace and mechanical engineers, she was influenced to select mechanical engineering as her intended major. The theme, "broaden participation in robotics," was referenced twice during the interview. College Student E expressed concern about how other students who are not involved in robotics are not able to understand the importance of STEM: "Oh, I just think that's very important, right now, that students can see what STEM is, and how it's going to improve in the future and, uh, have an impact in the future." When asked about her career pathway after college, College Student E indicated that she would like to work for a "government-owned" company like "NAVAIR," "SPAWAR," or "work with the Navy."

College Student F—Research Question 3. Research Question 3 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?" College Student F was a Latina (female) student who participated in high school educational robotics competitions for 6 years, which include both middle and high school (6 years of participation). She attended a state university college and her major was mechanical engineering. Her highest mathematics class in high school was Pre-Calculus, and at the time of the interview, she was enrolled in Math 105 in college. College Student F's responses identified with six of the 16 themes that related to Research Question 3. Table 29 presents College Student F's responses as themes for Research Question 3.

College Student F considered that her overall mathematics ability in high school and her math performance from ninth through 12th grade were high. However, in ninth grade, she was enrolled in Integrated Mathematics II and scored B's both semesters. In 10th grade, she was enrolled in Integrated Mathematics III, and she scored a D- her first semester and a B- the second semester. During the interview, College Student F indicated that in 10th grade she had problems with her math teacher: "I had a bad grade on the first semester because I think it was the teacher and then I told the principal to move me." In 11th grade, she was enrolled in Pre-Calculus and scored a B- the first semester and an A the second semester. In 12th grade, she was enrolled in AP Statistics and scored Bs both semesters.

Table 29

College Student F: Themes in Responses to Research Question 3

Research question (RQ)	Theme	Frequency by reference
RQ3: How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?	● Concrete experience	12
	● Active experimentation	8
	● Robotics influences to take higher level math courses	6
	● Robotics helps improve in math	5
	● Follow pre-determined sequence of math courses-program	4
	● Robotics helps grasp math concepts	4
	● High math performance 11th & 12th	1
	● High math performance 9th & 10th	1
	● High overall math ability in HS	1

The experiential learning theme of "concrete experience" was referenced 12 times during College Student F's interview. She explained that during her participation in robotics, her main role was more of designing and building. Additionally, she attributed these hands-on experiences to choosing mechanical engineering as her major: "I feel like, uh the things, building robots made a huge impact in my life. Since middle school I wanted to be part of this." She described some of the activities related to building a robot: "Well, like we measured the robot . . . mhh, there are rules about the dimensions and it was very important to be within those rules." Additionally, she made eight references to the experiential learning theme of "active experimentation." College Student F described situations where robotics students need to adapt through experimentation.

> I would say like, sometimes things don’t work out ‘cause, just like, you have to keep figuring it out. Like you might need a metal piece that you don’t have but you can like build it with other parts but there are rules. (College Student F)

Six times “robotics influences to take higher level math courses” was referenced during the interview. College Student F knew as early as seventh grade that she was interested in robotics and engineering. She also knew that because of that interest, she needed to take higher level math classes. During her senior year, she had the choice of either Financial Mathematics or an AP math class, she decided on AP Statistics. When asked about taking AP Calculus AB instead of AP Statistics, she mentioned that the teacher teaching that class was not a good teacher and she already had a bad experience in her sophomore year with a similar teacher.

“Robotics helps improve in math” was referenced five times during the interview. Particularly, her interest in robotics and engineering motivated her to do well in mathematics courses.

> Well, definitely. So I feel like knowing that I was gonna be in the major of robotics or engineering field, like, made more interested in mathematics, so that’s why “*le puse mas ganas*”—I put much more effort to math.

“Follow predetermined sequence of math courses-program” emerged four times during the interview with College Student F. When talking about the mathematics courses in high school, she mentioned that those were the courses she needed to take to graduate and go to college: “Mm, well, I had to take those courses in order to graduate.” When referring to the mathematics college course that she was enrolled in, during the interview she made a similar remark: “It is not like I have a choice, I need to take that class to graduate as a mechanical engineer, so." The theme of "robotics helps grasp math concepts" was referenced four times. Similar to other participants, College Student F described how gears in robotics help one to understand math concepts related to designing the mechanism that makes the robot move, also known as "drive mechanism." Sometimes it is necessary to have a fast robot, other times you need a slow but strong robot.

College Student F—Research Question 4. Research Question 4 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?" College Student F's responses identified with four of the 11 themes related to Research Question 4. Table 30 presents College Student F's responses as themes for Research Question 4.

Table 30

College Student F: Themes in Responses to Research Question 4

Research question (RQ)	Theme	Frequency by reference
RQ4: How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?	● Robotics influenced my career-major ● Robotics develops 21st century skills ● Other activities that influence to pursue STEM ● Robotics increase interest in STEM ● Career pathway after college—undecided	14 10 8 6 1

College Student F made a reference to “robotics influenced my career-major” 14 times during the interview. She said that because of robotics, she pursued a mechanical engineering degree.

> Well, I could say that, uh, robotics influenced me to go into an engineering field and eventually I knew what kind of engineering field I wanted to be in—mechanical engineering—and that’s gonna determine what I get out of life.

College Student F added that if she were to be exposed to other fields in high school, most likely she would have taken a different path:

> Definitely! Like, I feel like If I would’ve explored some other, like pathway, I don’t know if I would’ve gone with music, I would’ve been somewhere in music. But now that I explored robotics first I feel like engineering was the one that connected to it and I liked it. And yeah, now I’m doing something that I like.

“Robotics develops 21st century skills” was referenced 10 times by College Student F. During her high school senior year, College Student F was involved in the leadership activities of her robotics school club. She described how the club members were helping their robotics coach organize a robotics tournament to raise funds to help their program: “Planning the robotics tournament took a lot of work, but like, at the end it was really nice to see everything come together.” In addition, College Student F was involved in other STEM extracurricular activities during high school, she made eight references to “other activities that influence to pursue STEM.” She described how her relationship with one female engineer who acted as a judge in their robotics tournament also influenced her decision to pursue mechanical engineering: “And then I talked to . . .

and she told me she preferred mechanical engineering because this, or that, because it was fun and then eventually I came up with the decision of mechanical engineering."

"Robotics increase interest in STEM" was referenced six times during the interview. College Student F has been involved in robotics since middle school. She has participated in different robotics platforms such as Seaperch and VEX robotics. She noted that her participation early in middle school increased her interest in STEM and contributed to her continued participation in robotics to this interest level that kept increasing every year. College Student F was undecided as to her career pathway after college but she was interested in pursuing internships with companies related to her major as early as the next year. When asked about a particular field of interest she mentioned, "I like the car industry, but I still need to explore more and be more informed about that."

College Student G—Research Question 3. Research Question 3 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?" College Student G was a Latina (female) student who participated in high school educational robotics competitions for 2 years during high school (2 years of participation). She attended a state university and her major was mechanical engineering. Her highest mathematics class in high school was AP Calculus AB and at the time of the interview, she was enrolled in Math 141 in college. College Student G was classified as a foster youth student when she was enrolled in high school. College Student G's responses identified with nine of the 16 themes that related to Research Question 3. Table 31 presents College Student G's responses as themes for Research Question 3.

Table 31

College Student G: Themes in Responses to Research Question 3

Research question (RQ)	Theme	Frequency by reference
RQ3: How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?	● Concrete experience	8
	● Active experimentation	7
	● Robotics helps improve in math	6
	● Robotics helps grasp math concepts	5
	● Teacher-mentor-robotics peers influence to pursue higher level math	5
	● Robotics influences to take higher level math courses	3
	● Good overall math ability in HS	1
	● High math performance 9th & 10th	1
	● Below average - math performance 11th & 12th	1

College Student G considered that her overall mathematics ability in high school was good. She indicated that her mathematics performance in her ninth and 10th grades was high but in her 11th and 12th grade, her performance was below average due to personal living situation. During ninth grade, she was enrolled in Integrated Mathematics II and scored a C- the first semester and an A her second semester. In 10th grade, she was enrolled in Integrated Mathematics III and scored an A- both semesters. In 11th grade, she was enrolled in Pre-Calculus and scored a B the first semester and an A- the second semester. In 12th grade, she was enrolled in AP Calculus AB and scored Cs in both semesters.

Regarding the experiential learning themes, College Student G referenced “concrete experience” eight times and “active experimentation” seven times. She described how the robotics experiences modify students’ perspectives: “Uh, it changes the way you think about, uh like real-life issues, it really helps apply what you learn in a classroom studying into real-life situations.”

She noted that her role during her junior year was more into designing and building the robot. She shared an experience that involved designing and building a mechanism for the robot to shoot a ball—"There was one of these challenges that we had to get through in robotics"—and how it gave her and her robotics peers a different perspective on real-world applications. College Student G referenced "robotics helps grasp math concepts" five times. When she was describing the experience of designing the shooter mechanism, she indicated that she and her robotics teammates had to use trigonometry concepts to calculate the trajectory of the ball, "You had to use sine and cosine—trigonometry concepts and basic geometry to solve that issue." She added, "I remember my teacher trying to help me understand how that's related to math and it was a really big eye opener."

College Student G made six references to "robotics helps improve in math." She explained the differences between a traditional math classroom environment and the environment in robotics: "In a math class, you are on your own—in robotics it's a lot of team working and collaboration . . . it really helps you understand the math better when you work together." She stated that she applied that idea to her math classes:

> The best thing that you can do for yourself is to reach out for help and so talking to other students and really trying to understand what your confusion is. I applied that during my math courses the best that I could.

The theme, "teacher-mentor-robotics peer influence to pursue higher level math," was referenced five times during the interview. College Student G described how she was going to drop her AP Calculus class in her senior year due to her personal living situation (foster youth student) but a mathematics teacher encouraged and supported her to continue and finish her AP Calculus class, "I think it definitely, had a huge impact his support." Similarly, College Student G referenced "robotics influences to take higher level math courses" three times. In one of her references, she indicated that due to her exposure to programming and computer-aided design (CAD) activities that occur in robotics, she felt compelled to take higher level math courses: "Yes, I was encouraged to take higher level math courses because a lot like, the programming and like, the coding that is done in robotics and CAD designing specifically."

College Student G—Research Question 4. Research Question 4 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?" College Student G's responses identified with six of the 11 themes related to Research Question 4. Table 32 presents College Student G's responses as themes for Research Question 4.

Table 32

College Student G: Themes in Responses to Research Question 4

Research question (RQ)	Theme	Frequency by reference
RQ4: How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?	● Robotics develops 21st century skills ● Robotics influenced my career-major ● Other activities that influence to pursue STEM ● Broaden participation in robotics ● Career pathway after college—private sector ● Career pathway after college—undecided	11 8 5 3 2 1

College Student G made 11 references to "robotics develops 21st century skills." She described how her role in her robotics team changed from her junior to her senior year. In her junior year, she was mainly involved in designing and building and in her senior year she extended her responsibilities to managing her team (leadership). She noted that from her leadership experiences, she learned about herself:

> You learn a lot about yourself . . . you'll find out things that maybe you just weren't ever capable of and, uh, you use those experiences, uh, as an advantage, and uh, to just seek out like more—to learn more about it—and that a very memorable experience that I actually had in high school that I enjoyed a lot and that has taught a lot about myself.

The theme of "robotics influenced my career-major" was referenced eight times during the interview. College Student G explained how her participation in robotics helped her in identifying her career and her major:

> Yeah, it played a huge role. Uh, I think a lot of the things that I enjoyed doing in robotics helped me gain an interest and it strengthened that for me to go after like STEM-related major and specifically mechanical engineering.

College Student G also noted that influence played by other activities including the influence that mentors have over students. "Other activities that influence to pursue STEM" was referenced five times:

> Because of all like the influences too, like the mentors and you know, hearing their experiences, uh, I just thought that would be the right major for me and a lot of the things that we learned in robotics like CAD designing, uh, I'm applying right now in college.

“Broaden participation in robotics” was referenced three times. College Student G expressed concern about the importance of exposing more students to STEM programs like robotics: “Nowadays with just technology advancing and all that, uh, the youth, they’re really like the future and I think engaging them in a lot of like STEM programs can be very beneficial.”

College Student G would like to work for a private company after she finishes her degree, but she added, “Uh, so I’d like to go in with an open mind.” Additionally, she mentioned that she would like to work for Solar Turbines due to her involvement in another STEM extracurricular program named Solar’s Young Women Academy, where she was exposed to the company: “I do have in mind, uh, the gas and oil industry with Solar Turbines just because I was involved in the academy for women, uh, and we were very involved with solar turbines.”

Collective Qualitative Data Analysis Per Common Theme Per Research Question

Research Question 3. “How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?” Table 33 presents the themes that resulted from all seven college students for Research Question 3 based on the number of responses for each participant. Overall, 11 of the 16 themes/patterns significantly describe the high school mathematics course performance of Latino/a college students who participated in the robotics competitions.

Table 33

Research Question 3: Common Themes in Responses by All College Student Participants by Frequency of Reference

Theme	College student respondent	Frequency of reference
● Concrete experience	7	45
● Active experimentation	7	33
● Robotics helps grasp math concepts	7	33
● Robotics helps improve in math	7	31
● High math performance 9th & 10th	6	6
● Robotics influence to take higher level math	5	17
● High overall math ability in HS	5	6
● High math performance 11th & 12th	5	5
● Teacher-mentor-robotics peers influence to pursue higher level math	4	12
● Abstract conceptualization	4	7
● Reflective observation	4	5
● Follow pre-determined sequence of math courses-program	2	5
● Robotics has no direct math-class connection	2	3
● Below average - math performance 11th & 12th	2	2
● Good overall math ability in HS	2	2
● Good - math performance 9th & 10th	1	2

Note. Research Question 3 was, “How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?”

Common Theme 1: Concrete experience. Of the seven college students interviewed, all seven provided a response with a total of 45 references that fit within the common theme of experiential learning, “concrete experience.” All college students during the interviews described specific concrete experiences related to their participation in robotics competitions. College Student E mentioned, “I remember when we were learning the coding and the programming for the robot especially with the robot’s autonomous program.”

Common Theme 2: Active experimentation. Of the seven college students interviewed, all seven provided a response with a total of 33 references that fit within the common theme of experiential learning, “active experimentation.” During the interviews, all college students narrated robotics experiences that involved “trial and error,” “experimentation,” or “testing” to accomplish tasks related to the design or building process of the robot. College Student A described an experience where his teammates were engaged in active experimentation:

> They did trial and error—and if they would’ve known that there was an equation that you can use in order to optimize the time you have put in to that instead of testing one, so forth until you get the right one—there’s actually a better way to do it.

Common Theme 3: Robotics helps grasp math concepts. Of the seven college students interviewed, all seven provided a response with a total of 33 references that fit within the common theme of “robotics helps grasp math concept.” All college students described experiences that aided them to understand math concepts. Some of the mentioned experiences included basic arithmetic, algebra, geometry, and trigonometry concepts. College Student C noted that robotics helped him understand math concepts:

> I guess ‘cause robotics taught how to visualize the ideas, in the sense of like, like for example, volume or area or like washers inside of space, the empty space in between. I was able to understand, like, why such math for— no formulas, applied and would work in that sense.

Common Theme 4: Robotics helps improve in math. Of the seven college students interviewed, all seven provided a response with a total of 31 references that fit within the common theme of “robotics helps improve in math.” During the interviews, all seven college students described experiences where, through their participation in robotics, they felt they improved their performance in mathematics. Some of the descriptions included how robotics helps to visualize math information and math applications in real-world problems. In College Student A’s words,

> It, allows us to be more engaged with the subject, because it’s something that’s gonna benefit us. And this is something that we can apply towards the competition, so we can learn, so we can have better skills. It’s something I’ve seen not only in myself, but in my classmates.

Common Theme 5: High math performance in ninth & 10th grade. Of the seven college students interviewed, six provided a response with a total of 31 references that fit within the common theme of “high math performance in ninth & 10th grade.” From the interviews, it was discovered that six of the seven college students considered they had a high math performance in their high school freshman and sophomore years. Only one college student (E), noted that her math performance in ninth and 10th grade was good.

Common Theme 6: Robotics influence to take higher level math. Of the seven college students interviewed, five provided a response with a total of 17 references that fit within the common theme of “robotics influence to take higher level math.” Five college students considered that robotics influence students to pursue higher level mathematics courses. Some of the indicators mentioned during the interviews included curiosity or expectations to learn more math because of their interest in STEM. College Student B and College Student C made more emphasis on how other factors influenced them to pursue higher level math courses, such as mentors and peers.

Common Theme 7: High overall math ability in HS. Of the seven college students interviewed, five provided a response with a total of 17 references that fit within the common theme of “high overall math ability in HS.” Five out of seven college students considered that throughout their high school mathematics classes’ experiences their ability was high. Both College Student E and College Student G indicated that their overall math ability in high school was good.

Common Theme 8: High math performance in 11th & 12th grade. Of the seven college students interviewed, five provided a response with a total of five references that fit within the common theme of “high math performance 11th & 12th grade. Five of the seven college students considered that during their 11th and 12th grades, they had a high math performance in their mathematics classes. Both College Student B and College Student G indicated that their math performance in 11th and 12th grade was below average.

Common Theme 9: Teacher-mentor-robotics peers influence to pursue higher level math. Of the seven college students interviewed, four provided a response with a total of 12 references that fit within the common theme of “teacher-mentor-robotics peers influence to pursue higher level math.” The college students who made references to this theme also shared that they were influenced to take higher level math classes by either their teacher(s), mentor(s), or robotics peers. The college students who were involved in robotics early in their high school years described how they were inspired by the senior students of their robotics club to aim higher. College Students D, E, and F made more references to being influenced to pursue higher level math from their participation in robotics.

Common Theme 10: Abstract conceptualization. Of the seven college students interviewed four provided a response with a total of seven references that fit within the common theme of “abstract conceptualization.” The college students that made references to this theme described experiences that enabled them to “visualize” abstract-theoretical math information. College Students D, F, and G made no references to this theme but when referring to experiential learning, they made more references to “concrete experience” and “active experimentation.”

Common Theme 11: Reflective observation. Of the seven college students interviewed four provided a response with a total of five references that fit within the common theme of “reflective observation.” The college students who made references to this theme described experiences that involved digesting the practical experience provided by their participation in robotics competitions, mathematics courses, and their connections. College Students D, F, and G made no references to this theme but when referring to experiential learning, they made more references to “concrete experience” and “active experimentation.”

Research Question 4. “How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?” Overall, six of the 11 themes/patterns describe the perception of Latino/a college students regarding the influence of their participation in robotics competitions to pursue a STEM college degree. Table 34 presents the themes that resulted from all seven college students for Research Question 4 based on the number of responses for each participant.

Table 34

Research Question 4: Common Themes in Responses by All College Student Participants by Frequency of Reference

Theme	College student respondent	Frequency of reference
● Robotics influenced my career-major	7	58
● Other activities that influence to pursue STEM	6	28
● Robotics develops 21st century skills	5	41
● Broaden participation in robotics	5	10
● Career pathway after college—undecided	5	5
● Robotics increase interest in STEM	4	30
● Robotics creates a sense of community	3	8
● Robotics develops a passion for STEM	2	9
● Career pathway after college—private sector	2	5
● Career pathway after college—government	1	1
● Career pathway after college—own business	1	1

Note. Research Question 4 was, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?"

Common Theme 1: Robotics influenced my career-major. Of the seven college students interviewed all seven provided a response with a total of 58 references that fit within the common theme of "robotics influenced my career-major." All college students agreed that their participation in robotics competitions influenced their decision to pursue a STEM college degree (career). Furthermore, their participation in robotics exposed them to different areas of STEM. This exposure influenced their decision on the selection of a specific STEM major.

Common Theme 2: Other activities that influence to pursue STEM. Of the seven college students interviewed six provided a response with a total of 28 references that fit within the common theme of "other activities that influence to pursue STEM." Throughout the six interviews with the college students that made references to this theme, it was mentioned the influence exercised to pursue STEM by other curricular activities such as “technical theater” and other STEM extracurricular activities such as FIRST Robotics, Seaperch, UAS-Drone Challenge, 3D printers, after school STEM programs, among others. College Student D made no references to this theme but she had more references to “robotics develops a passion for STEM.”

Common Theme 3: Robotics develops 21st century skills. Of the seven college students interviewed five provided a response with a total of 41 references that fit within the common theme of “robotics develops 21st century skills.” The college students that made references to this theme pointed out 21st-century skills such as collaboration, communication, teamwork, problem solving, critical thinking, creativity, perseverance, leadership, organization, initiative, among others. During their interviews College Students B and E made no references to this theme but they made more emphasis on “other activities that influence to pursue STEM” and “robotics influenced my career-major.”

Common Theme 4: Broaden participation in robotics. Of the seven college students interviewed five provided a response with a total of 10 references that fit within the common theme of “broaden participation in robotics.” The college students that made references to this theme expressed concern about the rest of the students that are not involved in STEM activities like robotics. It was mentioned that underrepresented minority students like English Learners (ELD), Latino/a, socio-disadvantaged, special education, and female students are not included in these type of activities. College Students D and F made no references to this theme, although College Student D made five references to “robotics develops a passion for STEM” and College Student F made 14 references to “robotics influenced my career-major.”

Common Theme 5: Career pathway after college—undecided. Of the seven college students interviewed, five provided a response with a total of five references that fit within the common theme of "career pathway after college—undecided." The college students who made references to this theme were open to explore different career pathways after college, but some of them were also interested in either retuning to San Diego or working for companies that connected with them through other high school STEM programs. Private companies like Qualcomm or Solar Turbines and government organizations like NAVAIR, SPAWAR, or the Navy were mentioned. Two college students did express specific interests for their career pathways. College Student A expressed interest in working for the private sector and College Student E intended to pursue employment in the government as a her career pathway after college.

Common Theme 6: Robotics increase interest in STEM. Of the seven college students interviewed, four provided a response with a total of 30 references that fit within the common theme of "robotics increase interest in STEM." Throughout the interviews with the college students who made references to this theme, there were commonalities in their responses about the impact that robotics has in promoting STEM . College Student C stated,

> But robotics shows you more, it opens up more branches or areas that people didn't really consider, 'cause most people consider it science or just science majors or, uh, doctors sort of. But they don't really consider the mechanical or mathematic-kind side of it. Because they're not—they haven't been offered such activities to get the sense of that, but with robotics they are able to finally see that or they're given a chance to see and explorer, what else the world awaits.

During the interviews, College Students B, D, and G made no references to this theme but made more references to “robotics influenced my career-major.”

Summary

This chapter reported the analysis and findings of the research aimed at answering a central research question: “Do Latino/a students who participate in out-of-school high school educational robotics competitions perform better in mathematics courses in high school, and are these students influenced to pursue college STEM degrees?” This mixed-methods ex post facto study used two data collection methods: archival data to answer the quantitative research questions and interviews with seven Latino/a college students to respond about the qualitative research questions.

The quantitative data analysis responded to Research Questions 1 and 2. The quantitative analysis included before participation and after participation in robotics competitions data in the form of high school mathematics grades for intervention and control groups. The quantitative analysis included descriptive statistics and inferential analysis. The inferential analysis tool used was a *t* test to compare two independent samples before and after participation in robotics competitions. The before-participation inferential analysis used average mathematics grades in the two semesters prior to engagement in robotics competitions. The after-participation inferential analysis used average mathematics grades in the two semesters after participation robotics competitions. Additionally, a *t* test was also used to analyze significance in average mathematics grades between Latino (male) and Latina (female) students after participation in robotics competitions.

The qualitative data analysis answered to Research Questions 3 and 4. A comprehensive analysis of the qualitative data collected from seven interviews yielded a total of 27 themes and 409 frequencies. Further analysis of the themes generated 11 key study findings in relation to Research Question 3. Moreover, the qualitative analysis generated four key study findings in relation to Research Question 4. Chapter V presents a summary of findings, conclusions, implications for action, and recommendations for future research.

CHAPTER V: FINDINGS, CONCLUSIONS, AND RECCOMENDATIONS

Summary

Chapter V begins with the purpose statement, research questions, methodology, population, and sample information. The chapter continues with a summary of the findings for each research question, followed by conclusions, and implications for action. Recommendations for future research are also provided in this chapter. The chapter concludes with final comments from the researcher about this study.

Purpose Statement

The purpose of this mixed-methods ex post facto study was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino/a students in Southern California who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and high school Latino/a students who did not participate in out-of-school high school educational robotics competitions. A secondary purpose was to examine the difference in academic performance in mathematics as measured by class grades between high school Latino (male) and Latina (female) students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions in Southern California. A third and final purpose was to describe the experiences of Latino/a college students who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions and how these experiences influenced their interest in enrolling in college courses leading to a STEM college degree.

Research Questions

Central research question.

Do Latino/a students who participate in out-of-school high school robotics competitions perform better in mathematics courses in high school, and are these students influenced to pursue college STEM degrees?

Quantitative research questions.

1. Do Latino/a students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latino/a students that do not participate?
2. Do Latino (male) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latina (female) students that participate in out-of-school high school robotics competitions a minimum of 2 consecutive years?

Qualitative research question.

3. How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?
4. How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?

Methodology

A mixed-methods ex post facto design was used in this study to capture both quantitative and qualitative data. For the quantitative portion of the research design, archival data in the form of mathematics courses grades for 2015-2016 and 2017-2018 school years was gathered for 30 10th- and 11th-grade high school Latino/a students who participated in the 2016-2017 San Diego VRC High School Robotics League and also participated the following year in the same robotics league in 2017-2018 when they were enrolled as 11th- and 12th-grade high school students (intervention group). Additionally and for comparison purposes, archival data were also gathered to form two control groups of 30 high school Latino/a students each; a 2015-2016 control group and a 2017-2018 control group. Control groups of students were randomly selected matching all the characteristics of the intervention group but whose characteristics did not include the independent variable, which was voluntary participation in out-of-school high school educational robotics competitions in 2 consecutive school years (2016-2017 and 2017-2018).

For the qualitative portion of the research design, 10 Latino/a college students, each representing at least one high school from the eight Sweetwater Union High School District (SUHSD) schools that were part of the quantitative data set were located. These Latino/a college students participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive school years (2016-2017 and 2017-2018). The Latino/a college students were invited to be a part of the intervention group's qualitative data by volunteering to be in a face-to-face interview conducted by the researcher. However, only seven Latino/a college students volunteered to participate in the interview. The seven interviewed Latino/a college students graduated from four of the eight SUHSD high schools that were part of the quantitative data set. The interviews the researcher conducted were intended to gather the participants' perceptions about their performance in mathematics courses in high school and whether their participation in out-of-school high school educational robotics competitions influenced their decision to pursue a STEM college degree.

Population

The population for this research study were Latino/a high school students who participated voluntarily in out-of-school high school educational robotics competitions a minimum of 2 consecutive years. In addition, the population of this study included Latino/a college students who participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years and were also part of the intervention group. The target population was composed of all 11th- and 12th- grade Latino/a students (30) for the 2017-2018 school year who participated in 2016-2017 and 2017-2018 San Diego VEX VRC high school robotics league.

Sample

The purposeful sample for the quantitative portion of the study was composed of 30 high school Latino/a students who voluntarily participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years. In addition, to support the qualitative research design of this study, nonprobability sampling techniques of purposive and convenience sampling were used. From the 15 potential Latino/a college participants identified as the qualitative target population (referenced in Table 1), 10 were located and were contacted through e-mail and/or phone calls with an invitation to participate in the study. Seven students agreed to volunteer to participate in the interviews based on their availability. These seven students were already in college and graduated from one of the following SUHSD high schools: Montgomery High School, San Ysidro High School, Southwest High School, and Sweetwater High School.

In addition, these college Latino/a students participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years (2016-2017 and 2017-2018) and were also part of the quantitative data set.

Major Findings

The intent of this research was to examine the difference in academic performance in mathematics between high school Latino/a students in Southern California who participated a minimum of 2 consecutive years in out-of-school high school educational robotics competitions (hereafter known as robotics competitions) and their perceptions on the influence these activities had on them to pursue college STEM degrees. The major findings of this study are the reflection of quantitative and qualitative data analyses presented in Chapter IV. The following major findings and descriptions are organized by research question.

Research Question 1 Major Findings

The quantitative data analysis provided results to support three major findings when responding to Research Question 1, "Do Latino/a students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latino/a students who do not participate?"

Major Finding 1. *Latino/a students who participated in robotics competitions a minimum of 2 consecutive years, present no significant statistical difference in mathematics performance compared with Latino/a students who did not participate in such activities during high school.*

Major Finding 2. *Latino/a students from the intervention group presented a positive significant statistical difference in mathematics performance before engagement in robotics competitions as compared with Latino/a students from the control group who did not participate in such activities during high school.* Although there was no significant statistical difference between intervention and control groups after participation in robotics competitions, through this study it was discovered a significant statistical difference between both groups prior to participation.

Major Finding 3. *Students who had multiple years of experience in participation in robotics competitions achieved at a significantly higher level in high school mathematics courses than students who had not participated in robotics competition experiences.* From this study's qualitative data, it was discovered that several Latino/a students had over 2 years of experience participating in robotics competitions. Five out of the seven college students interviewed, who were also part of the quantitative dataset, had 3 years of participation in robotics competitions. Two of the seven college students participated in robotics competitions during their entire high school program (4 years of participation). One of the seven college students had 6 years of participation, which included all middle and high school years. The students' broad exposure to robotics previous to this research study could have played a role in students' positive mathematics performance including their experiences of being exposed to mathematics concepts related to algebra, geometry, and trigonometry (Barger & Boyette, 2015) in hands-on and project-based classroom environments in real-life application settings. These experiences align more readily to mathematics concepts in higher level mathematics classes, potentially helping students involved in robotics for a longer period of time to achieve higher mathematics scores compared with Latino/a students who were not exposed to such activities. Moreover, it was discovered that all college students interviewed found that robotics played a role in their mathematics performance during high school. Seven of the seven college students responded 64 times in response to the themes of “robotics helps improve in math” and “robotics helps grasp concepts.”

Research Question 2 Major Findings

The quantitative data analysis provided results to support two major findings when responding to Research Question 2: “Do Latino (male) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latina (female) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years?”

Major Finding 4. *There is no significant statistical difference between Latino (male) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years compared with Latina (female) students who participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years*. From the quantitative data analysis, it was discovered that there was no significant difference in mathematics performance between Latino (male) and Latina (female) students who participated in out-of-school high school educational robotics competitions.

Major Finding 5. *Latina (female) students involved in robotics competitions had a higher enrollment participation rate in Advanced Placement (AP) mathematics courses compared with Latino (male) students involved in robotics competitions.* During the second year of participation in robotics competitions (2017-2018), nine of the 12 Latina (female) students, which represents 75% of all Latina (female) students of the intervention group, were enrolled in an AP mathematics class compared with only four of the 18 Latino (male) of students, which represents 22% of all Latino (male) students. In addition, in 2017-2018, two 11th-grade (junior) Latina (female) students were enrolled in an AP mathematics course compared with no enrollment from Latino (male) students. Moreover, seven of the eight 12th-grade Latina (female) students, which represents 87.5% of all 12th-grade Latina (female) students, were enrolled in an AP mathematics course compared with only four of the seven males, which accounts for 57% of all AP Latino (male) students.

Research Question 3 Major Findings

The seven Latino/a college students interviewed provided qualitative data from which four major findings were developed when responding to Research Question 3, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?"

Major Finding 6. *Interviewed college students described their performance in mathematics courses in high school as high or good*. This major finding correlates with the following common themes: Theme 7, "high overall math ability in HS"; Theme 5, "high math performance in 9th & 10th grade"; and Theme 8, "high math performance in 11th & 12th grade." Five of the seven interviewed college students described their overall performance in mathematics in high school courses as "high." Two of the seven indicated "good." Similarly, six of the seven college students considered that they had a high math performance in their high school mathematics during their ninth and 10th grades. Only one college student considered that she had a “good” mathematics performance in her high school mathematics courses during ninth and 10th grades. Likewise, five of the seven college students considered that they had a high math performance in their high school mathematics during their 11th and 12th grades.

However, two students considered that they had a “below average” math performance in their high school mathematics courses during their 11th- and 12th-grade years. Conversely, when the researcher compared one of these student’s responses regarding her mathematics performance during her 11th and 12th grades, archival quantitative data showed that in her high school junior year (11th), she was enrolled in Compacted Integrated Mathematics III (Pre-Calculus) and she scored an A- during the first semester and a B+ second semester. During her senior year, she took AP Calculus AB, and she scored a C- during first semester and a B- in second semester. It is worth mentioning that this college student was classified as a “foster youth” student during her high school program. Equally important, this college student mentioned during her interview that she had personal issues related to her living situation that affected her academic performance.

Likewise, when the researcher compared the second college student’s responses regarding her mathematics performance during her 11th and 12th grades, archival quantitative data showed that in her high school junior year (11th), she was enrolled in Pre-Calculus and scored a B in her first semester and an A- during her second semester. During her senior year, she was enrolled in AP Calculus AB, and she scored a C in both semesters. Finally, archival quantitative data validated the qualitative data gathered during the interviews regarding college students' performance in mathematics courses in high school that the majority of students performed at a high or above average level.

Major Finding 7. *Interviewed Latino/a college students denoted that participation in robotics competitions helps students grasp math concepts and improve in mathematics*. This major finding correlates with the following common themes: Theme 3, "robotics helps grasp math concepts" and Theme 4, "robotics helps improve in math." All Latino/a college students interviewed described experiences where, through their participation in robotics competitions, they felt they improved their performance in mathematics in high school. Some of the responses included how robotics helped them visualize math information and math applications in real-world problems. Moreover, regarding mathematics concepts, some of the mentioned robotics experiences included that students had been exposed to basic arithmetic, algebra, geometry, and trigonometry concepts.

Major Finding 8. *Interviewed Latino/a college students declared that robotics or people involved in robotics, like teachers, mentors, and peers, had an influence on them to pursue high-level mathematics courses in high school and in college*. This major finding correlates with the following common themes: Theme 6, "robotics influence to take higher level math" and Theme 9, "teacher-mentor-robotics peers influence to pursue higher level math." Five of the seven Latino/a college students considered that robotics influences students to pursue higher level mathematics courses while four of the seven made references that included teachers, mentors, or peers as sources of influence for students to pursue higher level mathematics courses. Additionally, some of the responses mentioned during the interviews included curiosity or expectations to learn more mathematics because of their involvement in robotics or because they were influenced to have an interest in STEM. It is worth mentioning that Latino/a college students who were involved in robotics early in their high school years described how they were inspired by the senior students of their robotics clubs to enroll in higher level mathematics courses.

Major Finding 9. *Interviewed Latino/a college students described high school experiences in robotics competitions that align with experiential learning as in concrete experience, active experimentation, abstract conceptualization, and reflective observation*. This major finding correlates with the following common themes: Theme 1, "Concrete Experience"; Theme 2, "Active Experimentation"; Theme 10, "Abstract Conceptualization"; and Theme 11, "Reflective Observation."

"Concrete Experience" and "Active Experimentation" had a combined frequency of 78 responses among all seven interviewed Latino/a college students. During the interviews, all Latino/a college students discussed robotics experiences that involved "trial and error," "experimentation," or "testing" to accomplish tasks related to the design or building process of the robot. Five of the seven Latino/a college students made reference to the theme of "Abstract Conceptualization." Their responses indicated that robotics enabled students to "visualize" abstract-theoretical mathematics information. Four of the seven Latino/a college students made reference to the theme of "Reflective Observation," and these responses reflected when they were involved in digesting the practical experience provided by participation in robotics competitions, mathematics courses, and their connections were made evident or easy.

Major Finding 10. *Latino/a high school students that participate in robotics activities that involve concrete, hands-on experiences are able to make sense of abstract concepts following Kolb's experiential learning cycle.* This major finding correlates with the following common themes: Theme 1, "Concrete Experience"; Theme 3, "Robotics helps grasp math concepts"; and Theme 4, "Robotics helps improve in math."

"Concrete Experience", "Robotics helps grasp math concepts", and "Robotics helps improve in math" had a combined frequency of 109 responses among all seven interviewed Latino/a college students. Kolb & Kolb (2009) denoted that concrete experiences are the foundation for the experiential learning cycle. The experiential learning cycle is flexible and sensitive to the learning situation it includes four stages: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). The cycle functions like a spiral with no specific entry point (A. Y. Kolb & Kolb, 2009). However, based on the concrete experience, students can observe and reflect about their experiences to distill abstract concepts from which inferences for actions are drawn (A. Y. Kolb & Kolb, 2012).

Research Question 4 Major Findings

The seven Latino/a college students interviewed provided qualitative data from which four major findings were elicited when responding to Research Question 4, "How do Latino/a college students who participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?"

Major Finding 11. *Participation in robotics competitions has an influence on students to pursue a STEM career or college major*. All Latino/a college students interviewed agreed that their participation in robotics competitions influenced their decision to pursue a STEM college degree (career). Furthermore, their participation in robotics guided their decision on the selection of a specific STEM major. Several studies have demonstrated that the utilization of robotics in education can intensify the engagement and interest in STEM fields and careers (Kim et al., 2015; Mohr-Schroeder et al., 2014).

Major Finding 12. *Participation in robotics competitions increases students' interest in STEM.* Throughout the interviews, Latino/a college students described the impact that robotics had in promoting and exposing them to STEM. In recent years, schools have been using educational robotics competitions mainly to foster students' interest in STEM (Barger & Boyette, 2015; Robinson, 2014).

Major Finding 13. *There are other out-of-school (extracurricular) and within school (curricular) high school activities that influence students to pursue STEM.* This major finding correlates with common Theme 6, "other activities that influence to pursue STEM." Six of the seven interviewed Latino/a college students mentioned the following out-of-school high school activities that influence students to pursue STEM: FIRST Robotics, VEX Robotics, Seaperch, NAVAIR Unmanned Airborne Systems (Drones), 3D printers, ACE mentoring program, MESA program, and Solar Turbines' Young Women Academy. In addition, a Latino/a college student indicated that a curricular class also influenced him to pursue STEM: "Technical Theater." He enrolled in that class because he liked to build things and during the course of the class, he built theater sets. Moreover, two Latino/a college students also pointed out high school science classes such as physics and chemistry as subjects that influenced their interest in STEM.

Major Finding 14. *Participation in robotics competitions develops 21st-century skills in participants*. This major finding correlates with common Theme 3, “robotics develops 21st-century skills.” During the interviews, Latino/a college students voiced the role that robotics plays in developing 21st-century skills such as collaboration, communication, teamwork, problem solving, critical thinking, creativity, perseverance, organization, initiative, and leadership. As noted by Merdan (2017), robotics challenges students in a multidisciplinary STEM context, addressing real-life societal needs, and promoting the development of 21st-century skills. Specifically related to robotics competitions, Robinson (2014) identified several outcomes of student participation in robotics competitions included the development of 21st-century skills like teamwork, collaboration, persistence, positive work ethic, commitment, punctuality, and professional behavior.

Unexpected Findings

The researcher discovered six unexpected findings as a result of this research study. The unexpected findings are a reflection of both quantitative and qualitative data analyses and their associations. Participants in the interviews that elicited qualitative data were also a part of the quantitative dataset.

Unexpected Finding 1

Latino/a students who participated in robotics competitions a minimum of 2 consecutive years (intervention group) had a high-good overall mathematics performance in high school. The quantitative target population of this study performed 87.51(*M*) before participation in robotics competitions and 85.21 (*M*) after participation. In addition, the qualitative data showed the same trend as the quantitative data; Latino/a students were performing high-good overall in high school mathematics courses. Of the seven Latino/a college students interviewed, five indicated they had high mathematics performance in high school while two mentioned that their overall math ability in high school was good, although their archival mathematics grades were in the range of C- and A-; further these grades were attributed to personal students' stressors. This was considered an unexpected finding because the researcher was not expecting these levels of mathematical performance.

Unexpected Finding 2

Latino/a students who participated in robotics competitions a minimum of 2 consecutive years (intervention group) completed or were on track to complete high-level mathematics courses in high school. From the quantitative dataset, all Latino/a students, but one male student, after participation in robotics competitions were either enrolled in a higher level mathematics class or on track to complete a higher level mathematics class before completing high school, as described by SUHSD's 2017-2018 mathematics course sequence. Moreover, from the qualitative dataset, all interviewed Latino/a college students were enrolled in a higher level mathematics class during their 12th grade in high school. This was an unexpected finding because the researcher expected to find students in a variety of math levels and not just students who were already on track to take higher level math courses.

Unexpected Finding 3

All Latino/a college students interviewed who participated in robotics competitions a minimum of 2 consecutive years were enrolled in a STEM college degree or on their way to pursue it (community college). From the qualitative data, all participants (Latino/a college students) were enrolled in one of the following colleges: San Diego City Community College, Southwestern Community College, San Diego State University, University of California San Diego, or University of California Berkeley. The participants enrolled in a 4-year university declared that they were enrolled in one of the following college majors: electrical engineering or mechanical engineering. The participants attending community colleges, expressed an interest to transfer to a 4-year university and declare one of the following majors: mechanical engineering or civil engineering. This was an unexpected finding because the researcher expected to find Latino/a college students in different majors including STEM.

Unexpected Finding 4

Latino/a college students participated in robotics competitions 2 or more consecutive years. From the qualitative dataset, five out of seven Latino/a college students had more than 2 years of participation in robotics competitions. Two Latino/a college students had 3 years of participation, two Latino/a college students had 4 years of participation, and one Latino/a college student had 6 years of participation, which included middle and high school years. This was an unexpected finding because the researcher assumed that most Latino/a high school students would have at most 2 consecutive years of participation in robotics competitions.

Unexpected Finding 5

Latina (female) college students who participated in out-of-school high school educational robotics competitions a minimum of 2 consecutive years were more open and accessible to participate in this study than Latino (male) college students. The qualitative target population selected for this study included a total of 15 Latino/a college students:

seven Latino (male) and eight Latina (female) college students. Ten were located and contacted with an invitation to volunteer to participate in this research study: five Latino (male) and five Latina (female) college students. Latina (female) students agreed to volunteer upon the first contact from the researcher. In contrast, three Latino (male) students were contacted more than five times, and at the end, two out of five agreed to participate. The researcher did not have any commentary about why females were more eager than males to participate in this study, therefore this finding was completely unexpected. However, several studies indicate that females are more concerned with helping others and they are more people oriented (Su & Rounds, 2015; Diekman, Weisgram, & Belanger, 2015).

Conclusions

The researcher identified five conclusions as a result of conducting this study. The conclusions address the following central research question: “Do Latino/a students who participate in out-of-school high school educational robotics competitions perform better in mathematics courses in high school, and are these students influenced to pursue college STEM degrees?”

Conclusion 1

Latino/a students enrolled in high school high-level mathematics courses who participate in robotics competitions do not have a significant higher mathematics performance over Latino/a students enrolled in high school high-level mathematics courses who don’t participate in such activities. There are limited quantitative studies regarding the impact of robotics in student learning measures (Alimisis, 2013; Benitti, 2012). However, in a similar study conducted by Nugent et al. (2016), it was found that mathematics knowledge did not show increases from participation in robotics clubs and competitions. This research study adds to the current literature and corroborates this conclusion.

Conclusion 2

Latino (male) students who participate in robotics competitions do not achieve at a significant higher mathematics performance than Latina (female) students who participate in robotics competitions. Sass (2015) stated that gender gaps in mathematics achievement are generally small throughout elementary, middle, and high school, and females are more likely to successfully complete high school and attend college. In the same way, Wang and Degol (2017) pointed out that recent meta-analyses have revealed that gender differences in math ability are “negligible”; there are no significant differences in cognitive ability level between males and females. Although females are more likely than males to be highly skilled in both mathematics and verbal domains, females have potentially a greater variety of career options (Wang & Degol, 2017). There are limited studies regarding gender academic gaps in Latino/a students. This research study adds to the current literature.

Conclusion 3

Latino/a college students who participated in robotics competitions had an overall high-good performance in mathematics courses throughout high school. As reported by Afari and Khine (2017), the experience of participation in robotics engages students in authentic activities essential to transfer learning such as algorithmic skills. Furthermore, Barger and Boyette (2015) revealed that there are multiple mathematics concepts utilized in robotics, including algebra, geometry, and trigonometry. Moreover, robotics in education increases several students’ skills and abilities including enhancement of higher order thinking skills such as abstraction, critical thinking, and solving complex problems (Afari & Khine, 2017; Merdan, 2017).

Conclusion 4

Latino/a college students who participated in robotics competitions perceive that their participation in robotics competitions influenced their decision to pursue a STEM college degree. The conclusion of this study corroborates the conclusion of other studies. Several studies have demonstrated that robotics in education can intensify engagement and interest in STEM fields and careers (Kim et al., 2015; Mohr-Schroeder et al., 2014). Furthermore, there is a wide variety of studies that have reported that robotics in education is very effective at attracting the attention of students toward career pathways related to STEM (Afari & Khine, 2017; Druin & Hendler, 2000; Eguchi, 2016; Emeagwali, 2015; Merdan, 2017).

Conclusion 5

Robotics experiences influences Latino/a students to achieve at a higher level in mathematics and to pursue STEM like careers. As a result, it is concluded that all students regardless of grade level, gender, ethnicity, socioeconomic status, or academic classification (English learner, foster youth, or special education) should have equal opportunities to participate in out-of-school high school robotics competitions. The conclusion of this study corroborates the conclusion of other studies. Minorities, females, and students with disabilities among other underrepresented groups have been identified as an abundant but underexploited source of STEM workforce capacity (Green & Sanderson, 2018; McNeely & Fealing, 2018; Wang & Degol, 2017).

Conclusion 6

Latino/a students can garner abstract mathematical concepts if they get involved in concrete, hands-on experiences such as robotics competitions. According to Kolb & Kolb (2009) concrete experiences are the foundation for the experiential learning cycle. Moreover, when a concrete experience is heightened by reflection, offering meaning by thinking, and transformed by action the experience and the knowledge drawn from it becomes deeper, broader, richer, and meaningful (A. Y. Kolb & Kolb, 2009).

Implications for Action

The prior conclusions provide insight into the role that participation in robotics competitions plays with Latino/a students in Southern California as it relates to their mathematics performance and the influence these activities have for students to pursue STEM college degrees. This section addresses the researcher’s recommendations drawn from the conclusions of this research and those findings supported by the literature.

Implication 1

Integrate experiential learning activities similar to robotics in mathematics courses to improve mathematics students’ achievement. Robotics provides the perfect hands-on vehicle to increase students' mathematics knowledge by exposing them to concrete learning experiences through exploration and manipulation of tangible objects (Barker & Ansorge, 2007; Haury & Rillero, 1994). Similarly, experiential learning guides the concrete learning experience of students based on each individual student’s experiential learning style (Nugent et al., 2016; Kolb & Kolb, 2012). If students are exposed to concrete hands-on experiential learning experiences, they may learn mathematics more effectively. The hands-on approach allows students to learn mathematics even before being exposed to traditional-formal instruction (Haury & Rillero, 1994). Kablan (2016) reported that concrete learners showed higher performance in mathematics when exposed to manipulatives. Similarly, Shih et al. (2012) found that through the implementation of Kolb's learning cycle students can increase their mathematical achievement levels along with the stimulation of collaboration between them.

Implication 2

Engage underrepresented groups such as English Learners (ELs), Latino/a, socioeconomically-disadvantaged, foster youth, special education, and female students in robotics competitions. Participation in robotics competitions is voluntary, but efforts need to be made to include students who will benefit the most from these experiences. Robotics is a field that continues to grow and expand, and it has the potential to create substantial impact in education at all levels, from kindergarten all the way up to graduate school (Alimisis, 2013; J. Johnson, 2003; Mataric, 2004). Recent studies in the use of robotics in education suggest the possible impact on student learning in specific subjects such as science, technology, and mathematics (Afari & Khine, 2017; Robinson, 2014).

Implication 3

Expand access in school master schedules as elective courses or in the mathematics and/or science track that includes experiences similar to robotics competitions within the school day. Bevan (2013) contended that educational robotics competitions fit in between formal classroom settings and informal out-of-school program environments. However, most of the competitive robotics teams conduct their activities in out-of-school settings. Moreover, these activities occur in an informal learning setting where students do not follow a formal curriculum and do not receive a grade for participation or for their performance (Bevan, 2013). Alfieri et al. (2015) utilized the term “robot-math” to describe how to teach mathematics through robotics. They argued that in robot-math instruction, the intention is to first use math-related skills in robotics-related challenges through exploration. Later, these activities will help students transfer and extend those mathematics skills into academic skills (Alfieri et al., 2015).

Implication 4

Offer similar STEM out-of-school activities like robotics competitions to increase student engagement and exposure to STEM fields and careers. Robots are very effective at attracting the attention of students toward career pathways related to STEM (Druin & Hendler, 2000; Emeagwali, 2015; Merdan, 2017). In addition, Bascou and Menekse (2016) found the use of robotics as a mechanism to support learning for students who might not be initially interested in STEM academic areas. Similar STEM out-of-school activities include programs such as ACE mentoring program, FIRST robotics, and Seaperch, which is an underwater robotics program.

Implication 5

Expand participation in robotics competitions and similar STEM programs at the middle school level or earlier to expose students to STEM fields and careers. Students’ learning experiences created by using robotics in education generate interest and create motivation to explore further STEM fields and careers (Eguchi, 2016). Students need to be immersed in the STEM “flow” as early as possible in their academic journey (Lyon et al., 2012).

Recommendations for Further Research

This mixed-methods study was delimited to Latino/a high school students in Southern California who participated in VEX Robotics League Competitions (VRC) for a minimum of 2 consecutive years. Additionally, it was also delimited to study Latino/a college students who participated a minimum of 2 consecutive years in out-of-school Sweetwater Union High School District educational robotics competitions in Southern California that were also part of the quantitative dataset. The researcher respectfully proposes the following recommendations for future research.

Recommendation 1

A research similar to this study should be conducted to include a larger general student population across several high school districts that can be further disaggregated and analyzed by ethnicities, gender, grade levels, specific academic courses, and so forth.

Recommendation 2

Research studies similar to this study should be conducted on similar out-of-school STEM educational programs such as FIRST robotics, BotBall, RoboCup, Seaperch, BEST Robotics, World Skills (SkillsCA, SkillsUSA), Zero Robotics, and Tomorrow’s Engineers EEP Robotics Challenge.

Recommendation 3

Additional research should be conducted to analyze the impact of high school STEM in-school curricular sequencing particularly in mathematics and science and their influence on students to pursue STEM postsecondary opportunities.

Recommendation 4

Research similar to this study should be conducted to include academic performance information for science courses such as physics, physics honors, or AP physics.

Recommendation 5

Additional research should be conducted to analyze the influence that high school science courses have on students to pursue STEM college degrees.

Recommendation 6

Additional research should be conducted to analyze the impact of out-of-school (informal) STEM educational programs as compared with STEM curricular (formal) master schedule courses to include science, mathematics, pre-engineering courses, Career Technical Education STEM-related courses, and those similar.

Recommendation 7

Additional research should be conducted to analyze the impact of out-of-school educational robotics competitions for students enrolled in lower level mathematics courses as it pertains to their mathematics academic achievement.

Recommendation 8

Additional research should be conducted to analyze the relationship between participation in robotics, experiential learning, and the development of 21st century skills.

Concluding Remarks and Reflections

The high pace caused by the advancement of technology keeps creating a new and different future. Careers and jobs are updated, modified, enhanced, or replaced with new possibilities. What can be done in such tumultuous times? The following options are presented: do nothing and get swallowed by the rest of the world; try to catch up with technology and get lost in the quest; or create the future, defining our own destiny. Malcolm X said, “Education is our passport to the future, for tomorrow belongs only to the people who prepare for it today” (Blackpast, 2007, III—Education, para. 1). With this in mind, I and others ought to create our own future with the opportunities presented today. The prosperity of this nation relies on its people’s capacity to adapt to these changes and produce a reliable “flow” of high-quality STEM professionals that is at par with the demands of the changing world.

The growing Latino/a community represents an unexploited source of talent that can help the United States mitigate the STEM workforce deficit at all levels. Moreover, females have increased participation in the STEM arena, and they have proven to be strong, competent, and reliable professionals. However, there are still strides that need to take place in order to increase their participation in the STEM workforce aiming for an equitable STEM workplace. Certainly, both Latino/a and female students embody a portion of the underrepresented groups that need to be included in the search for viable solutions to satisfy the lack of workers in America’s STEM workforce. The United States’ stability depends on it.

Robotics contraptions have been around for many years. In today’s world, robotics are everywhere: in industrial, commercial, medical, and military applications. However, utilization of robotics in education remains as an untapped fount of innovative solutions to increase student engagement, academic achievement, and exposure to STEM fields and careers. The experiences with robotics could also assist students by using hands-on approaches to learn complex abstract mathematical concepts. I hope to encourage—through this research study—education trailblazers to keep investigating how to make better use of robotics in education. A good teacher will never be replaced by a machine (robot). Teachers touch the heart and soul of students. Teachers aspire to challenge the human spirit; robots aspire solely to challenge human capacities.

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APPENDICES

APPENDIX A

Synthesis Matrix

	World Leadership: STEM	STEM Education Historical Background	United States STEM Workforce	Women & STEM	Hispanics & STEM	Hispanics in the United States	Math Importance in STEM	Robotics in Education	Robotics and Academic Achievement	Robotics Competitions	Experiential Learning Theory
(Abdulwahed & Nagy, 2009)											X
(Afari & Khine, 2017)								X	X		
(Alimisis, 2013)								X			
(Allen-Ramdial & Campbell, 2014)		X		X	X						
(American Immigration Council, 2017)	X	X	X		X						
(Atmatzidou & Demetriadis, 2016)								X	X		
(Ayebo, Ukkelberg, & Assuah, 2017)							X				
(Baker & Robinson, 2016)											X
(Ball et al., 2017)	X	X	X	X	X						
(Barger & Boyette, 2015)								X	X		
(Barker & Ansorge, 2007)								X	X		X
(Bascou & Menekse, 2016)								X	X		
(Beaudin, 1995)											X
(Beckett et al., 2009)									X		
(Beede et al., 2011)	X	X	X								
(Benitti, 2012)								X		X	
(Bergsteiner, Avery, & Neumann, 2010)											X
(Breineret et al., 2012)	X	X		X	X						
(Bright, 2017)							X				
(Brown et al., 2011)	X	X	X	X	X						
(Burke & Mattis, 2007)	X			X	X						
(Byars-Winston, Estrada, & Howard, 2008)	X				X	X					
(Bybee, 2010)	X		X	X	X						
(Caron, 2010)								X	X		
(Chen & Weko, 2009)	X		X	X	X						

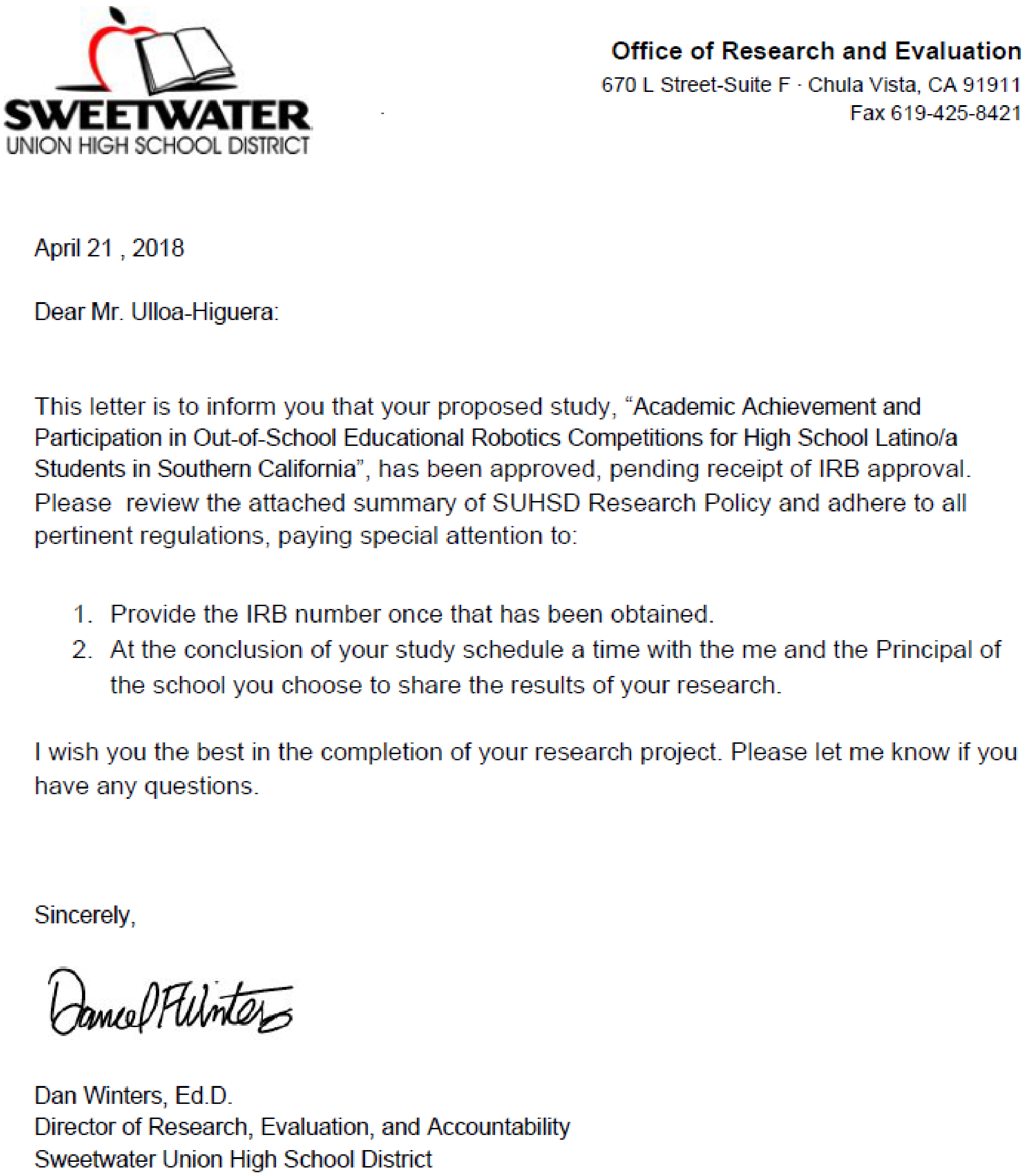
	World Leadership: STEM	STEM Education Historical Background	United States STEM Workforce	Women & STEM	Hispanics & STEM	Hispanics in the United States	Math Importance in STEM	Robotics in Education	Robotics and Academic Achievement	Robotics Competitions	Experiential Learning Theory
(Chesky & Wolfmeyer, 2015)	X	X	X	X	X						
(Christenson, 2011)		X									
(Chute, 2009)	X		X								
(Colby & Ortman, 2015)						X					
(Coxon, Dohrman, & Nadler, 2018)								X			
(Diekman, Brown et al.,2010)			X	X							
(Diekman, Weisgram et al., 2015)			X	X							
(Doerschuk et al., 2016)	X			X	X						
(Druin & Hendler, 2000)								X	X		
(Eguchi, 2016)								X		X	
(Emeagwali, 2015)	X		X					X	X		
(Fayer, Lacey, & Watson, 2017)			X		X	X					
(Flores, 2017)						X					
(French et al., 2014)							X				
(Funk & Parker, 2018)	X		X	X	X						
(Garcia-Navarro, 2015)						X					
(Gereffi et al., 2008)	X		X								
(Gonzalez-Barrera & Lopez, 2015)						X					
(Graf, Fry, & Funk, 2018)	X		X								
(Granovskiy, 2018)	X	X	X	X	X						
(Green & Sanderson, 2018)	X		X				X				
(Hanson, 2013)	X				X						
(Haury & Rillero, 1994)											X
(Healey & Jenkins, 2000)											X
(Hernandez et al., 2014)			X	X							
(Hinojosa et al., 2016)	X		X	X	X						
(Hom, 2014)	X	X		X							
(Johnson & Londt, 2010)								X			

	World Leadership: STEM	STEM Education Historical Background	United States STEM Workforce	Women & STEM	Hispanics & STEM	Hispanics in the United States	Math Importance in STEM	Robotics in Education	Robotics and Academic Achievement	Robotics Competitions	Experiential Learning Theory
(Johnson, 2003)								X	X		
(Kablan, 2016)											X
(Kandlhofer & Steinbauer, 2016)								X	X		
(Keefe, 2010)	X		X	X	X						
(Kelley & Knowles, 2016)		X									
(Kim et al., 2015)								X	X		
(Kolb & Kolb, 2009)											
(Kolb, 2013)											X
(Kolb & Kolb, 2012)											X
(Kolb, 1984)											X
(Kotok, 2017)					X						
(Krogstad, 2016)					X	X					
(Landivar, 2013)	X		X	X	X						
(Le & Robbins, 2016)	X		X	X	X						
(Mac Iver & Mac Iver, 2013)								X	X		
(Martinez et al., 2017)							X				
(Mataric, 2004)								X	X		
(McDonald, 2016)	X		X	X	X						
(Melchior et al., 2017)								X	X	X	
(Menekse et al., 2017)										X	
(Merdan, 2017)								X	X	X	
(Mohr-Schroeder et al., 2014)								X	X		
(Morel-Baker, 2018)	X	X	X	X							
(National Research Council, 2009)	X		X								
(National Science Board, 2018)	X		X								
(National Science Foundation, 2017)	X	X	X	X	X						
(Noonan, 2017)	X		X								
(Nugent et al., 2016)								X	X	X	

	World Leadership: STEM	STEM Education Historical Background	United States STEM Workforce	Women & STEM	Hispanics & STEM	Hispanics in the United States	Math Importance in STEM	Robotics in Education	Robotics and Academic Achievement	Robotics Competitions	Experiential Learning Theory
(Papert, 1980)								X	X	X	X
(Prediger, 2001)							X				
(Price, 2010)	X	X	X	X							
(Redmond-Sanogo, 2016)			X	X			X				
(Reider, Knestis, & Malyn-Smith, 2016)			X								
(Riegle-Crumb, 2010)				X							
(Robinson & Stewardson, 2012)								X		X	
(Robinson, 2014)	X							X		X	
(Sass, 2015)	X		X	X	X						
(Sassler et al.,2017)	X		X	X							
(Shih et al., 2012)								X	X		X
(Smith et al.,2018)							X				
(STEM Education Coalition Policy Forum, 2016)	X		X								
(Stepler & Lopez, 2016)						X					
(Su & Rounds, 2015)	X			X	X						
(Telles, 2018)						X					
(Thomas & Williams, 2010)	X	X	X								
(U.S. Bureau of Labor Statistics, 2018)			X	X	X						
(U.S. Census Bureau, 2018)						X					
(Vela & Gutierrez, 2017)			X			X					
(Vilorio, 2014)	X	X	X								
(Wang & Degol, 2017)	X		X	X							
(White & Massiha, 2016)	X		X	X							
(Witherspoon et al., 2016)				X					X	X	
(Woodruff, 2013)	X	X	X								
(Wyrick & Hilsen, 2002)											X
(Xie, Fang, & Shauman, 2015)	X		X	X	X						

APPENDIX B

SUHSD Data Access Approval



SWEETWATER
UNION HIGH SCHOOL DISTRICT

Office of Research and Evaluation
670 L Street-Suite F · Chula Vista, CA 91911
Fax 619-425-8421

April 21 , 2018

Dear Mr. Ulloa-Higuera:

This letter is to inform you that your proposed study, "Academic Achievement and Participation in Out-of-School Educational Robotics Competitions for High School Latino/a Students in Southern California", has been approved, pending receipt of IRB approval. Please review the attached summary of SUHSD Research Policy and adhere to all pertinent regulations, paying special attention to:

1. Provide the IRB number once that has been obtained.
2. At the conclusion of your study schedule a time with the me and the Principal of the school you choose to share the results of your research.

I wish you the best in the completion of your research project. Please let me know if you have any questions.

Sincerely,

Daniel P Winters

Dan Winters, Ed.D.
Director of Research, Evaluation, and Accountability
Sweetwater Union High School District

APPENDIX C

E-Mail Invitation to Participate

Dear ___________________:

My name is Jesus Leonardo Ulloa-Higuera and I am a doctoral candidate in the School of Education at Brandman University. The purpose of this email is to invite you to participate in a research study related to your participation in VEX robotics competitions. You meet the selection criteria for this study based on the information provided by your high school robotics coach (teacher) and/or counselor as a potential candidate for this research study.

RESEARCH PURPOSE: The purpose of this mixed method ex post facto study is to examine the difference in academic performance in mathematics as measured by class grades between high school Latino/a students in Southern California that participated a minimum of two consecutive years in out-of-school high school educational robotics competitions and high school Latino/a students that did not participate in out-of-school high school educational robotics competitions. A secondary purpose is to examine the difference in academic performance in mathematics as measured by class grades between high school Latino (male) and Latina (female) students that participated a minimum of two consecutive years in out-of-school high school educational robotics competitions in Southern California. A third and final purpose is to describe the experiences of Latino/a college students that participated a minimum of two consecutive years in out-of-school high school educational robotics competitions and how these experiences influenced their interest in pursuing a STEM college degree.

PROCEDURE: If you choose to participate in this study, you will be invited to a one-on-one interview with me for approximately 45-60 minutes. We will conduct this interview based on your availability and location. During the interview, I will ask you 10 questions designed to allow you to share your experiences related to your participation in high school robotics VEX competitions. You will have the liberty to stop or withdraw from the interview at any time. The interview will be audio-recorded for transcription purposes and it will remain confidential. After the interview and as soon as the interview transcript becomes available, I will share it with you to corroborate your answers. At that time, you will be able to make any corrections as you feel necessary.

RISKS, INCONVENIENCES, and DISCOMFORTS: There are no major risks to your participation in this research study. The interview will be at a time and location convenient to you.

POTENTIAL BENEFITS: There are no major benefits to you for participating. However, you may benefit by contributing to the body of knowledge related to this research study providing insight from your personal experiences.

ANONYMITY: If you agree to participate in this study, you can be assured that all information shared with me will remain confidential. Your personal information will not be associated with the transcripts of the interview or any notes. All information will remain in a private and locked cabinet, accessible only to me.

Please let me know if you are interested in participating. Feel free to contact me directly if you have any questions or concerns. You can email me directly at julloahi@mail.brandman.edu or by phone call/text at 619-843-6862. If you have any questions, comments, and concerns about this study and your rights as a participant, you may write or call the Office of the Vice Chancellor of Academic Affairs, Brandman University, at 16355 Laguna Canyon Road, Irvine, CA 92618, (949) 341-7641.

Thank you in advance for your consideration,

Jesus Leonardo Ulloa-Higuera
Doctoral Candidate, Ed.D.
1248 Stagecoach Trail Loop
Chula Vista, CA 91915

APPENDIX D

Interview Protocol Outline

Date:
Place:
Interview Participant:

Introductions and Brief Description

Good morning/afternoon/evening! Thank you very much for agreeing to participate in this interview supporting my dissertation research as part of my doctoral studies in Organizational Leadership at Brandman University regarding Latino/a participation in out-of-school high school educational robotics competitions, mathematics performance, and pursuing a STEM college degree. I am interviewing a Latino/a college student that participated in out-of-school robotics competitions during high school. The primary purpose of this interview is to discover the impact of your participation in robotics competitions and your mathematics performance during high school. A secondary purpose is to discover in what ways your participation in robotics competitions influenced your decision to pursue a STEM college degree. This interview should take between 30-60 minutes to complete and will include (#) questions. It may also include some follow-up questions if I need further clarification so that I may best understand your replies.

Informed Consent

Please allow me to remind you that any information obtained in connection to this study will remain confidential. All of the data will be reported without reference to any individual(s) or any institution(s). After I record and transcribe the data, I will send it to you via email so that you can check to make sure that I have accurately captured your thoughts and ideas.

Did you receive the Informed Consent and Brandman Bill Of Rights I sent via email?

Do you have any questions or need clarification about either document?

At any point during the interview, you may ask to stop the interview. With your permission as we previously discussed, I would like to tape record this interview so that I ensure accurate recording of your responses.

Do you have any questions before we begin?

- *Interview Questions to follow*

APPENDIX E

Interview Questions

Demographic questions

- What is your gender?
- What is your ethnicity?
- What high school did you graduate from?
- How many consecutive years did you participate in robotics competitions when you were in high school?
- What was the highest mathematics course you took in high school? (e.g. Integrated Math III, Pre-Calculus, Calculus, AP Calculus)
- What is your intended college major?
- What college mathematics class (course) are you currently enrolled in (or most recently were you enrolled in)?

Quantitative Research Questions	
1. Do Latino/a students that participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latino/a students that do not participate?	*The answer to this question will come from the quantitative data analysis (mathematics classes' grade point averages for both control and intervention groups.*
2. Do Latino (male) students that participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years achieve at a higher academic performance in mathematics than Latina (female) students that participate in out-of-school high school educational robotics competitions a minimum of 2 consecutive years?	*The answer to this question will come from the quantitative data analysis (mathematics classes' grade point averages for both control and intervention groups)*
Qualitative Research Questions	**Interview Question**
3. How do Latino/a college students that participated in out-of-school high school educational robotics competitions describe their performance in mathematics courses in high school?	1. How would you describe your mathematics ability in high school? Prompting question: High, average, or would you say you experienced challenges? 2. Describe your mathematics grades in your freshman and sophomore years in high school and the mathematics courses you took. Describe your performance in those classes.

	3. Describe your mathematics grades in your junior and senior years in high school and the mathematics courses you took. Describe your performance in those classes. 4. Did your participation in robotics competitions influence positively, negatively or not at all your mathematics performance in high school courses? Prompting question: Which mathematics courses did you feel robotics influenced the most? (List courses based on answers from previous questions) 5. From your point of view, does robotics competitions help students in mathematics courses in high school and if so, how or how not?
4. How do Latino/a college students that participated in out-of-school high school educational robotics competitions perceive they were influenced by their experience in robotics competitions to pursue a STEM college degree?	6. When did you realize that you were interested in pursuing a STEM college degree? 7. What motivated you to pursue a STEM college degree? 8. To what extent (if any) did your participation in robotics competitions influence you to pursue a STEM college degree? 9. What career pathway are you interested in pursuing after you finish college? 10. Is robotics an experience that can influence others to pursue a career in science, technology, engineering or mathematics? Prompting Questions: Why? Or Why Not?

APPENDIX F

Informed Consent and Audio Recording Release

INFORMATION ABOUT: Academic achievement and participation in out-of-school educational robotics competitions for high school Latino/a students in Southern California.

RESPONSIBLE INVESTIGATOR: Jesus Leonardo Ulloa-Higuera

PURPOSE OF STUDY: You are being asked to participate in a research study conducted by Jesus Leonardo Ulloa-Higuera, a doctoral student from the School of Education at Brandman University.

The purpose of this mixed method study is to examine the difference in academic performance in mathematics between high school Latino/a students in Southern California that participated a minimum of two consecutive years in out-of-school high school educational robotics competitions and high school Latino/a students that did not participate in such events. A secondary purpose is to examine the difference in academic performance in mathematics between high school Latino (male) and Latina (female) students that participated a minimum of two consecutive years in out-of-school high school educational robotics competitions in Southern California. A third and final purpose is to describe the experiences of Latino/a college students that participated a minimum of two consecutive years in out-of-school high school educational robotics competitions and how these experiences influenced their interest in enrolling in college courses leading to a STEM college degree.

Your participation in this study is voluntary and will include an interview with the identified student investigator. The interview will take approximately 45 minutes to complete and will be scheduled at a time and location of your convenience either in person or via phone conversation. The interview questions will pertain to your perceptions and your responses will be confidential. Each participant will have an identifying code and names will not be used in data analysis. The results of this study will be used for scholarly purposes only.

I understand that:

a) The researcher will protect my confidentiality by keeping the identifying codes safeguarded in a locked file drawer or password protected digital file to which the researcher will have sole access.

b) My participation in this research study is voluntary. I may decide to not participate in the study and I can withdraw at any time. I can also decide not to answer particular questions during the interview if I so choose. Also, the Investigator may stop the study at any time.

c) If I have any questions or concerns about the research, please feel free to contact Jesus Leonardo Ulloa-Higuera at julloahi@mail.brandman.edu or by phone at 619-843-6862; or Dr. Lisbeth Johnson (Advisor) at ljohnso3@brandman.edu

d) No information that identifies me will be released without my separate consent and all identifiable information will be protected to the limits allowed by law. If the study design or the use of the data is to be changed, I will be so informed and my consent re-obtained.
e) If I have any questions, comments, or concerns about the study or the informed consent process, I may write or call the Office of the Vice Chancellor of Academic Affairs, Brandman University, at 16355 Laguna Canyon Road, Irvine, CA 92618, (949) 341-7641.

I acknowledge that I have received a copy of this form and the “Research Participant’s Bill of Rights.” I have read the above and understand it and hereby consent to the procedure(s) set forth.

_________________________________ Date:________________
Signature of Participant or Responsible Party

_________________________________ Date:_______________
Signature of Principal Investigator

APPENDIX G

National Institute of Health Certificate

Certificate of Completion

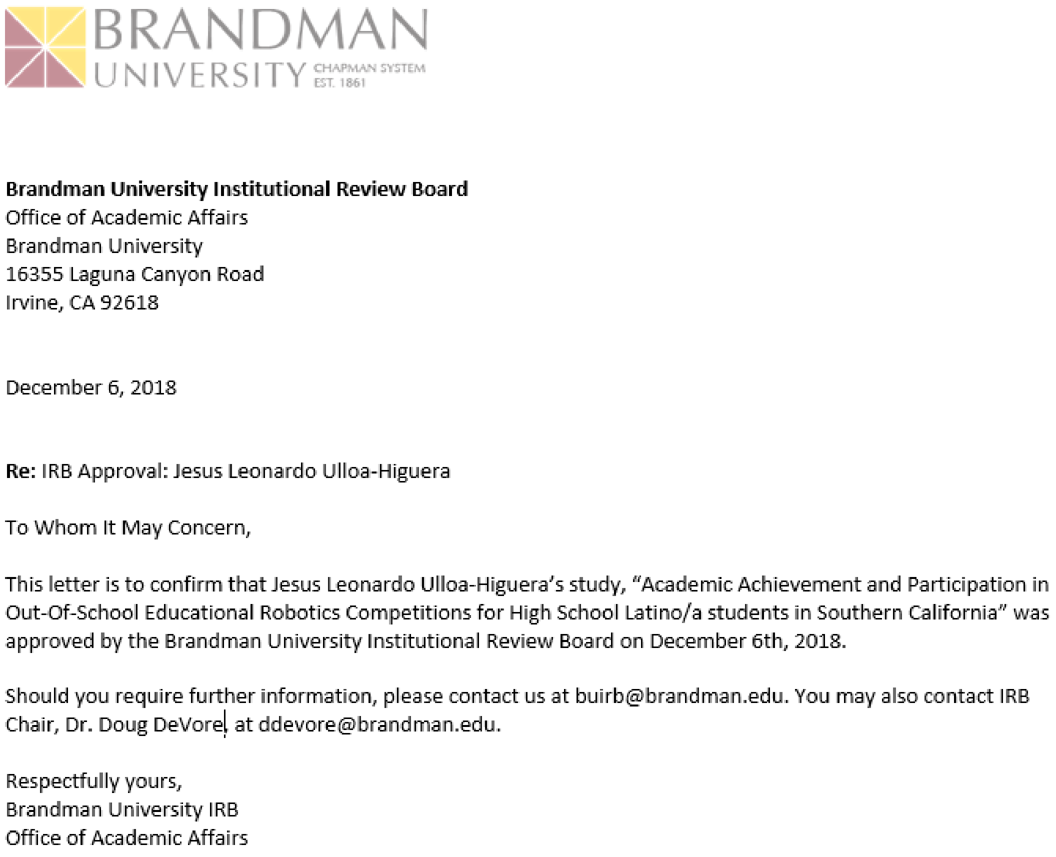
The National Institutes of Health (NIH) Office of Extramural Research certifies that **Jesus Ulloa-Higuera** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 05/20/2017.

Certification Number: 2392062.

APPENDIX H

Brandman University Institutional Review Board (BUIRB)



Brandman University Institutional Review Board
Office of Academic Affairs
Brandman University
16355 Laguna Canyon Road
Irvine, CA 92618

December 6, 2018

Re: IRB Approval: Jesus Leonardo Ulloa-Higuera

To Whom It May Concern,

This letter is to confirm that Jesus Leonardo Ulloa-Higuera's study, "Academic Achievement and Participation in Out-Of-School Educational Robotics Competitions for High School Latino/a students in Southern California" was approved by the Brandman University Institutional Review Board on December 6th, 2018.

Should you require further information, please contact us at buirb@brandman.edu. You may also contact IRB Chair, Dr. Doug DeVore, at ddevore@brandman.edu.

Respectfully yours,
Brandman University IRB
Office of Academic Affairs

APPENDIX I

BRANDMAN UNIVERSITY CHAPMAN SYSTEM EST. 1861

BRANDMAN UNIVERSITY INSTITUTIONAL REVIEW BOARD

Research Participant's Bill of Rights

Any person who is requested to consent to participate as a subject in an experiment, or who is requested to consent on behalf of another, has the following rights:

1. To be told what the study is attempting to discover.

2. To be told what will happen in the study and whether any of the procedures, drugs or devices are different from what would be used in standard practice.

3. To be told about the risks, side effects or discomforts of the things that may happen to him/her.

4. To be told if he/she can expect any benefit from participating and, if so, what the benefits might be.

5. To be told what other choices he/she has and how they may be better or worse than being in the study.

6. To be allowed to ask any questions concerning the study both before agreeing to be involved and during the course of the study.

7. To be told what sort of medical treatment is available if any complications arise.

8. To refuse to participate at all before or after the study is started without any adverse effects.

9. To receive a copy of the signed and dated consent form.

10. To be free of pressures when considering whether he/she wishes to agree to be in the study.

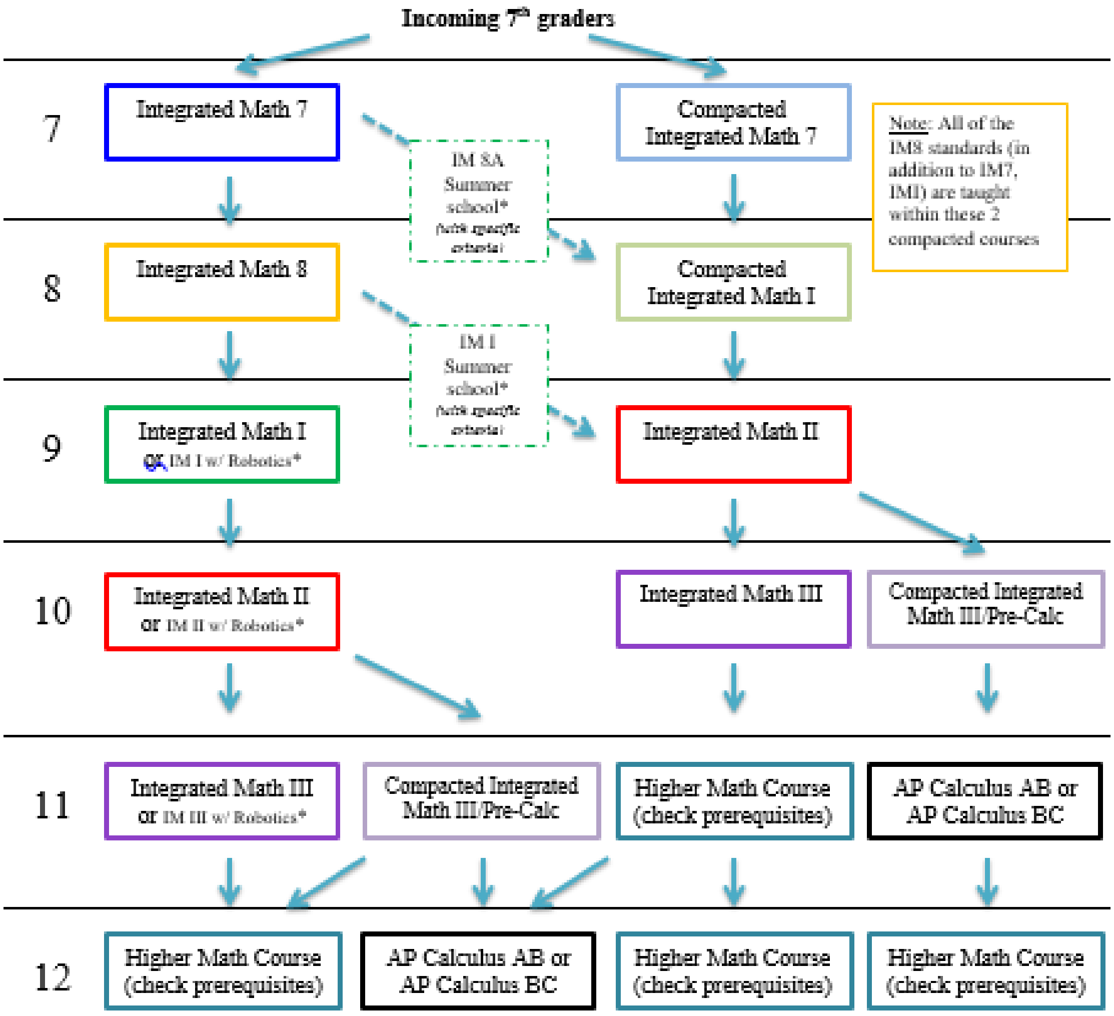
If at any time you have questions regarding a research study, you should ask the researchers to answer them. You also may contact the Brandman University Institutional Review Board, which is concerned with the protection of volunteers in research projects. The Brandman University Institutional Review Board may be contacted either by telephoning the Office of Academic Affairs at (949) 341-9937 or by writing to the Vice Chancellor of Academic Affairs, Brandman University, 16355 Laguna Canyon Road, Irvine, CA, 92618.

Brandman University IRB Adopted November 2013

APPENDIX J

SUHSD Mathematics Course Sequence 2017-18

Source: SUHSD Curriculum and Instruction Office



Note: All of the IM8 standards (in addition to IM7, IMI) are taught within these 2 compacted courses

Higher Math Courses:

- Pre-Calculus
- Pre-Calculus Honors
- AP Statistics
- Discrete Math/Finite Math*
- Calculus Concepts*
- Math Applications & Concepts*
- Financial Literacy*

Additional Course III Option:

- Financial Algebra* (12th grade only)

Important Considerations:

- Course grade of "C" or higher second semester needed for CSU/UC eligibility
- Course grade of "D" or higher fulfill high school graduation requirement

*These courses are available at select sites

APPENDIX K

Quantitative Data for Intervention and Control Groups 2015-16 & 2017-18

2015-16 SCHOOL YEAR DATA

				Semester 1		Semester 2		Final
Name	GR	M/F	Course Name	Letter	Score	Letter	Score	Grade
Intervention St 1	9	M	INTEGRATED MATH I	B	86	C	76	81
Intervention St 2	9	M	INTEGRATED MATH I	C	76	C	76	76
Intervention St 3	10	M	INTEGRATED MATH II	B	86	B	86	86
Intervention St 4	10	M	INTEGRATED MATH II	A	96	A	96	96
Intervention St 5	9	F	INTEGRATED MATH I	A+	100	A+	100	100
Intervention St 6	9	M	INTEGRATED MATH I	B	86	A	96	91
Intervention St 7	10	M	INTEGRATED MATH III	A+	100	A	96	98
Intervention St 8	10	F	PRE-CALCULUS	C-	72	B-	82	77
Intervention St 9	9	M	INTEGRATED MATH II	D	66	D-	62	64
Intervention St 10	10	F	INTEGRATED MATH III	D+	69	A	96	82.5
Intervention St 11	10	F	INTEGRATED MATH II	D-	62	C	76	69
Intervention St 12	10	M	INTEGRATED MATH III	C-	72	B-	82	77
Intervention St 13	9	M	INTEGRATED MATH I	C+	79	B+	89	84
Intervention St 14	9	M	INTEGRATED MATH I	B+	89	B	86	87.5
Intervention St 15	9	F	INTEGRATED MATH I	A-	92	A	96	94
Intervention St 16	10	M	COMPCTD INTGRATD MATH III	A	96	A-	92	94
Intervention St 17	10	F	INTEGRATED MATH II	B-	82	B	86	84
Intervention St 18	9	F	INTEGRATED MATH II	A-	92	A	96	94
Intervention St 19	9	F	INTEGRATED MATH II	A+	100	A+	100	100
Intervention St 20	10	F	COMPCTD INTGRATD MATH III	A	96	A-	92	94
Intervention St 21	10	F	INTEGRATED MATH II	A	96	A+	100	98
Intervention St 22	9	M	INTEGRATED MATH I	C+	79	B	86	82.5
Intervention St 23	9	M	INTEGRATED MATH I	B	86	C	76	81
Intervention St 24	10	F	INTEGRATED MATH III	A-	92	A-	92	92
Intervention St 25	9	M	INTEGRATED MATH II	A	96	A	96	96
Intervention St 26	9	M	INTEGRATED MATH II	D	66	B	86	76
Intervention St 27	10	F	INTEGRATED MATH III	A	96	A+	100	98
Intervention St 28	10	M	INTEGRATED MATH III	A	96	A	96	96
Intervention St 29	10	M	INTEGRATED MATH III	A	96	A	96	96
Intervention St 30	9	M	INTEGRATED MATH II	A	96	A	96	96

				Semester 1		Semester 2		Final
Name	GR	M/F	Course Name	Letter	Score	Letter	Score	Grade
Control St 1	9	M	INTEGRATED MATH I	F	60	F	60	60
Control St 2	9	M	INTEGRATED MATH I	F	60	F	60	60
Control St 3	10	M	INTEGRATED MATH II	B	86	B	86	86
Control St 4	10	M	INTEGRATED MATH II	C+	79	F	60	69.5
Control St 5	9	F	INTEGRATED MATH I	A+	100	A	96	98
Control St 6	9	M	INTEGRATED MATH I	C-	72	C	76	74
Control St 7	10	M	INTEGRATED MATH III	B-	82	C	76	79
Control St 8	10	F	PRE-CALCULUS	B	86	B	86	86
Control St 9	9	M	INTEGRATED MATH II	D	66	D	66	66
Control St 10	10	F	INTEGRATED MATH III	A	96	A	96	96
Control St 11	10	F	INTEGRATED MATH II	D	66	C-	72	69
Control St 12	10	M	INTEGRATED MATH III	D+	69	F	60	64.5
Control St 13	9	M	INTEGRATED MATH I	C-	72	D+	69	70.5
Control St 14	9	M	INTEGRATED MATH I	C-	72	B-	82	77
Control St 15	9	F	INTEGRATED MATH I	D-	62	D-	62	62
Control St 16	10	M	COMPCTD INTGRATD MATH III	B	86	C	76	81
Control St 17	10	F	INTEGRATED MATH II	B-	82	B-	82	82
Control St 18	9	F	INTEGRATED MATH II	B-	82	F	60	71
Control St 19	9	F	INTEGRATED MATH II	A+	100	A+	100	100
Control St 20	10	F	COMPCTD INTGRATD MATH III	A-	92	B	86	89
Control St 21	10	F	INTEGRATED MATH II	B-	82	B-	82	82
Control St 22	9	M	INTEGRATED MATH I	D	66	D	66	66
Control St 23	9	M	INTEGRATED MATH I	A-	92	C+	79	85.5
Control St 24	10	F	INTEGRATED MATH III	C	76	B-	82	79
Control St 25	9	M	INTEGRATED MATH II	B	86	B-	82	84
Control St 26	9	M	INTEGRATED MATH II	A	96	B-	82	89
Control St 27	10	F	INTEGRATED MATH III	A-	92	B-	82	87
Control St 28	10	M	INTEGRATED MATH III	C	76	B	86	81
Control St 29	10	M	INTEGRATED MATH III	B	86	B	86	86
Control St 30	9	M	INTEGRATED MATH II	B	86	B	86	86

2017-18 SCHOOL YEAR DATA

				Semester 1		Semester 2		Final
Name	GR	M/F	Course Name	Letter	Score	Letter	Score	Grade
Intervention St 1	11	M	INTEGRATED MATH III	C	76	B	86	81
Intervention St 2	11	M	INTEGRATED MATH III	A-	92	A+	100	96
Intervention St 3	12	M	PRE-CALCULUS	B-	82	C	76	79
Intervention St 4	12	M	PRE-CALCULUS	A	96	A+	100	98
Intervention St 5	11	F	INTEGRATED MATH III	A	96	A	96	96
Intervention St 6	11	M	INTEGRATED MATH III	A	96	A	96	96
Intervention St 7	12	M	AP CALCULUS AB	A+	100	B+	89	94.5
Intervention St 8	12	F	AP CALCULUS BC	A-	92	B	86	89
Intervention St 9	11	M	INTEGRATED MATH III	F	60	F	60	60
Intervention St 10	12	F	AP STATISTICS	B	86	B	86	86
Intervention St 11	12	F	INTEGRATED MATH III	D+	69	C-	72	70.5
Intervention St 12	12	M	DISCRETE MATHEMATICS	C-	72	D	66	69
Intervention St 13	11	M	INTEGRATED MATH II	C	76	B-	82	79
Intervention St 14	11	M	INTEGRATED MATH III	C	76	D-	62	69
Intervention St 15	11	F	INTEGRATED MATH III	C	76	C	76	76
Intervention St 16	12	M	AP CALCULUS BC	A-	92	A-	92	92
Intervention St 17	12	F	AP CALCULUS AB	F	60	C+	79	69.5
Intervention St 18	11	F	AP CALCULUS AB	B	86	A	96	91
Intervention St 19	11	F	AP CALCULUS AB	A-	92	A	96	94
Intervention St 20	12	F	AP CALCULUS AB	A	96	A	96	96
Intervention St 21	12	F	AP CALCULUS AB	C-	72	B-	82	77
Intervention St 22	11	M	INTEGRATED MATH III	B	86	A	96	91
Intervention St 23	11	M	INTEGRATED MATH III	A-	92	B-	82	87
Intervention St 24	12	F	AP CALCULUS AB	C	76	C	76	76
Intervention St 25	11	M	PRECALCULUS HONORS	A-	92	A-	92	92
Intervention St 26	11	M	PRECALCULUS HONORS	C-	72	C	76	74
Intervention St 27	12	F	AP CALCULUS AB	A	96	A	96	96
Intervention St 28	12	M	AP CALCULUS AB	A-	92	A	96	94
Intervention St 29	12	M	AP CALCULUS AB	A	96	A	96	96
Intervention St 30	11	M	PRECALCULUS HONORS	A-	92	A-	92	92

				Semester 1		Semester 2		Final
Name	GR	M/F	Course Name	Letter	Score	Letter	Score	Grade
Control St 1	11	M	INTEGRATED MATH III	B	86	B	86	86
Control St 2	11	M	INTEGRATED MATH III	F	60	F	60	60
Control St 3	12	M	PRE-CALCULUS	C	76	C+	79	77.5
Control St 4	12	M	PRE-CALCULUS	B	86	A-	92	89
Control St 5	11	F	INTEGRATED MATH III	B	86	B	86	86
Control St 6	11	M	INTEGRATED MATH III	D	66	D	66	66
Control St 7	12	M	AP CALCULUS AB	A	96	A-	92	94
Control St 8	12	F	AP CALCULUS BC	B	86	C	76	81
Control St 9	11	M	INTEGRATED MATH III	A	96	B+	89	92.5
Control St 10	12	F	AP STATISTICS	C	76	C-	72	74
Control St 11	12	F	INTEGRATED MATH III	B+	89	B-	82	85.5
Control St 12	12	M	DISCRETE MATHEMATICS	B	86	D+	69	77.5
Control St 13	11	M	INTEGRATED MATH II	B-	82	C-	72	77
Control St 14	11	M	INTEGRATED MATH III	B-	82	C-	72	77
Control St 15	11	F	INTEGRATED MATH III	A-	92	A-	92	92
Control St 16	12	M	AP CALCULUS BC	B	86	A-	92	89
Control St 17	12	F	AP CALCULUS AB	B	86	A	96	91
Control St 18	11	F	AP CALCULUS AB	B-	82	B+	89	85.5
Control St 19	11	F	AP CALCULUS AB	B	86	C	76	81
Control St 20	12	F	AP CALCULUS AB	B-	82	B+	89	85.5
Control St 21	12	F	AP CALCULUS AB	B	86	A	96	91
Control St 22	11	M	INTEGRATED MATH III	C	76	B	86	81
Control St 23	11	M	INTEGRATED MATH III	C	76	D	66	71
Control St 24	12	F	AP CALCULUS AB	C	76	C	76	76
Control St 25	11	M	PRECALCULUS HONORS	C	76	B+	89	82.5
Control St 26	11	M	PRECALCULUS HONORS	A-	92	A	96	94
Control St 27	12	F	AP CALCULUS AB	B-	82	A	96	89
Control St 28	12	M	AP CALCULUS AB	C	76	A	96	86
Control St 29	12	M	AP CALCULUS AB	A-	92	A	96	94
Control St 30	11	M	PRECALCULUS HONORS	A	96	A	96	96

APPENDIX L

Standard Letter Grade Scale

Letter grade		Percentage
A+	100	97–100%
A	96	93–96%
A-	92	90–92%
B+	89	87–89%
B	86	83–86%
B-	82	80–82%
C+	79	77–79%
C	76	73–76%
C-	72	70–72%
D+	69	67–69%
D	66	63–66%
D-	62	60–62%
F	60	< 60%