Engaging Hispanic Science Learners Within California's Central Valley: A Mixed Methods Study of the Perceptions of High School Teachers Relative to Advanced Placement Science Courses

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Engaging Hispanic Science Learners Within California’s Central Valley: A Mixed Methods Study of the Perceptions of High School Teachers Relative to Advanced Placement Science Courses

A Dissertation by

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Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

Engaging Hispanic Science Learners Within California’s Central Valley: A Mixed Methods Study of the Perceptions of High School Teachers Relative to Advanced Placement Science Courses

by Dave Menshew

Purpose: The purpose of this mixed methods study was to examine the engagement of Hispanic Advanced Placement science learners in California’s Central Valley as perceived by high school teachers.

Methodology: The mixed method study surveyed 20 Advanced Placement science teachers from the region of interest. Likert surveys were used to determine: 1) their perceptions of the engagement of Hispanic students by the AP Program, and 2) barriers presented by the AP Program. Quantitative results indicated teacher support for the AP Program and few barriers as currently administered. A focus group of 12 teachers recruited from the 20 surveyed provided qualitative data which gave depth to the study and suggested changes in program practices to inform future teaching.

Findings: Participants perceived that the AP Program promotes engagement and learning in high school science classrooms and does not present significant barriers to Hispanic science students’ access to the curriculum, learning or course completion. Some changes in practice to improve the AP Program were suggested.

Conclusions: Current AP Program practice meets the needs of Hispanic science learners in the region studied but would benefit from increased science offerings and recruitment in elementary school. Participants indicated that AP Program could be improved if there are more students participating in the Advancement Via Individual Determination
Program in both middle and high school thereby equipping them with the skills to be successful. Targeted support for Hispanic learners at the high school level, particularly those who struggle with the vocabulary demands of AP science was suggested.

**Recommendations:** A number of studies were suggested that may build on this research project. Among them, surveying Hispanic AP teachers, studying the differences in the level of rigor practiced by AP teachers, and differences between data obtained from the focus group as compared with data from the surveys only. Participants indicated the role of parents on many levels. This may indicate the opportunity to study parent and other family member role models as pertains to college attainment. Differences in AP offerings would be another area for study.
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CHAPTER I: INTRODUCTION

Background

Each day, the Earth’s population awakens to an environment that is fraught with degrees of danger that arguably rival the worst times in recorded history. As recently as January 2018, the Bulletin of the Atomic Scientists, a document published by a group including 17 Nobel Laureates, chose to move the “Doomsday Clock” to two minutes until midnight. The clock is a measure of the closeness humankind is to an apocalyptic event, which could end its existence. Its current setting ties for the closest to midnight in the history of the practice. Worldwide challenges that factor into the clock’s time include global warming and nuclear perils and indicate an imminent threat to humanity (Bulletin of the Atomic Scientists, 2018).

Challenges to the United States’ position in the world order are coming from many sources. The Islamic State of Iraq and the Levant (ISIS) “poses a major threat to the U.S. and to U.S. interests abroad, and that threat is growing every day.” (Morell, 2015, para. 1). China, whose construction of militarized islands in the South China Sea has alarmed its neighbors, is now promoting a worldwide trading program that some have compared to the Marshall Plan, which in part, helped to propel the U.S. to global superpower status post-World War II (Griffiths, 2017).

The national security of the United States, amid such dangers as listed above, but also including environmental terrorism, pollution, disease, and threats to the nation’s food supply, require a knowledgeable scientific community skilled in developing appropriate solutions. The current sophisticated nature of warfare calls for experts who can design, operate, troubleshoot and repair devices that provide assurances of national security
(Skaggs, 2014). These challenges also suggest the need for a citizenry equipped with a substantial grasp of science and can understand the urgency of the threats facing them (World Economic Forum, 2016). Stated more specifically, an understanding of science, technology, engineering, and mathematics (STEM) is key to meeting the demands of the future (Swanson & Kelly, 2014).

Many experts indicate that the United States is not meeting these challenges. Friedman and Mandelbaum (2012) state that the country has fallen behind other nations in the face of rapid globalization. One source describes globalization as a “process of interaction and integration among the people, companies, and governments of different nations…” (“Globalization,” 2015, para. 1). The National Academies of Sciences, Engineering, and Medicine (2017) concluded that “evidence suggests that as a nation, the United States is not adequately developing and sustaining a workforce with the skills needed to compete in the 21st century…” (National Academies of Sciences, Engineering, and Medicine [NASEM], 2017, para. 1). Another well-known group even indicates that the United States’ failures in education are themselves threats to national security (Council on Foreign Relations [CFR], 2012). This conclusion was based on the need for digesting the documentation that is needed with today’s sophisticated weaponry.

To remedy this situation, effective ways to engage and motivate students in California, if not the entire country, should be explored. Spicer (2015) notes that “engagement is more than being on task or paying attention, but is a condition influenced by many factors including student background, the learning context of the classroom, teacher characteristics, and the features of instruction (p. 4). Eccles and Wang (2012) observe that engagement is the result of motivation, and that academic motivation is the
desire to succeed in schoolwork. The establishment of the Next Generation Science Standards is one approach being attempted by some states to provide a way to engage students in science learning. As the approach is still in its infancy, and has not been fully tested in most states, its exploration is beyond the scope of this study.

The literature indicates that one way to engage students is through Advanced Placement (AP) curriculum, which is often viewed favorably by colleges and universities in their admission processes. Grove makes the point that to attain college acceptance, students engage in the most challenging classes offered by the high school, which are typically AP. It could be argued that the engagement is a result of the motivation to attend a college or university (Grove, 2016). However, issues of social justice have been raised about AP courses based on uneven access to this curriculum by some groups, notably Hispanics (Cassity, 2013). This has been addressed by the College Board, suppliers of the AP testing, by responding with the “All In” campaign ("All In AP," 2015). This program, however, does little to counter claims that further reductions in costs could be made, particularly because each of the 23 executives who lead the College Board is annually paid an average of $355,271 (Weissmann, 2013).

High numbers of students who were qualified but chose not to take the recommended AP courses argue for the need for improved engagement of the students in these courses of study. Per Chau (2012), in 2011, “Seventy percent of prepared Hispanic students, 62 percent of white students, and 42 percent of Asian students are also not taking recommended AP courses…” (para. 7). These were students who had taken the prerequisites but chose not to take the more advanced AP courses.
Economics may play a role in these decisions, as the cost of exams can be burdensome. One principal of an AP school in the county proposed for this study indicated in 2016 that students pay $82 per exam (J. Manning, personal communication, August 17, 2016). The College Board has responded to concerns about barriers to testing experienced by low-income students by reducing fees. For 2017-2018, the regular examination fee is $94, with a $32 reduction for those with financial need. For these students, the school forgoes the $9 rebate from the College Board resulting in a $53 cost (AP Fee Reduction, 2017).

Other efforts to engage students include the International Baccalaureate (IB) Programme, sometimes introduced in elementary, middle school and lower high school grades, but in Diploma form consisting of rigorous multi-dimensional university preparation in grades 11-12. Unlike AP, the International Baccalaureate Organization’s declared goal is focused on the peaceful application of rigorous coursework stating that graduates should be able to “…help create a better and more peaceful world through intercultural understanding and respect” ("IB Mission," 2005-2017, para. 4). However, IB is not as widely available as AP, in part because it is substantially more expensive for school districts to offer. Per the College Board (2016) the cost to establish an AP course of 25 students ranges from $1090 to $11,650 depending on the subject ("AP startup costs," 2016).

In 2013, the Hewlett-Woodmere Public Schools system in New York commissioned a cost comparison of AP and IB approaches. The study showed that the costs were substantially different. AP expenses were lower in part because the new courses would replace existing non-AP courses. Professional development for AP takes
place during the summer, so there would be no substitute costs. Any compensation for the teacher’s time would be per existing contract. Likewise, curriculum development would be budgeted for after adoption in response to any staff change. The total projected cost for this approach would be $443,805 (“Cost Comparison,” 2013).

According to the Hewlett-Woodmere study, the IB program would require expenditures not anticipated in AP. Professional development days were expected to last three days each, with associated costs to include teacher substitutes, air fare, lodging, and meals. There is also mandated coursework for participating staff and a required coordinator. Two-year sequencing or double period scheduling would also impact full time employee costs. Per the study, the total budget would be $1,254,798 over four years. ("AP vs. IB Costs," 2013).

Looking at this approach on a per student basis, each IB learner costs his or her district $14,500 per year, which includes the application fee, candidate fee, and evaluation fees. The annual fee to the school district is $11,700 ("IB Fees," 2016). According to one principal of an IB program school, students pay $113 per exam (J. Manning, personal communication, August 17, 2016).

Per the National Center for Education Statistics (2017), White high school students are still the majority in United States’ public schools. They outperform Hispanic students on several measures. In addition to lower AP coursework matriculation noted above, Hispanic students show a performance gap when compared to Whites and Asians in science (Crisp & Nora, 2012). Hispanics achieved substantially lower rates on the American College Test (ACT). The ACT science benchmarks for grades 8, 10, and 11 or 12 in the 2012 report indicated that while Hispanics did better than African American
students, they performed well below Whites and Asians and their scores grew at a slower pace (ACT, 2012).

Other measures, such as the Scholastic Aptitude Test (SAT) showed Hispanics achieving lower than Whites with a combined score mean of 1345 versus 1576 in 2015. Lower Hispanic performance is also evidenced in the change in SAT scores over time. Hispanic scores have dropped 26 points since 2006 versus a six-point drop for Whites (Jaschik, 2015). Hispanic high school graduation rates also lagged those of Whites 75.2% to 86.6% (GradNation, 2015). Further, while there is interest among Hispanics in STEM, their persistence to completion is at issue. One study noted that even though Hispanics enter STEM in colleges and universities at the same rates as Whites, only 16% complete their degree. For Whites, the rate is 25% (Crisp & Nora, 2012). This has implications for employment in science and engineering. A 2016 report of science and engineering indicators showed that 74.6% of those who held these degrees were White, whereas only 7.7% were Hispanic (National Science Board [NSB], 2016, table 3-19). There has been some improvement in the number of Hispanics taking STEM coursework. Even when Hispanics do attain STEM degrees, they are still not as prepared as other groups for careers in this field. For example, in 2012, 53% of the engineering credentials earned by Hispanics are at a level beneath that of a bachelor’s degree (compared to 34% by White students). This is significant as the jobs requiring bachelor’s degrees and higher have mean salaries of $90,000, those below have mean salaries of $54,000. ("Engineering Emergency," 2012). Hinojosa et al. (2012) indicate that while Hispanics comprise 14% of the nation's workforce but only 6% of STEM employment. However, Laura Merner, author of a report by the American Institute of Physics on Hispanics in
STEM, indicated that improving numbers of Hispanics is not translating evenly into all
areas of science where trained specialists are needed. She stated, “for every 1,000
bachelor’s degrees earned by Hispanics, 2 [sic] are in physics” (Merner, 2014, p. 7).
Another study showed that an average of classes graduating 2008-2010, 81% of physics
degrees were earned by Whites, 4% by Hispanics (Mulvey & Nicholson, 2012, table 1).

With Hispanics being the least engaged in AP coursework and therefore at a
disadvantage for college and university admission, a starting point for this study was
suggested. Hispanics are the second fastest growing segment of the American student
population, and in some areas, the majority (Bara, 2014). The projected national
population of Hispanics expected to reach 106 million by 2050 (Krogstad, 2014). In July
2014, Hispanics became the majority of California’s public school students (Panzar,
2016). Presently they do not enter STEM careers at the same rate as other groups (Crisp
& Nora, 2012; Estrada et al., 2016). If they are to have access to the opportunities that
come with future technological advances, it is arguable that their engagement in science
related fields is critical if the nation is to remain a prominent member of the world
community and thereby accrue the benefits of that position.

Whereas the California Central Valley was selected for this study largely for its
convenience, it is also a region of great need. The Economist referred to this region as
the “Appalachia of the West” (Wozniacka, 2013). Searching for evidence of this claim
revealed that in 2010, Forbes Magazine, using business metrics, noted that four of the top
20 of “America’s most miserable cities” are in this region ("Conditions," 2010,
exression 1). Using violent crime rate as a basis and searching for the “most dangerous
cities in America” for 2015, Forbes includes one of this region’s municipalities on that
list ("Most Dangerous," 2015). Viewing a list of cities with the highest car theft, three of the top 10 are in the region ("Thefts," 2015). Using the Drug Enforcement Administration National Clandestine Laboratory Register’s data for 2004-2012, CNN reported 73 methamphetamine labs in one county of the region, which includes this study’s area. If calculated per square mile, this is the highest rate in the in the state (Yellin, 2017). The entertainment industry views the region in a manner consistent with these reports. The popular television series “Sons of Anarchy” was set in the region of the study, with many of the place names unchanged. While these claims are not part of the study per se, it may be argued that the forces in motion from these conditions may in turn create barriers that affect the student success outcomes. Such perceptions, combined with demonstrated realities make the California Central Valley a more challenging place for students to succeed than elsewhere within the state, regardless of ethnicity, but certainly for Hispanics.

In Stanislaus County, there are some areas of weakness in terms of college completion and therefore access to STEM opportunities. Per California Department of Education data, of the 2016 California graduates 37.2% of Hispanics met the UC/CSU entrance requirements as compared to 51.7% Whites. The Hispanic dropout rate for the same period was 10.9% as compared to 8.2% for Whites (California Department of Education [CDE], 2017). It may be argued that a higher dropout rate and lower college readiness in the now majority and still increasing population, is worthy of further examination.
Statement of the Research Problem

In comparison to other developed countries, as measured by the Program for Individual Student Assessment (PISA) “the most recent PISA results, from 2015 placed the U.S. an unimpressive 38th out of 71 countries in math and 24th in science. Among the 35 members of the Organization for Economic Cooperation and Development, which sponsors the PISA initiative, the U.S. ranked 30th in math and 19th in science” (Desilver, 2017, para. 2). At the same time, the nation’s second fastest growing student population, Hispanics, who are the majority in some states, including America’s most populous, California, are not being engaged in science. This is evident by their lack of participation in science related areas.

The problem is that despite their numerical prominence in California, STEM coursework and careers are not being promoted to Hispanics. This represents a threat to the economic viability of the state. The study, then, seeks to find ways to engage Hispanics so that they become science learners at rates which far exceed the present so that the United States benefits from their participation. Of interest to this study is the engagement of those students who are Hispanic and have taken one or more Advanced Placement courses in California’s Central Valley at comprehensive public high schools.

Purpose Statement

The purpose of this mixed methods study was to identify and describe to what extent teacher program practices promote the engagement of Hispanic students in Advanced Placement science. In addition, it was the purpose of this study to identify the barriers experienced by the students in their Advanced Placement science classes.
Research Questions

Research question 1: To what extent does the Advanced Placement Program succeed in promoting Hispanic student engagement and learning in high school science classrooms?

Research question 2: What program practices promote engagement and improve learning among Hispanic Advanced Placement students in high school science classrooms?

Research question 3: To what extent does the Advanced Placement Program present barriers to Hispanic students’ access, learning of science concepts, and course completion in high school science classrooms?

Research Question 4: What do Advanced Placement teachers perceive as changes in practice needed to overcome the identified barriers?

Research Question 5: What program practices do Advanced Placement science teachers recommend to support Hispanic students?

Significance of the Problem

Schmidt, (2012) stated that “the ultimate test of an educational system is whether it makes sure that every student, whatever their background, is exposed to the content they need to compete in today’s society” (para. 1). The Next Generation Science Standards (NGSS) narrow the focus saying, “the NGSS call for science teachers to provide all students access to a rich and engaging curricula that is appropriately challenging [sic]” ("Access and equity," 2016, p. 8-2). It can be argued that high school students are a form of human capital. The United States has a tradition of investing heavily in human capital through such programs as Pell Grants, the Morrill Land Grant Acts, and the G.I. Bill of Rights. However, America has had dual traditions of supporting
and neglecting the development of its human capital. For example, one means of support has been the funding offered by the grants noted above. These programs have promoted a strong middle class and workforce through the establishment of post-secondary institutions and helping students attend those (Steigleder & Soares, 2012). States and local school districts offer many solutions to both what is required by law and perceived as needed to deliver proper education to their students.

At the same time, there have been instances of the inequity of access to the core curriculum. One observer noted “a scandalous child poverty rate” that affects all aspects of learning (Buntin, 2014). Other issues include wide varieties in teacher preparation programs, some only 12-15 weeks in length, that often do not focus on subject expertise. There are also issues of curriculum, unequal spending on classrooms, differences in approaches by both districts and states; these are just some of the limits to students having equal access to the curriculum (p. 59). It should be noted that these issues particularly affect Hispanic science learners (Crisp & Nora, 2012). A review of the efficacy of so-called ‘teacher internships’ and use of ‘emergency credentials’ adds yet another layer of concern, especially when such elements are routinely found in low-wealth districts. Issues of social justice will be discussed in Chapter V.

Against the background noted above, the last few decades have seen the skill sets needed to compete both here in the U.S and internationally change dramatically. This has placed new pressures on institutions at all levels to better prepare the nation’s workforce. STEM skilled workers are needed in greater numbers than ever before (Crisp & Nora, 2012). These professionals require increasingly sophisticated training rooted in advanced courses. According to the National Math and Science Initiative, “student achievement in
STEM begins with an interest in STEM, and this interest must be seeded at an early age…” (“Initiative," 2016, para. 6). Ideally, an interest in science should begin in elementary school and be developed throughout high school. Unfortunately, the preparation of these teachers may be inadequate. Per one source, “only 48% of America’s 8th grade science teachers have an undergraduate major in science” (Ryshke, 2016, expression 15). Dailey (2015) noted that at the national level “93% of middle school physical science students did not have a teacher who was science certified or who possessed a degree in physical science” (p. 5). At the high school level, subject specific numbers are even higher with 61% of chemistry teachers and 67% of physics teachers not having the proper certification.

Hispanic students engaged in science in lower grades can develop an interest in STEM courses at colleges and universities. This post-secondary engagement is critical for there to be an adequate supply of STEM professionals graduating with the appropriate degrees (Hossain & Robinson, 2012). The students who take STEM courses in college and career have insights about the experience that helped engage them. Often these students take Advanced Placement courses to prepare for this transition, and their experiences may be used as indicators of successful program elements.

Demand for STEM trained professionals is a significant issue. According to one report, there are “3.6 unemployed workers for every science, technology, engineering, and mathematics (STEM) job in the U.S.” with “only one unemployed STEM worker for two unfilled STEM jobs throughout the country.” Thus, it appears that there are careers waiting for those who are qualified. The findings of this study could help the understanding of that situation by revealing both barriers and program elements that
engage Hispanic science learners. If addressed at the elementary and secondary levels, the groundwork can be laid for partnerships within industry to supply advance trained science workers and become a “win-win” for both partners.

Definitions

1. **Achievement gap** – The U.S. Department of Education website defines achievement gap as “the difference between how well low-income and minority children perform on standardized tests compared with their peers. For many years, low-income and minority children have been falling behind their white peers in terms of academic achievement” (Achievement Gap, 2004, para. 3).

2. **Culturally responsive teaching** – Per Wages (2015) this approach to education employs “using a student’s cultural knowledge, prior experiences and performance to make learning more appropriate” (p. 76).

3. **Engagement** - Spicer (2015) notes that “engagement is more than being on task or paying attention, but is a condition influenced by many factors including student background, the learning context of the classroom, teacher characteristics, and the features of instruction (para. 5).

4. **English language learner** – “A person who is learning the English language in addition to his or her native language (Wages, 2015, p. 76).

5. **Hispanic** – The definition of Hispanic is not easily stated. Different sources and individual Hispanic leaders vary in their interpretation. *Hispanic Economics* (2004) indicates that a Hispanic is “a person of Latin American or Iberian ancestry” (para. 8). According to the Pew Research Center, defining who is Hispanic is a difficult issue, noting that the Federal government views it as an ethnicity and not a race. Provisions are
being made for the 2020 census, when the survey may include combined questions that address both race and ethnicity (Krogstad & Cohn, 2014; Gonzalez-Barrera & Lopez, 2015). For the purposes of this study, those AP teachers who have identified themselves as having Hispanic students were included.

6. **Hispanic serving institution** – This is a term described in the Journal of Hispanic Higher Education as recognizing institutions of a post-secondary nature that have at least 25% of the student body as Hispanics (Fosnacht & Nailos, 2016).

**Delimitations**

The study was generalized to public-school AP science teachers in California’s Central Valley who have taught Hispanic students. To broaden the study to a larger area would have created significant concerns. For example, different parts of the state deal with college preparation in different ways, including varying educational priorities regarding Hispanic science students. The economics of the Central Valley, focused largely on agriculture, make it unique with respect to its demographics and history. Each county within California has its own County Office of Education administered by a County Board of Education. Within those counties are numerous school districts, each with their own interpretations of how to deliver instruction. As such, differences will be found in policies regarding science education. The Central Valley was selected as a population of convenience. Nonetheless, a strong argument could be made for selecting this region because 44.8% of the population is Hispanic, against 38.8% of the state ("U.S. Census," 2015). Lopez and Krogstad (2015) indicate that Hispanics in California are expected to reach 47.6% of the population by 2050. It is conceivable that the eight
counties that make up the Central Valley represent the future Hispanic population of the state between now and 2050.

**Organization of the Study**

The remainder of the study is organized into four chapters, a bibliography, and appendices. Chapter II presents a review of what is known about Hispanic science education including engagement techniques, barriers, and successful program practices. Issues of economics, gender differences, cultural impact, and institutional biases are examined. Chapter III explains the research design and methodology of the study. This chapter includes an explanation of the population, sample and data gathering procedures as well as procedures used to analyze the collected data. Chapter IV presents, analyzes, and provides a discussion of the findings of the study. Chapter V contains the summary, conclusions, implications, and recommendations for action and further research.
CHAPTER II: REVIEW OF THE LITERATURE

In Chapter I, it was stated that the current international environment presents a multitude of challenges that test mankind’s ability to manage them and successfully move forward. Arguments were made that improved American efforts to educate its population and meet these challenges are needed. One approach would be to enhance the engagement of all demographic populations. The largest in some areas and second fastest growing is the Hispanics. This group represents potential for growth as it is presently underrepresented and underperforming in Science, Technology, Engineering, and Mathematics (STEM). This study focuses on Hispanic students who have successfully completed one or more Advanced Placement (AP) science courses in a high school located in California’s Central Valley. Some of the factors that engaged these learners or acted as barriers to their success were identified.

Review of the Literature

In Chapter II, the nature of the threats facing the United States are more closely examined, the points are made that Hispanics are the second fastest growing demographic group in the state, yet despite challenges to the environment, health care, national security, and other major concerns, they are not receiving the substantial science education required to address those concerns when compared to non-Hispanics. The present level of Hispanic student success and factors that influenced their success, or evidenced their lack of engagement, along with factors that program practices, are examined. The challenge posed through the literature is to find ways to remedy these problems and promote that which is successful.
Threats Present Challenges and Opportunities

Moving into the 21st century, the world continues to be a challenging place for the community of nations. *The Bulletin of Atomic Scientists*, a publication of the Taylor and Francis Group authored by 17 Nobel Laureates, shows the researchers’ examination of global conditions. On The Bulletin’s site (2018), the “Doomsday Clock,” a measure of the likelihood of a global catastrophe caused by humans, is set at “two minutes to midnight” based on threats from a list of contributing factors (*Bulletin of the Atomic Scientists*, 2018, p. 2). At midnight, the planet would be experiencing a state of global anthropogenic catastrophe. *The Bulletin's* scientists indicate the time setting is “an expression of dismay that world leaders continue to avoid addressing existential threats that threaten the very existence of civilization and therefore should be the first order of business for leaders who care about their constituents and their countries” (*Bulletin of the Atomic Scientists*, 2016, p. 4).

Globalization has been defined as “the free movement of goods, services and people across the globe in a seamless and integrated manner” (Management Study Guide [MSG], 2017, para. 2). Some writers indicate that this phenomenon demands a skill set commensurate with its challenges (Saavedra & Opfer, 2012). STEM is one way to teach students this skill set. According to one source, “best practices in STEM education focus on critical thinking, problem solving, and 21st century skills such as communicating and collaborating” ("STEM Fosters 21st Century Skills," 2017, para. 2)

Threats to the planet are axiomatically threats to the United States, as well. In addition to national security, climate change, health, and other concerns, America struggles to improve economic opportunity for its citizens (Cox, 2016). Poverty rates,
while seemingly low at 16%, are artificially held in check with the assistance of substantial public assistance programs began during President Lyndon Johnson’s “War on Poverty” in 1964 (Boteach, Stegman, Baron, Ross, & Wright, 2014). The literature indicates that a STEM education can be one way to avoid poverty. Williams (2014) notes the effects of making STEM education available to underserved communities provides opportunities for the U.S. to compete internationally. Sunstein (2013) states that those who major in science can contribute to economic growth. The National Academy of Sciences indicates that occupations served by STEM education are “a key component of the U.S. Economy” (National Academies of Sciences Engineering Medicine [NASEM], 2017, p. ix). Another benefit of STEM education is that it can bring new opportunities to underserved groups who are in the minority in STEM in both colleges and the workforce. Hispanics are the second fastest growing population in the U.S. and can benefit from these opportunities (Williams, 2014). In California, this group is the majority of students at 52% and according to Mendoza (2013) this state is a “potential model for the rest of the country which is going through a slower but similar demographic shift” (para. 1). Globalization, a process that brings new competition into the environment, is suggested as a source of some of the difficulties now facing America by Friedman and Mandelbaum (2012). Their thesis is that America, once the rebuilder and global leader, is increasingly falling behind the world it helped to invent post-World War II (loc. 7050). These authors likened the success the U.S. enjoyed prior to that conflict and how the environment changed, to a runner who had “won his national championship year after year, but this time the judge handed him the trophy and said ‘Congratulations. You will never compete in our national championship again. From now on, you will have to race in the
Olympics, against the best in the world – every day, forever” (loc. 553). This argument has been updated with the assertion that it is not only the post-World War II changes that challenge the U.S. but also the rate of change. Friedman (2017) contends that humans live in a linear world, but significant factors such as globalization and technology are changing exponentially. It may be argued that STEM education is the vehicle of that change. According to Mandelbaum (2016), those nations who are producing the highest scores in STEM education are the ones who may fare best in a globalized world. It may be argued then that improving STEM education is one response to globalization. One source indicates that “as a nation, the United States is not adequately developing and sustaining a workforce with the skills needed to compete in the 21st century” (National Academies of Sciences Engineering Medicine [NASEM], 2017, para. 1). Avery, et al. (2013) indicate that for the United States to stay globally competitive, STEM has become a priority. But it could be argued that between “becoming a priority” and developing and sustaining a skilled workforce there is a gap worthy of examination. A review of NASEM’s report mentioned above, the terms “Latino,” “Latina,” and “Hispanic” are absent.

**Maintaining national Security, a challenge for the United States.** It has been argued that armed conflict affects STEM education. Lewin, writing in 1967, stated that “war is the principal motivation force for science at every level from the abstractly conceptual to the narrowly technological” (Lewin, 2016, para. 45). Today’s international climate, as evidenced by the Doomsday Clock, indicates that the world still experiences similar situations. It could be argued that there are several notable military threats to the national security of the United States which are worthy of consideration in this discussion.
Russia, North Korea, and the so-called Islamic State have all offered well publicized challenges to U.S. interests. Recent events suggest that China, too, is becoming a force worthy of concern. That nation’s rise to prominence on the world stage is taking several forms. One report stated that it is “to increase its military spending by 7-8% in 2016” (Fenby, 2016, p. 1). Behavior by the Chinese leadership has created tensions in the South China Sea with incursions into disputed waters and the building of new islands in less than a year (Watkins, 2015). Its leaders have demanded that the United States and other powers no longer navigate the formerly free passage in the international waters of the South China Sea. Through these sea lanes, “a third of the world’s oil passes, and which Beijing claims almost in its entirety” (para. 12). The Japanese have seen incursions by hundreds of Chinese vessels, accompanied by armed coast guard ships into its exclusive economic zones (Lake, 2016). China’s insistence on controlling the area has been further demonstrated through actions by its military aircraft by unsafely approaching United States’ ships and more recently aircraft on several occasions that were in the region (Tomlinson, 2016; Held, 2017). Other writers see China as a threat as well (Fallow, 2015; Watkins, 2015; Kurlantzick, 2015). It is arguable that the behavior of China’s leaders points to expansionist policies that will continue to conflict with American interests. As former Ambassador Charles Freeman indicated, “China’s new anti-carrier weapons endanger U.S. force projection capabilities in the Western Pacific; its anti-satellite programs imperil U.S. global surveillance and communication capabilities; its growing operations in cyberspace menace U.S. government operations and the economy of the American homeland” ("China’s Challenge," 2016, para. 9). Examining what has been called by researchers as the “Chinese Dream” Zhou (2014) notes that China has
reduced the technological gap with the West from 50 years to 10 in three decades. He
states that “China has reached or even surpassed international levels in many aspects”
(p.3). These developments suggest the need for qualified technicians to counter the
challenges brought by such a vigorous competitor and therefore ways to engage and
educate them.

**Cyber Security a Concern.** Internet security is a threat beyond China. Hackers acting
on behalf of North Korea were reported to have successfully damaged Sony Pictures’
business in a cyber-attack in 2015, costing the company $15 million. By one report,
associated costs pushed the total to $35 million ("Hack," 2016). The FBI supported this
view (Harris & Youssef, 2016). More recently, mounting evidence has been offered that
Russian-backed hackers have attempted to influence the American presidential election
of 2016. In December of that year, 35 Russian government officials were declared
“persona non-grata” and given 72 hours to leave the United States in response ("Russian
Expulsions," 2016, para. 11). According to an article in the *Washington Post*, support for
this opinion comes from consultant firms who identified two Russian sponsored hacking
groups who accessed the Democratic National Committee’s computers. One of these is
suspected of conducting a cyber-attack on the U. S. State Department (Rubin, 2016).
Recently, the former head of the Central Intelligence Agency stated that suspicions of
Russian interventions were “well-founded” ("Russian Intervention," 2017, p. 1).
Mansfield-Devine (2014) writing in the journal *Network Security* observes that “hacking
groups with powerful motivations are becoming increasingly skilled and resourced.
Whether the motivation is political or criminal, we’re more likely to see large-scale
breaches in the future” (p. 16). As with military threats, these challenges suggest a need
for highly skilled personnel to overcome them. This requires an appropriate educational pathway with qualified teachers.

**Health Care a Concern.** In addition to the threats stated above, health care is another area that affects Americans and where qualified personnel is needed. Maintaining the nation’s health is of concern to all citizens, and costs associated with it are significant.

Per the World Health Organization, the United States spent more on health care per capita ($9,403) and as a percentage of its gross domestic product (17.1%) than any other nation in 2014 ("WHO Health Information," 2015). Some sources hold that this spending has not translated into benefits for the population at the same levels. One study by the Commonwealth Fund indicated that the U.S. health care system was found to be the most expensive and worst-performing in terms of health access, efficiency, and equity (Davis et al., 2014). This would suggest the need for trained experts to address these issues and help bring U.S. health care quality to that or above its peers internationally. In terms of its impact on Hispanics, and thereby creating a stakeholder dynamic which conceivably includes both health benefits from the legislation as well as foreseeable careers in STEM to support that carte, ACA has notable statistics. According to a 2015 government report, in the first quarter of enrollment in 2013, 4.2 million Hispanic adults gained coverage. This seems to be supported in that “ACA invested 11 billion in Community Health Care Centers, which increased access to health care by almost 35 percent to Hispanic patients who rely on these centers” ("The ACA is Working for the Latino Community," 2016, para. 10). Recent changes in Washington may impact this situation.

The work being done by the ACA supports work done by others. There is a recognition that the American health care system can improve its service to underserved
communities. Researchers at Wake Forest School of Medicine suggest that the medical community is beginning to see the importance of this stating that “…Hispanics’ health is vital to the public health of the nation.” ("Health of Hispanics," 2016, para. 3). This source indicates that numerous barriers create gaps in awareness. These include language difficulties, and cultural insensitivity suggesting the need for engaging members of this population to address these issues. Understanding through research is also a problem because “an incomplete understanding of Hispanic populations in academic research has produced a lack of comprehensive data addressing Hispanic health” (para. 9).

If engaging all members of the population is a desirable option for addressing health care, and there is a need for trained personnel in this field, it is conceivable that this would offer career options for Hispanics. Presently 30.4% of the nation’s most populous state, California, is Hispanic. At the same time, only 4.8% of all doctors in California are of the same group. These professionals bring language and cultural understanding to their service of fellow Hispanics. However, as one 2015 UCLA study showed, the number of Hispanic physicians is declining even as the overall population increases (Rivero, 2015).

**Environmental Concerns.** An area less often reported in the literature is the degree to which Hispanics engage in advocacy for environmental concerns. Matters such as immigration, poverty, and political activism tend to dominate the attention of the mainstream media. However, a research brief by the Hispanic Access Foundation (2017), responding to this concern noted that Hispanic voters “consistently articulate concern about pollution, and global warming and are overwhelmingly supportive of a broad policy agenda actively addressing these problems” ("Environment," 2017, para. 2).
A national organization called Green Latinos also illustrates this population’s involvement in global concerns. Its website states that the organization’s members are “committed to addressing national, regional and local environmental, natural resources and conservation issues that significantly affect the health and welfare of the Latino community in the United States” ("Environmental Priority," 2016, para. 1). The study of environmental issues is a significant part of STEM. This has been demonstrated by their inclusion in the Next Generation Science Standards. This suggests a core that could be built upon when seeking engagement pathways for Hispanic science learners.

As with environmental issues, Hispanics are often overlooked as space researchers. However, of the 532 people to travel in space, 11 or 2% are Hispanic ("NASA: Astronaut Facts," 2013; "Hispanic Astronauts," 2016). Notable members of the community who contributed to America’s space exploration were Dr. Ellen Ochoa, the first Latina astronaut, and Jose Hernandez, who applied 12 times before he was selected in 2009 (Hinojosa, 2014). He has since gone on to become a spokesman for goal attainment.

**STEM as a Response**

According to multiple sources, the challenges and threats above need to be met with a greater emphasis on STEM education to produce more STEM professionals equipped to address them. STEM as a response to this situation is summed up in a statement by one source that states “The United States is losing its competitive edge in math and science while the rest of the world soars ahead. America’s knowledge capital, which fuels innovation and economic growth, is at risk” (National Math and Science Initiative [NMSI], n.d., para. 1). The situation is complicated by the fact that “STEM employment growth is outpacing the general economy by about 300%” (Swanson, 2014,
The AFL-CIO’s Department for Professional Employees (2016) makes the point that “as changes reshape the world of work, these (STEM) professionals are consistently in demand. However, some STEM occupations are struggling, especially in the natural sciences and some engineering professions (para. 1).

One approach suggests that to meet these challenges, the need for early intervention in education was suggested by Roberts (2014) who also indicated that STEM is important for the nation and that it is “essential to tap interest early in both boys and girls” (para, 1). However, STEM as a pursuit in colleges and universities can be challenging to many learners. When examining why American students often may begin a STEM degree yet not finish it, Ralph and Todd Stinebrickner found in 2013 that students on average are overly optimistic about completing their degrees. Specifically, 13.4% believe they will drop science when they begin college, in reality, 37.5% actually drop (Stinebrickner & Stinebrickner, 2013).

Hispanics as a group are underrepresented in STEM coursework and subsequent careers. They encounter challenges that have often been discussed in the literature. In 1994, Congress recognized and addressed this in the Goals 2000 Educate America Act. Funds were then made available to post-secondary institutions through programs such as the Louis Stokes Alliance for Minority Participation program, Federal TRIO programs supporting disadvantaged students from middle school to college, and Minority Engineering Programs (Crisp & Nora, 2012). Goals 2000 was defunded in 2001 as the Nation transitioned to the No Child Left Behind Act (H.R.1) ("Goals 2000," 2016).

The National Science Board suggests that “education at all levels in science, technology, engineering, and mathematics – STEM – develops, preserves, and disseminates
knowledge and skills that convey persona, economic and social benefits” ("Why is this important?" 2012, para. 1). All 50 states have mathematics and science infused into their adopted K-12 curriculum. With the exception of Colorado, Massachusetts, and Vermont, all states have high school math and science coursework graduation requirements. Maine has a proficiency requirement. ("Math and Science Requirements," 2015). Klein and Rice (2012) sees the need for increased STEM expertise to counter national security challenges and divides this topic even further. These authors make the point that “America’s educational failures pose five distinct threats to national security: threats to economic growth and competitiveness, U.S. physical safety, intellectual property, U.S. global awareness, and U.S. unity and cohesion” (Klein & Rice, 2012, p. 7). Other voices include the director of the Los Alamos Laboratory who presented a TED talk equating national security and STEM (McMillan, 2013). U.S. News and World Report’s Levy & Plucker (2015) also supported the need for the development of STEM talent saying that “the country’s defensive capabilities often depend on brains not brawn” (para. 2). David Skaggs (2014) a former congressperson from Colorado, links economic strength and the ability of the United States to defend itself to the attainment of post-secondary degrees. This would include STEM education. He further connects the two through the economy stating that “national security is inherently a function of the economy and the economy is a function of educational attainment” (para. 6). His thesis is supportive of encouraging educators to use the relationship between these two to gain leverage in the national debate about what is important. They can then influence policy makers at all levels to support STEM education.
Buchanan (2012) makes the point that “an educated population is essential to a nation’s prosperity” (para. 1). It also plays a role “in creating citizens who understand how a democracy works” (para. 2). STEM education is credited by some writers as fulfilling the need to develop a highly-informed population, one capable of critical thinking. According to one source, STEM education supports learners’ academic growth, develops early critical thinking, and lays the groundwork for later interest in STEM (Howard-Brown & Martinez, 2012). This aspect of democracy creates both challenges and opportunities. The World Economic Forum's Global Risks Report (2016) indicates that a more informed people can be both blessing and curse, in that governments may act out of "uncertainty about how to deal with a more informed, connected, and demanding citizenry, which can lead to an escalating downward spiral of broken trust and harsher response on either side" (p. 7). At the same time, making critical decisions such as response to climate change must be informed by budgetary concerns as a part of policy development. Such decisions could take the form of "finding ways to factor climate and regulatory risks into short term decision decision-making processes, and related financial metrics is essential for driving climate risk-informed investments" (p. 56).

Other sources state that if there is to be a maintenance of American preeminence in STEM internationally, which allows for meeting the nation’s needs for long-term environmental resources, and technological innovations, the nation needs a suitably equipped STEM workforce (Committee on STEM Education National Science and Technology Council [CSENTC], 2013). This suggests the development of STEM education that is equal to the task (National Science Board [NSB], 2016; Engler, 2012). A STEM-informed citizenry is also important to Ron Mobed, listed by STEM Connector
as one of 2016’s 100 CEO Leaders in STEM. He believes “investing in STEM education is crucial to ensuring there is a pipeline of talent for future generations of science research and a STEM educated workforce who will have the scientific literacy to understand why we need to do so” (Bert, 2016, p. 98). This sentiment was echoed by many of his peers in the same publication.

Is America Delivering?

There is support for the view that the United States is not producing students who can compete with their peers in other nations. The Programme for Individual Student Assessment (PISA) measures science literacy, among other subjects. An examination of the United States’ scores over the past three testing cycles reveals relatively flat progress. Indeed, the Organization for Cooperation and Development “no significant change in these performances over time” ("PISA 2012 Results," 2012, para. 1). During the same period, China, the world’s most populous and arguably rapidly emerging nation, began in third place and had risen to the top improving its scores each year. A National Education Association’s review of 2012 results noted, “the fact that the U.S. hasn’t mustered any better than a barely average ranking has always triggered an alarm among many policy makers” (Walker, 2013, para. 3). Another source contends that STEM is needed to prepare future Americans. It quotes President Obama’s goal of “moving our nation from the middle to the top of the pack in math and science education” (para. 1) and suggest that to do this; diverse learners must be included. (Howard-Brown, Martinez, & Williams, 2017). Hispanics are presently the most numerous group of these learners in America (U.S. Census, 2010). As such it may be argued that their inclusion deserves closer examination.
**Effect of socioeconomic standing on PISA scores.** PISA scores do not tell the whole story of a nation’s science understanding. The literature supports the effect of socioeconomic status (SES) on PISA scores, one source pointing out that the U.S. has “many more disadvantaged students in its representative sample than higher scoring students (Carnoy & Rothstein, 2015, para. 14). The authors state, “How well students in any country perform on an international test may be affected by how well a particular test is aligned with that country’s curriculum or by other factors not reflective of actual proficiency in the tested subject.” (p. 124). Mullins, too, implicates SES as a factor in American scores, stating that “other countries with similar rates of poverty don’t have such large educational disparities” (Mullins, 2013, para. 6). These assertions raise issues beyond the control of the instructors or students and support the argument that measures other than PISA should be weighed to assess the efficacy of American students in science. One source from the University of Minnesota indicates an approach to the challenges of engaging Hispanics may be found in how educators view the problem. As students of color do not graduate at the same rates as white students, perhaps an approach that views the outcome issues as an “opportunity gap” and thus focus on the experiences of the students (De Davila & Michaels, 2016, para. 9). This suggests that any study of student science achievement in the United States considers SES standing as a variable. Data shows more Hispanic children are living in poverty than any other group of American students (para. 14). This situation is compounded when one examines the differences in economic factors visited upon immigrant students’ families as opposed to those born in the United States (para. 15). One study notes that school districts where Hispanics predominate are included more often on fiscally disadvantaged lists. It is
notable that for each 1% increase in Hispanics, there is a 3.3% greater likelihood of the school district being classified fiscally disadvantaged. By comparison, for the same increase in African American population, the likelihood is 1.8% (Baker, 2014). This suggests significant challenges for the educators tasked with the job of engaging Hispanic learners. Arguably, those challenges should be investigated.

Another internationally-recognized measure of science understanding is the Trends in International Mathematics and Science Study (TIMSS). While one analysis of these scores showed that of the 63 nations participating in the exams, American eighth graders scored “significantly above the international average and significantly below students from eight other nations” (Loveless, 2013, para. 4). As additional economically developing nations join the TIMSS program, “leading the world in reading, math or science remains a challenge for the U.S.” (para. 5).

To use TIMSS to compare with PISA scores is difficult to interpret for science. This challenge was seen when using TIMSS for a longitudinal study of student achievement. According to the to the Brown Center Report on American Education (2013) TIMMS data were described as “spotty,” noting that science has “even less data with highest figures dating back to 1990 and then diminished tracking after that” ("Brown Center," 2013, p. 18). This would appear to leave the PISA as a more consistent source of data for the study. At the same time, it must be realized that the effect of African American students’ scores as impactors on PISA is also found in the literature. According to a 2012 report, the U.S. average of PISA science tests 2006-2012 was 496. The two lowest scoring ethnic groups, and therefore those who impacted the scores downward the most were African Americans with a 427.67 average, and Hispanics with a 455 average
("NCES PISA by Race," 2012). This, along with high poverty rates found in both groups are overlapping factors that affect PISA scores.

“Socio-economic background has a significant impact on student performance in the United States, with some 15% of the variation in student performance explained by this” ("PISA 2012 Results," 2012, p. 1). This is similar to the OECD average. “Although this impact has weakened over time, disadvantaged students show less engagement, drive, motivation, and self-beliefs.” (p.1). Morsy and Rothstein noted in 2015, “The socioeconomic disadvantages of recent-immigrant low-wage Hispanic workers’ families are probably more similar to those of African Americans” (p. 5). Their report does not discuss Hispanics “because data are insufficiently disaggregated to shed light on the socioeconomic disadvantages that many experience (p. 5). Available data are too confounded by national differences (e.g., Cuban versus Mexican) and generational differences (recent immigrants versus assimilated third-generation and beyond). This study deals only with the situation of the Hispanic learners.

As stated by Conroy and Rothstein (2016) comparisons between the United States’ PISA scores and other nations are incomplete, not taking into consideration the effect of disadvantaged students, cited in their study for the U.S. as African American and Hispanic. They also contend that there is “simply no good way to compare social classes across countries” (Part IV, para. 12).

**Decision Makers Take Notice**

The challenges to America have not gone unnoticed by policymakers in Washington. At a combined meeting in 2005, the councils of the National Academy of Sciences and the National Academy of Engineering “expressed concern that a weakening
of science and technology in the United States would inevitably degrade its social and
economic conditions…” (National Academies, 2007, p. ix). A commission was
convened to investigate this concern, with a report delivered in 2007. This report, *Rising
Above the Gathering Storm*, led, among other things, to the creation of the National Math
and Science Initiative. This group’s stated purpose is "to address one of this nation's
greatest economic and intellectual threats - the declining number of students who are
prepared to take rigorous college courses in math and science and are equipped for
careers in those fields" ("NMSI," 2016).

The literature suggests that to successfully compete with other nations, and to
maintain leadership on the world stage, the United States should continue to train or
import more science, technology, engineering, and math professionals. If imported, the
STEM industries can simply advertise and pick what they need from the available pool of
offshore talent, seeking H1B visas. These limited forms of admittance allow for highly
skilled workers who work in specialty occupations enter and remain in the United States
for up to six years ("Visa," n.d.). At least one source finds that this approach to meeting
America’s STEM professional needs is bad for business “…many companies use the
visas to displace American workers and drive down salaries, both of which are expressly
prohibited by law” (Times, 2016, para. 6). Offshore outsourcing is but another issue that
can remove jobs from the U.S. One source indicates as many as the employment of 14
million white collar Americans are in danger of being lost to America (Roberts, 2016).

If American education is to provide the workers, all available sectors of the population
are needed, and the maximum utilization of their talents is key. As noted by Crisp and
Nora (2012) meeting the demand for STEM skilled workers will be problematic if America’s population diversity is not mirrored in the sciences.

**Controversy Over Need**

However, the discussion of America having an adequate supply of STEM workers has both its supporters and detractors. It is an important question, as at the heart of this study was the argument that America’s need for STEM workers drives the need to provide maximized engagement of the labor pool. Involving those who are underrepresented in the workforce present opportunities for improvement in education practice.

According to an analysis of Bureau of Labor Statistics data from 2000 to 2013, adjusted for inflation, “median salaries for workers in computer and, mathematical, health care practitioner, engineering, and science occupations, rose 8 percent, 7 percent, 6 percent, and 5 percent respectively, even as those for the average U.S. worker showed no growth” (Rothwell, 2014). The report states “nearly 80 percent of STEM graduates say their degrees are somewhat closely related to their jobs” (para. 7).

An opposing viewpoint is taken by the Center for Immigration Studies (CIS), whose work, published one year before the U.S. and New World Report cited above, stated that “America has more high tech college graduates than needed to fill high tech job now and, importantly, the nation will keep producing many more such graduates than job opening in the future…” (North, 2013, para. 1). The article also states that during a similar period of time, 2000 to 2012 Internet technology workers only gained 18 cents an hour (para. 25). One could argue that the narrower base of comparison is inconsistent with the 8 percent change cited above and would need to be investigated further. It
should also be noted that the objectivity of the CIS has been called into question by the Southern Poverty Law Center, which has accused the organization of bias in their presentation of facts (Piggott, 2017).

The Institute of Electrical and Electronics Engineers (IEEE), took a stronger position in an article titled “The STEM Crises is a Myth” (Charette, 2016). The IEEE claims that “companies would rather not pay STEM professionals high salaries with lavish benefits, offer them training on the job, or guarantee them decades of stable employment” (para. 28). The motivation this organization claims is that an excess of STEM workers helps the companies’ profits keeping worker costs down.

**Programs to Provide STEM Educated Professionals**

If the United States needs STEM to meet the many and changing challenges of the 21\textsuperscript{st} century and beyond, it needs a reliable source of STEM talent. There are several approaches designed to accomplish this task. The adoption of the Common Core and the Next Generation Science Standards are K-12 statewide programs that promote science learning through research-based approaches with updated the core science content. Utilizing both cross- and spiral-curricular approaches, proponents claim that both provide the understanding that 21\textsuperscript{st} century students need to be successful. While not adopted in all 50 states, each offers responses that are being widely attempted and will need more study to determine if these programs will deliver the desired results.

AP courses, the International Baccalaureate Programme (IB), and dual enrollment science coursework are other approaches that have been adopted at the site level. Each provides methods to address the need for STEM professionals. While AP is for students at the secondary level only, the IB offers elements that extend into middle schools.
Per Rothschild (1999) The Korean War (1950-1953), necessitated the improvement of American education “as a matter of survival in a death struggle with communism” (p. 176). One response was The Ford Foundation’s creation of “Fund for the Advancement of Education” (p. 176) which led to the involvement of key players, who formed a committee to give students accelerated college experience. The group’s plan to accomplish this was called General Education in School and College: A Committee report by members of the Faculties of Andover, Exeter, Lawrenceville, Harvard, Princeton, and Yale. It was in this document that the term “advanced placement” was first used (Members of the faculties of Andover, Exeter, Lawrenceville, Harvard, Princeton, and Yale, 1952, p. 118). As a program, Advanced Placement began first as a pilot effort in 1952 with 11 subjects. By the 1955-56 academic year, the program was in place, and the College Board recruited to begin its administration. The 1960’s was a period of expansion using positive feedback from participating teachers to attempt to improve program practice. Initiatives driving the expansion at that time were the Pre-AP and AP Vertical Teams which were designed to prepare middle school students for success in the accelerated study ("A brief history," 2003).

This approach offers an accelerated way for students to prepare for college and university by exposing them to concepts and methods normally reserved for post-secondary study (College Board, 2016). It does have its detractors. Costs of the tests may be burdensome for those students in lower SES (College Board, 2016; Manning, 2016). Costs to the institutions can also limit the availability (Weissman, 2013). However, research shows increasing numbers of students are taking the tests (Democratic Wave, 2014). Yet, there is the issue of students who are qualified but do not take the
exam which is required for college credit (Chau, 2012). This has been noted in the literature as far back as 1999 (Rothschild, 1999). Perhaps in response to these market forces, McGraw Hill Education sells what it describes as a digital solution for AP success called AP Advantage. A review of the website provides no data to support the company’s claim that the program will “help students overcome obstacles to AP success” ("AP Advantage," 2015, para. 1). The College Board acted with the “All In” program in 2014, focusing on what the Board described as “our nation’s students of color” (Wilkins, 2016, expression 1). The goal of this effort was to engage this student population and increase the number of AP potential student enrollment in rigorous coursework. This source also indicated that there was much to be done as there were nearly 300,000 students who had the potential to take AP but chose not to.

**Does taking AP courses in high school affect college graduation rates?**

Ewing and Howell (2015) make the point that first year college performance is an indicator of degree attainment and that students who take AP exams tended to have higher GPAs both overall and subject areas. Kaliski and Godfrey (2014) found that AP biology students scoring a five on that exam had 0.10 higher college GPAs than their peers. AP chemistry students had 0.24 higher, with AP physics students’ scores that were 0.21 higher (p. 25).

Narrowing the focus to Hispanic students, a study conducted by the Center for College Readiness in 2015 showed that Hispanics who scored 3 or higher (on a five-point scale) on AP exams were 27% more likely to graduate than non-AP students. Whites were 19 percent more likely to graduate and African Americans 21% ("AP and College Readiness," 2015). A 2014 study by the College Board found that “AP students
performed well in subsequent college courses in the discipline” (College Board, 2015, p. 4). However, upon closer examination, a key finding in the report stated that “in most subjects, they (former AP students) performed the same as or better than, non-AP students…” (p. 4). This suggests the need for more investigation into the factors that affected the performance of those students who achieved above their peers. The effect of AP courses on the success of Hispanic learners was documented in the above study showing that “from 2003 to 2013, the number of underrepresented students graduating from high school having taken one AP exam tripled” (p. 8). The Hispanic increase in the probability of college graduation within 60 months was 28%. This compared to 33% for Whites and 28% for African Americans.

**International Baccalaureate as an Option**

The International Baccalaureate Diploma Program (IB) originated in 1951 at “The Conference of Internationally-Minded Schools” in Geneva, Switzerland. This was when the term “International Baccalaureate” was first used. (International Baccalaureate Organization [IBO], 2015). Unlike AP coursework, IB provides a diploma that is recognized worldwide. Per the International Baccalaureate organization, this feature serves to “facilitate geographic and cultural mobility and to promote international understanding ("Key Facts," n.d., para. 3). An example of this would be a study wherein IB diploma program students were compared to those students not seeking the IB diploma through multiple measures. This study makes the point that both IB students and those not in the program were utilizing the same institutions. The finding showed that the non-IBs had higher entrance exam scores, while the IB diploma graduate has higher GPAs and graduation rates. The report indicated “nearly three times more of them
graduated after four years” (Ateskan et al., 2014, p. 8). The findings indicated that the IB students were better prepared and able to build better on their high school experiences (p. 12). Sometimes this can be realized in unexpected ways. Other studies of the skill and mindset preparation taught in the IB program confirms the efficacy of the development of the “internationally minded” nature of IB graduates and that each will be a “conscientious citizen who will strive to put part of the IB mission statement into practice of making the world a more peaceful place (Wells, 2016, p. 117).

Both AP and IB have costs that are far beyond those of non-specialty coursework in high school. Startup costs for each program are substantial. According to the College Board (2016), the cost to establish an AP course of 25 students ranges from $1,090 to $11,650 depending on the subject ("Launch AP," 2017)

In 2013, the Hewlett-Woodmere Public Schools system in New York commissioned a cost comparison of AP and IB approaches. The study showed that the costs were substantially different. AP expenses were lower in part because the new course would replace an existing non-AP course. Professional development for AP takes place during the summer, so there would be no substitute costs. Any compensation for the teacher’s time would be per existing contract. Likewise, curriculum development would be budgeted for after adoption in response to any staff change. The total projected cost for this approach would be $443,805 ("Cost Comparison," 2013).

Per the Hewlett-Woodmere study, the IB program would require expenses not anticipated in AP. Required professional development were expected to last three days each, with associated costs to include teacher substitutes, transportation airfare, lodging, and meals. There is also mandated coursework for participating staff, and a required
coordinator. Two-year sequencing or double period scheduling would also impact full-time employee costs. According to the study, the total budget would be $1,254,798 ("Cost Comparison," 2013).

A review of the IB website shows that there are multiple ways to examine the fees associated with offering any of these programs. A school applying for candidacy is charged a $4,000 application fee to seek IB certification for any of the four programs. If school leadership is seeking to add the career-related program to its certification, there is a fee of $8,000. Both fees above are for schools in the United States. There are annual school fees for each level of IB from primary to middle, diploma and career. As this study is comparing the diploma program, the relevant fee is $11,370. There are some discounts for schools offering combinations of IB programs. Assessment fees for the diploma program vary somewhat depending on the time of year that the assessments are taken. They include a candidate registration fee of $164-168 per registration session and a $113-116 fee per candidate subject fee. Core fees are required for each candidate ranging for $87-89 for the extended essay, $44-45 for the theory of knowledge and $10 for creativity action and service ("IB Fees," 2016).

The more rigorous curriculum provided by IB is suggested as one way to address the achievement gap for students with multiple issues found in the Hispanic population. Low SES is often associated with this population often with significant results. Miksic (2014) states that “low-SES, minority, immigrant students who went through the (IB) program attended more selective colleges, and persisted in college, far above their peers in the non-IB classroom or even AP classes” (Miksic, 2014, para. 11).
The Effect of Teacher Preparation on STEM Success

The issue of global competitiveness has extended into STEM educator training, where there is a recognition of the need for “well-qualified STEM teachers who understand what is needed to develop relevant and high-quality STEM programs” (Avery & Reeve, 2013, p. 1). The need for teachers to deliver quality instruction is recognized and supported by labor leaders in the profession. The National Science Teachers Association’s position both supports the concept of preparing students as well as holding teachers accountable for performance-based measures. Their goal is “to ensure that all students have sufficient knowledge and technology for success in the 21st century, the nation must attract, prepare, and retain well-educated, effective preK-12 science teachers ("NSTA," 2016, para. 1).

The effect of teacher preparation in positively affecting the number of students taking STEM courses was shown by Ramsey (2012). In this study of AP teachers and coursework, these educators were given seven days of additional specialized training each year, financial incentives, as well as ongoing teacher support. The program produced significant results. Before the interventions described in the study, 1556 students took the AP tests and scored a 3 or higher. After the interventions, 3256 took the courses and scored a 3 or higher, a 109% increase. It must be noted that both students and administrators were also incentivized, and therefore additional study would be needed to determine the effect of interventions on each group and the overall changes. One measure of student success is the AP Scholars Program. There are 12 levels of awards in the program. The basic level is for students who achieve a score of 3 or higher on three or more AP exams ("AP Awards," 2017). Other efforts promote AP excellence
as well. One notable endeavor is the National Math and Science Initiative’s Laying the Foundation (LTF) program. The Pasadena Independent School District in Texas claims a 200% growth by students in the LTF program. The district attributes this to improved teacher training along with open enrollment AP courses ("Pasadena," 2012). It is significant that the student group was 81.7% Hispanic, and 78% economically disadvantaged, suggesting a possible positive effect on teacher training. This approach was extended to all AP science teachers, and the district reported that at one high school, the number of AP science classes went from one to a “full range of AP classes, including multiple sections of AP Biology, AP Physics, and AP Chemistry” (para. 12).

**Who to Engage with Effective STEM Practice?**

With the discussion of STEM practice raised, the next area to investigate would be which population to focus on to maximize the effort. Hispanics are the second fastest growing population in the United States behind Asians but are the largest group behind Whites. (Brown, 2014). They are already the majority in many locations including California, the nation’s most populous state. They also show significant achievement gaps on many measures, and so suggested a starting point for this study. In 2012, ACT science scores, which are measures of college readiness for that subject, showed Whites at 22.3 and Hispanics three points below at 19.3. When compared to all students tested, Hispanics were 1.9 points lower. In 2014 and 2015, White students achieved composite scores of 22.3 and 22.4 respectively. During the same time, Hispanic students scored 18.8 and 18.9 (Jaschik, 2015).
Other measures show similar results. When using the Explore assessment (given in 8th grade) and PLAN (given in 10th grade), Hispanics were one point and 1.5 points lower than Whites respectively (“Do race/ethnicity gaps grow?” 2012).

High school graduation rates are another metric that compares achievement. According to a 2015 U.S. Department of Education report, the 2013 Hispanic high school graduation rate was 75.2%. Whites were 86.6% (“Gap and Graduation,” 2015). At the college or university level, according to one source, the problem does not lie in a lack of interest on the parts of Hispanics in science education. Lu (2015) notes that in 2010, 32% of all U.S. American undergraduates planned to study for a STEM degree. Of those, 36% were Hispanic. According to the U.S. Census, Hispanics comprised 17.6% of the general population, making those pursuing STEM degree 2.04 times the general Hispanic population (“Hispanic Population,” 2015). By graduation, only 9% were Hispanic (Nevarez, 2015). It is interesting to note that 2% of American institutions conferred 33% of the STEM certificates and degrees on Hispanics, suggesting the possibility that availability of programs may be an area for further study. In California, California Partnership Academy funding is used in part to promote STEM certifications. These documents are earned by students who complete rigorous technical training and coursework and are recognized in the industry to which they apply. They are funded under section 54692(d) of the California Education code (“CPA Certifications,” n.d.).

**Reasons for Hispanic Science Learners’ Achievement Gaps**

Loza (2015) cites numerous reasons for the achievement gaps between Hispanic students and other groups at high school and colleges. This source documented the experiences of the Hispanic small school learners. While there were some benefits to this
type of learning experience, quality courses were limited, and “lack of critical consciousness of being a culturally homogeneous group” was cited as a negative experience (p. 82). Students went on to report that the limited AP classes hindered their ability to enter college (p. 84). Systematic oppression in the school Loza examined in the forms of “academic tracking, classism, racism, and other biases” also acted to hinder these students’ progress on to colleges and universities (p.1). Students reported, inadequate opportunities to participate in extra-curricular activities or school sponsored activities and being placed improperly in classes. Students felt that these were barriers to college entrance. Using critical race theory (CRT) as a lens, Loza notes that the results he found were consistent with the basic tenets of this framework which are “(1) centrality of race and racism in society, (2) challenge to dominant ideology, (3) centrality of experiential knowledge, (4) interdisciplinary perspective, and (5) commitment to social justice” (p.8). In this study, the teacher’s experiential knowledge will supply the data which will inform the analysis and conclusions. In the literature, teachers indicate varying levels of institutional barriers. Igualada (2015) indicates that while teachers believe in equity of access to AP in theory, they believe that practices at the state and local levels hinder that access. Examples would be accountability and funding policies. McFeeters (2016) indicates that language, teacher influence, labeling and social influences are all factors in Hispanic students’ achievement gaps. Within teacher influences, Crisp and Nora (2014) indicate that differences in teacher quality to be an issue. School funding, which the authors state affects teacher efficacy, along with the numbers of teachers who are not properly trained in the subjects they teach are also noted. Looking nationally, these investigators contend that, “Hispanic students are more
likely to be taught science by teachers who did not major in the field or by inexperienced teachers” (p. 4). Cavazos (2012) notes that school counselors also had a significant impact on Hispanic students’ access to AP coursework and by extension, the benefits that come with these courses. Specifically, “orientation to the Mexican culture, perceptions of expectations, and perceptions from school counselors were significant predictors of enrollment in AP coursework” (p. 93).

Miksic (2014) speaks to social influences, citing “demographic changes in the structure of the family, such as the increasing number of households led by single mothers and absences of fathers” are placed first in his report. (para. 7). Other reasons for Hispanic achievement disparities include differences in social and cultural capital along with the educational attainment of parents. Keeley (2007) describes social capital as being “networks together with shared norms, values, and understandings that facilitate co-operation within or among groups” (p.102). Applying James Coleman’s social capital theory to the discussion at hand, Ramirez (2014) makes the point that relationships can be positive and protective factors that promote student success.

Walker and Pearsall (2017) also found that social influences were powerful factors in the underrepresentation of Hispanics in AP coursework. These authors assumed that it was access policies and procedures that were most significant. However, their research showed that a “multifaceted (communication, community building, peer relations, and student achievement) change effort more promising” (p. 22)

**Cultural capital as a consideration.** This concept was defined in three forms by Bourdieu (1986) and is examined more closely below. It can be argued that the home environment is a significant part of cultural capital, and a longitudinal study by Martin et
al. indicate that “roughly half of the observed gap was attributable to family background characteristics and pre-college academic preparation” (Martin, Spenner, & Mustillo, 2016, p. 1).

Bourdieu’s hypothesis states that differences in achievement are the result of differing allocations of cultural capital to different classes within society. This suggests a need for a broader scope of investigation than was initially anticipated for this study. Bourdieu’s point is that achievement by the student is the result of the cultural capital spent by the family of the student. Ryan (2012) looking at the transition to college as one measure of academic success, argues that attainment gaps between Hispanics and Whites persist in part due to the parents having less access to information about higher education. The issue here is one of the differences in social networks that disadvantages the Hispanic learners hoping to move to post-secondary schooling. Castillo (2014) notes that students who are deficit in the social capital needed to navigate the waters of college admission attainment successfully may find it replaced by educators who fulfill that need. In these cases, the educators act beyond their legal definition of in loco parentis to provide support in the areas of advice, informal counseling, and support that helps their students be successful. Castillo’s examples include teachers from popular media such as Louanne Johnson, portrayed in the 1995 film Dangerous Minds.

Educational attainment of the parents of Hispanic students was explored by Hannon (2016) relative to Scholastic Aptitude Test (SAT) found that the effect of parents’ role in performance was a complex one, but some generalizations were made. Among those was the suggestion that parents with higher levels of education were better role models. Presumably, parents with more education encourage their students to attain
higher levels of education. It may be argued that the parent’s education, if a significant factor could be confounded by low income. One source found that “more than 50 percent of Hispanic, low-income working families have a parent without a high school equivalency degree, compared with 16 percent for non-Hispanic whites” (“Race/Ethnic Income Gap,” 2015, para. 6).

Achievement gaps are also seen in the classroom based on teacher biases. Hunter (2016) discusses the effect of skin tone (called “colorism”) on the success of Hispanics in school. Findings show that “lighter skinned Hispanics and African Americans complete more years of schooling than their darker-skinned counterparts” (p. 54). This is consistent with studies done by Telles and Ortiz in 2009, Murgia and Telles in 1990, and Keith and Herring in 1991, among others. Central to understanding how colorism works is predicated on the halo effect phenomenon. In this, teachers will show a tendency to positively evaluate a student based on one trait such as appearance and apply this view to other traits. This, in turn, affects how they are treated, as the teachers may have higher expectations for their students, thus enhancing their performance.

**Approaches to Engaging STEM Students**

A variety of formal program practices are being tried to engage STEM students. In addition to Advanced Placement coursework and IB diploma program described above, 21st century learning skills have been proposed to better prepare learners for this millenium’s challenges. Alozie et al. (2012) describe adaptability, complex communication, non-routine problem solving, systems thinking and self-management as necessary 21st century skills to be mastered for students to be competitive in the 21st century. STEM connects to this skill set in that many careers in this field require a high
degree of technical skill development. This is being supported by current teacher training in some institutions. Serrano (2013) writing for Stanford University’s Worldview explains that the Framework for 21st Century Learning as consisting of “life and career skills, learning and innovation skills, information, media and technology skills” and should be taught to students to prepare them for success (figure 2). Storksdieck (2015) makes the argument that science media education is unrealistic in a rapidly changing technological world. While he embraces the role of 21st century skills in STEM learning, his suggestion is to encourage “information literacy” instead. In the process, he advocates the use of components of the Next Generation Science Standards (NGSS) without naming them as such, recommending that such learning “might be more easily achieved within the current strong movement to conceptualize STEM education within science and engineering practices and within the broad goals of strengthening learners 21st century skills” (p. 167).

NGSS occupies a place in the engagement of Hispanic students in STEM. Gallard, et al. (2014) note that under the new standards, equity, and diversity, which have not had center stage in science education, may now have a more prominent place in the national discussion. As of March 20, 2018, 19 states had adopted the standards and are progressing toward implementation. A review of the NGSS resources reveals an awareness of the need to address the achievement gaps among some student groups. Attempting to engage diverse classrooms, Achieve Inc. (2013), the educational entity charged with the dissemination and implementation of the standards acting under the organizational name of Nextgenscience.org is working with those states that have adopted the NGSS. This group has provided an approach titled “All Standards, All
Students” ("Appendix D," 2013, para. 3). This effort acknowledges the increasing diversity of America’s student population coexisting with achievement gaps among some groups. Specific recommendations of this report are for teachers to consider using: “(1) culturally relevant pedagogy, (2) community involvement and social activism, (3) multiple representation and multimodal experiences and (4) school support systems including role models and mentors of similar racial or ethnic backgrounds (p. 7).

Further, the report suggests that educators view Hispanic as a multiple member category and not engage in “masking potentially important differences in performance among Mexican-Americans, Puerto Ricans, and Cuban-Americans” (p. 15). The report adds that high achieving Hispanic students “may be disadvantaged by teachers or counselors who underestimate them and set low expectations for their success” (p. 15). These forces would presumably act against the engagement of members of this group. In this study, the selection process will not seek to include or exclude subgroups beyond public high school teachers who teach those students who they identify as Hispanic residing in California’s Central Valley and who have successfully completed one or more of AP science courses during the years 2013-2017.

Gallard et al. (2014) suggest developing equity within the STEM classroom by emphasizing the value of the diverse groups in a teacher’s classroom. Teachers can do this by learning about their students’ cultures and creating supportive classrooms that extend to other members of the profession, in effect developing a culture of accepting multiculturalism. Research suggests that teachers wanting to improve Hispanic science engagement, addressing the question of how STEM fits within this group of students’ career plans is key "for Hispanic students, a higher utility value, or perceived connection
to future goals, was also an important predictor for STEM success” (California Dept. of Education [CDE], 2016, p. 8-18). As noted by Anderson and Ward, (2014) differences in how students perceive their own abilities in science coursework affects Hispanics’ efficacy. Effective practice is that which has “implications for educators include the need for ways to improve perceptions of science identity and awareness of the utility of science and mathematics courses” (p. 1).

**Other Program Practices to Engage Students in STEM**

American public education has been moving toward a more diverse model. One study, beginning in 1968, shows that the top four ethnic groups have changed. Demographics indicate that “the percentage of white students has declined dramatically over the past fifty years, the percentage of black students has changed very little, and the percentage of Hispanic and Asian students has spiked (Camera, 2016). According to another report, white students, who comprised 80% of the national student population in 1968 had dropped to 51% by 2012. During the same time, Hispanic students have risen from 5% to 24% (Camera, 2016, fig 1c). It could be argued that what was a collection of schools with a white-dominated population, has changed to one where plurality is the norm. Monogue (2015) states that “by the middle of the 21st century, the United States will have no single racial majority. In 2011, a majority of the children born in the United States and nearly half of the students attending public school in the U.S. were non-white” (p. 3). The value of diversity has been supported by the literature. Wells, et al. (2016) note that “the benefits of school diversity run in all directions” and “there is increasing evidence that diversity makes us smarter – a finding that selective colleges embraced long ago” (p. 2). While these claims may seem difficult to support, the authors add that
“such exposure leads to improved cognitive skills including critical thinking and problem solving (p. 2). Haslerig, et al. note that three kinds of diversity, structural, informal, and classroom offer students the benefits of interactional and engagement experiences with diverse peers that yield educational benefits which include promotion of critical thinking and a variety of content-based competencies.

At the institution level, a model employed to engage Hispanic learners who could be considered the opposite of the diverse classroom is that of the Hispanic Serving Institutions (HSIs). This term was the result of the Higher Education Act, which was reauthorized in 1992. At that time, Congress set aside funding for non-profit schools in which at least 25% of the student population is Hispanic ("HSI Definition," 1999-2011, para. 1). As demographic trends indicate an increasing Hispanic population, these institutions will continue to serve this significant group. Fosnacht and Nailos note that most Hispanics who are in higher education are at an HSI. The beneficial effects, while described as positive and “relatively modest” (p. 198) when compared to non-HSIs students appears to be a starting point for creating educational environments that engaging Hispanic students. One program being attempted at some HSIs utilizes faculty who were nominated by students to serve as their institutional agents. Results indicated that these faculty members “had positive effects on their students’ experiences and educational outcomes” (Santiago, 2012, p. 150).

Teachers can also enhance the performance of Hispanic students in the classroom by using culturally responsive teaching. As noted by Wages (2015) “schools can assist Hispanic students by sending home a strong message communicating that family language and culture are valuable assets to be preserved as students learn English and
new content is mastered (p. 10). Research done by Terrazas-Arellanes et al. (2013) indicate the possible value of this approach to the growing arena of online science instruction. Findings indicate that even when only 71% of the science material to be tested was taught using collaborative online projects that preserved Spanish language and Mexican culture, pre- and post-tests showed of the two groups in the study significant gains were made. Of the two test groups involved in the study, one achieved a 24% increase, the other 19%.

The intersection of English language acquisition and core science concept learning has provided opportunities for many studies. One approach is to examine the effect of science instruction imbedded in English reading literacy; another is embedding English language literacy in science instruction. Tong et al. (2014) found in a longitudinal study that early intervention coupled with interdisciplinary curriculum is beneficial for students learning both language and science. This approach is in keeping with both Common Core and Next Generation Science Standards, which, if fully adopted and taught at all planned levels, is designed to deliver K-12 interdisciplinary teaching and to learn in both science and language development (Common Core, 2016; NGSS, 2016). The principle difference between these two approaches is that at the high school level, both skills would be taught in their respective single subject courses and be expected to be applied throughout the curriculum.

Teachers can use the diverse classrooms described above to enhance the performance of Hispanic students in the classroom by using culturally responsive teaching. As noted by Wages (2015) “schools can assist Hispanic students by sending home a strong message communicating that family language and culture are valuable
assets to be preserved as students learn English and new content is mastered (p. 10). Research done by Terrazas-Arellanes et al. (2013) indicate the possible value of this approach to the growing arena of online science instruction. Findings indicate that even when only 71% of the science material to be tested was taught using collaborative online projects that preserved Spanish language and Mexican culture, pre- and post-tests showed significant gains were made. Of the two test groups involved in the study, one achieved a 24% increase, the other 19%.

The role of educators in creating effective learning environments at the classroom level has been widely studied. Rubin, (2014) places the responsibility on teachers to create more engaging classrooms as one way to address the achievement gaps between Hispanics and other groups. He notes that “with increased student engagement, there are less distractions and negative behaviors; this, in turn, leads to increased academic performance and achievement” (p. 223-224). Johnson (2013) noted that teachers could positively affect Hispanic students’ learning experience, particularly through instruction that is responsive culturally and linguistically sensitive. Gonzalez (2014) emphasized the value of committed teachers using hands-on learning centers. The Association for Psychological Science (2015) supports this stating that “students who are able to test or demonstrate scientific concepts in ways that are hands-on understand the concepts more deeply and score better on science tests” ("Hands on science," 2015, para. 1).

Student engagement can be achieved through other means. Elizondo (2014) examined the use of meaningful responsibilities assigned to students as a factor and found that this practice contributed to high academic performance through the internalization of self-esteem and self-efficacy. Students demonstrate self-motivation and
begin to see themselves as contributing members of society. Hernandez et al. note that there is value to using goal theory to understand how best to engage underrepresented groups. They found that “interventions to broaden participation (in STEM by Hispanics) work in part because students align their goals with the norms, values and contextual demands in STEM fields” (p. 103).

The area of teacher satisfaction can also affect teacher impact in the classroom and thereby student performance. Moller et al. (2015) showed that Hispanic students are more likely to pursue STEM majors in college if their high school teachers taught in collaborative satisfying professional communities. The authors cite the effect of these communities in offering opportunities for the teachers to be “caring, competent, exciting math and science instructors who make a difference for Latinos/as who choose STEM as a major” (p.21). Hamre et al. (2012) suggest that a teacher’s ability to detect effective interactions, which arguably would be repeated to enhance overall classroom climate and therefore students’ learning experiences. This change in their belief system centered on their understanding of classroom interactions could be done without the expense of classroom observations, or coaching. The approach described above, is consistent with the DuFour model described by McLester (2012) which has been successful in locations such as Whittier Union High School District with an 80 percent and rising Hispanic student population.

**Other Methods of Engagement**

Bonfield (2014) determined that Hispanic science learners can be engaged through the use of research-proven methods such as outreach to multi-generational Hispanic families. This approach helps to create a supportive home environment that
encourages participation in science learning. This author also recommends the use of Hispanic role models and culturally-relevant informal science programs to engage this group of learners.

Another approach supported by the literature uses parents as the avenue to find ways to engage Hispanic students. Weiland (2015) studying mothers and their children visiting informal science centers found four themes that could help inform a study of engagement methods: unfamiliarity with the center, issues with cultural/linguistic access, ways of learning that were novel for their children, and challenges engaging with their own children. The parent/child engagement issue offers some interesting possibilities. The parents “wished they could have engaged more with their children while in the exhibit but felt constrained by either their own levels of science knowledge and/or by the lack of direction offered by the science center at each station” (p. 100).

**Barriers to Success in STEM**

The question of what acts as impediments to successful STEM coursework and careers may begin with institutional barriers. Cabrera (2014) found that such issues as sexism and racism affected the persistence of females in STEM education and were found to be institutionally based. Instructional models too affected the engagement and persistence of Hispanics students with the lecture approach an inferior one compared to research. The study noted, “undergraduate research participation opportunities in the first 2 years of college increases retention” (p. 44). According to a report by the President’s Council of Advisors on Science and Technology (2012), research opportunities have “especially high impact for women and members of other groups currently underrepresented” (p. 25).
By not including this data in their planning, it can be argued that barriers to promote the engagement of these groups are being created by some colleges and universities. Loza (2015) cites the concept of critical race theory whereby racism is America’s normal approach to race relations. By granting Whites privileges not enjoyed by other groups, including Hispanics, college attainment is made more difficult. Loza adds that the concept of the “centrality of experiential knowledge” is needed to understand racial inequality (p. 8). As applied to schooling, a Hispanic student may experience this phenomenon over time, he or she may find this too adds to the barriers to higher education. The concept of social justice as a barrier is beyond the scope of this study.

According to a 2015 report “low income students are now a majority of the schoolchildren attending the nation’s public schools” ("Percent of Low Income U.S. Students," 2016, figure 1). SES can be particularly influential as a barrier to Hispanic participation in STEM coursework and subsequent careers (Smith, 2014). As stated in a 2013 U.S. Dept. of Education report, “…underrepresented minorities, first-generation, and those from low income backgrounds leave STEM at higher rates than their counterparts” (Chen & Soldner, 2013, p. 3). Hispanic students often have these three characteristics. Hannon (2016) supports this by saying that “the lower the family income and/or parental education, the lower the SAT performance. Zwick (2012) extends the discussion by saying that the lower the SES of both the school and student has a significant effect on academic performance.

As mentioned above, AP coursework is one pathway to enhancing the chances of college or university admissions. Costs associated with this process could conceivably deter some low-income students from taking AP. However, there are fee-reduction
programs that mitigate this effect. It could be argued that the extra time a student must spend to be successful in AP coursework impacts his or her hours available to work outside the home and school, thereby contributing much needed resources to the often-low-income homes. Simms, et al. (2009) noted that of the more than 13.4 million families with children living on incomes less than 200 percent of the federal poverty level, 30 percent are Hispanic. This is the highest of all nonwhite ethnic groups. The same could be argued for IB diploma pursuit, which is also time-intensive. As students transition into colleges and universities, it could be argued that similar dynamics would apply, with the added expenses of colleges or universities. While there is financial aid available, it has lost its purchasing power over time. Quinlan (2016) states that in 1980, the average Pell grant covered 77 percent of the total cost of attending a four-year college. Today these grants cover only about 30 percent of the cost.

Data shows that degree completion is lower at Hispanic-serving institutions than at those who were not so designated (NAP, 2016). While it could be argued that attending these schools is a barrier based on the completion rate, researchers cite the higher numbers of students who are first generation, lower income and so do not have the resources needed for completion. Further study would be needed to determine the role of each factor.

Student mobility as a barrier to Hispanic student success has been studied with results showing that “student mobility is closely associated with increased probability of dropping out” and that “studies show that ethnic minorities and students from low-income families are highly mobile and the increased risk of dropping out of school is even greater” (Ross, 2014, p. 39).
Effect of Immigration Status

Another consideration that may be examined is that of the effect immigration status has on Hispanic student achievement. Auerbach (2015) notes that those students who are undocumented are protected by Plyler v. Doe, a landmark 1982 ruling which guarantees that K-12 students can attend America's public schools without having their status being questioned (Auerbach, 2015). Auerbach added that the adoption of "No Child Left Behind" legislation puts the onus on school districts to deliver well-defined yearly progress without regard for immigration status.

A cooperative study by Penn State and UC Irvine (2013) showed that "those whose mothers were authorized immigrants averaged more than two years more schooling than those whose mothers entered the country illegally" (Swayne, para. 2). The same investigators added that such "legacy effects" were responsible for more than a third of the education gap between Hispanic third generation and native White students (para. 2). Their recommendation was that one benefit of creating legalization pathways would be enhanced academic achievement.

Another barrier to Hispanic student achievement relative to immigration status is that of anti-immigrant sentiment. Recent actions by the leadership in Washington may have exacerbated this. Quiroga, Medina, & Glick (2014) described “immigration policies and associated practices as macroaggressions that create the context in which microaggressions and other forms of discriminatory actions flourish” (p. 1730). These may lead to feelings of mental suffering and perceptions of vulnerability in some members of the Hispanic population resulting in disruption of their childrens’ educations. Helms (2016), argues that this climate makes some Spanish-speaking families suspicious
of all institutions. This causes the parents to be less involved in their children’s educations leaving the district without the benefit of their input. This lack of connection to families complicates the challenge of successfully educating Hispanic students.

Lack of qualified science teachers is another barrier to success for these students. This is cited by the National Math and Science Initiative as one of two major issues impacting the number of students in STEM along with the lack of student engagement (National Math + Science Initiative [NMSI], 2013) ("NMSI," 2016). This, in turn, helps to perpetuate the problem as “the U.S. STEM crises cannot be remedied without a comprehensive and well-rounded approach to ensure that both students and teachers are on a path to success” (para. 1). Another reason for the lack of qualified STEM teachers is the insufficient professional development that integrates engineering and technology (Avery & Reeve, 2013). With the new emphasis on engineering practices in the NGSS approach, it can be argued that this connection is important to the success of the national shift in teaching model.

Greater compensation in the private sector also draws away those with STEM degrees from education. As one STEM teacher phrased it “taking a pay cut to become a teacher instead of an engineer is a tough pill to swallow. Offering a competitive salary and expanding programs like the Public Service Loan Forgiveness Act would go a long way toward persuading STEM graduates with other career options to consider teaching instead” (Murday, 2013, para. 6).
Conclusions

In Chapter II, literature was presented indicating significant challenges facing the global population. The argument was made that improved education efforts, particularly science education were needed in the United States if these challenges are to be met. Economics, military threats, and globalization are but three issues that are cited as reasons to improve science education. It was argued that engaging all populations is key and that the second fastest growing and majority in some areas, the Hispanics are an underserved and underrepresented group. As such they offer one potential solution to the challenges facing the nation.

Factors that are causing this gap in STEM education, degree and career attainment are many and may be divided to include those emanating from within educational institutions and those outside. Within the educational system, Hispanic students may experience program practices that hinder their success, institutional racism, failure to provide adequate supports, lack of suitable college prep courses and/or programs, poorly trained teachers, and underfunded schools. Factors outside the institutions may include Hispanics having inadequate social and cultural capital to meet the demands of college preparation. Their SES, student mobility, and lack of college graduates within the family who are role models can also act to reduce access to STEM coursework and careers.

In Chapter III, the research methods and processes that will be used to conduct this study will be introduced and explained. The purpose of the study will be reviewed, the rationale for the research design, instruments, and methods of data analysis discussed as well as the steps taken to assure the protection of participants in the study.
CHAPTER III: METHODOLOGY

Overview

Hispanics are an important part of California’s cultural fabric and are central to the state’s future economic prosperity. Critical to California’s prosperity is how well K-12 public schools prepare Hispanic students for success in college, career, and civic life. Given the many scientific and technology changes taking place math and science are foundational for student success. Hispanics are the fastest growing demographic group in California and must master these two subjects to be prepared to contribute to economic growth and personal prosperity.

The chapter begins with the purpose statement and research questions studied. It also describes the quantitative and qualitative research design, the population to be studied, and the methodology used to determine the sample population. The chapter then describes in detail the research instruments used, the methods of data collection, and the methods of data analysis. The assumptions and limitations of the study and the ethical procedures used to safeguard the human subjects who were voluntarily participants in the research study are also outlined in this chapter. The chapter concludes with a final summary of the overall methodology used in the research study.

Purpose Statement

The purpose of this mixed methods study was to identify and describe to what extent teacher program practices promote the engagement of Hispanic students in Advanced Placement science. In addition, it was the purpose of this study to identify the barriers experienced by the students in their Advanced Placement science classes.
**Research Questions**

**Research question 1:** To what extent does the Advanced Placement Programs promote Hispanic student engagement and learning in high school science classrooms?

**Research question 2:** What program practices promote engagement and improve learning among Hispanic Advanced Placement students in high school science classrooms?

**Research question 3:** To what extent does the Advanced Placement Program present barriers to Hispanic students’ access, learning of science concepts, and course completion in high school science classrooms?

**Research Question 4:** What do Advanced Placement teachers perceive as changes in practice to overcome the identified barriers?

**Research Question 5:** What program practices do Advanced Placement science teachers recommend to support Hispanic students?

**Research Design**

This study utilized a mixed methods approach. The surveys generated quantitative data that informed the focus group interview. Teachers who have taught one or more AP science courses during the years 2013-2017 in the region of interest, and who had one or more Hispanic science learners were surveyed. From the surveys, teachers were recruited for the focus group. The recruitment process first obtained permission of the leadership of the superintendents of districts in the region being studied. Department leadership in several schools within these districts were then be contacted, followed by individual teachers. Information about the study, its goals and objectives were provided,
and requests for permission from teachers to survey members of the target population obtained. From the surveys, a focus group was convened.

The data collected from the surveys and focus group was examined for themes which, yielded both quantitative and qualitative data. These data collection approaches allow the researcher to explore complex issues and give an opportunity for the participants to share their perceptions (Patten, 2012). Almalki (2016) indicated that a mixed methods approach, using triangulation based on quantitative and qualitative data and results, interpreted by the researcher offers benefits such as design efficiency. Another benefit is to help maintain the research focus with data sets building upon each other. McNaughton et al. (2012) agree on the function of triangulation in mixed methods approach, while stressing the need for what he calls “complementarity” which is described as "using a second method in parallel to provide an enriched understanding of the concept that the first has measured" (p. S59).

One challenge in using a mixed methods approach the amount of effort needed to make sense of the collected information. Discrepancies within the data set may raise other issues that speak to further research. Ivankova (2014) cautions that to achieve quality assurance one method is to proceed from quantitative investigation to qualitative. Specifically, Ivankova advocates for the in-depth exploration allowed through the qualitative process to enhance the overall quality of the study.

It was the experiences of AP science teachers who have taught one or more AP science courses in one of six representative comprehensive high schools within the Stanislaus or San Joaquin counties during the years of 2013-2017 that were examined.
Of primary importance is that the study captures the participants’ experience while teaching the AP courses. In explaining why the mixed method approach is appropriate, Zhang and Creswell (2013) suggest a mixed method study may be chosen for its utility in exploring issues of a human nature when one needs to combine the strengths of quantitative and qualitative research to enrich topic understanding. Creswell (2013) indicates that researchers may gather "multiple forms of data, such as interviews, observations and documents, rather than rely on a single data source. They then review all of the data and make sense of it, organizing into categories or themes that cut across all of the data sources." (p. 45). Swart (2017) pointed out that data should be "collected to capture the learning experience of the students while assessing for demonstration of critical thinking" (p. 31). In this study, it was the perspectives of the AP teachers about the learning experiences of the students that were used. Swart supports Zhang and Creswell's observation of the value of multiple sources by stating "findings from these different sources of data have the capacity to substantiate each other, while also identifying potential gaps and contradictions for further study” (p. 31).

Anticipated variables included perceptions of the AP science teachers of their students’ engagement and experiences with barriers encountered, and what effect those barriers may have had on the learning of science concepts and course completion of their Hispanic science students.

Previous key researchers who investigated the experiences of Hispanic science learners found that “there is a growing body of work to support the relative importance of K-12 academic experiences, cognitive factors, and socio-cultural factors influencing Hispanic students’ decisions to major in STEM as undergraduate students” (Nora and
Crisp, 2012, p. 4). The present study focused on the K-12 academic experiences but allowed for the data to represent other factors including socio-cultural influences as well. In one Harvard University study, there were indications of a notable positive correlation between AP participation, AP exam scores, college/university academic performance, success in the subject and overall performance and college completion (Smith, Hurwitz, and Avery, 2015).

**Population and Sample**

According to Mohamad Adam (2017) a “research population is generally a large collection of individuals or objects that is the main focus of a scientific inquiry” (Mohamed Adam, 2017, para. 1). The population for this study consisted of public school Advanced Placement science teachers who have taught Hispanic students in the California’s Central Valley in 2013-2017. Per the College Board (2017) in 2016, California students took 743,280 AP exams. Hispanics took 285,084. Of those, 2,439 took AP science exams (College Board, 2017). The exams included in this statistic were: biology, chemistry, environmental science, physics 1, physics 2, physics C – electricity and magnetism and physics C – mechanics. It is reasonable to assume that nearly all students who take an AP exam have completed the relevant coursework.

Per Buskirk (2017) a “target population provides the overall context and represents the collection of people, housing units, etc. about which inferences, and estimates are desired” (para. 7). For the purposes of this study, the target population consists of the AP science teachers in the Central Valley, a region that is bordered by the Coast Ranges in the west, the Sierras in the east, and includes the San Joaquin, Stanislaus, Madera, Fresno, Kings, Tulare, and Kern counties (University of California
Division of Agriculture and Natural Resources [UC Division of Agriculture and Natural Resources], 2015). For the purposes of this study, Stanislaus County, which consists of 24 school districts ("Districts," 2018) two districts were selected, Modesto City Schools and Patterson Unified were initially selected. Due to low response levels of participants, a second county was added containing additional districts.

One source describes a research sample as being “a group of participants in a study selected from the population from which the researcher intends to generalize” (Brandman University, 2015, p. 18). For purposes of convenience, the sample was selected from teachers working within either the Stanislaus and San Joaquin Counties. The sample consisted of 20 participants, drawn from the population, all of whom completed the survey. Twelve of the 20 participated in a focus group. While 20 participants may seem like a small number, however, “if it seems that spending relatively little time with ten to fifteen participants makes sense relative to the phenomenon under investigation, then have ten to fifteen participants” (Vagle, 2014, p. 75). Consultation with Dr. Patricia White indicated that a participant group of 12-16 was acceptable (P. White, personal communication, January 17, 2016.)

**Instrumentation**

A combination of a Likert scale survey and focus group interviews was used to determine attitudes about participants’ AP science teaching experiences (See Appendix A). The survey was aligned to the research questions and this information organized in a matrix (See Appendix B). Validation was achieved through a panel of experts consisting of 11 individuals, all holding Ph.D. or Ed.D. degrees, who have had extensive experience in science education or working closely with Hispanic students at a variety of levels.
Each reviewed the instrument and made recommended changes which were largely adopted. The instrument was then tested with three Advanced Placement teachers who taught AP science to Hispanic high school students in the region of interest. Each took the survey and completed a field test participant survey (See Appendix C). This information was used to further develop the survey instrument.

Following Brandman University Institutional Review Board approval (See Appendix D) the survey was completed by 20 Advanced Placement teachers within the target population. All participants, including field testers were formally invited to participate in the study, informed of their rights in writing and provided an informed consent form which all completed (See Appendices E, F, G). Steps consistent with Brandman policies and procedures were taken to assure that all participants were fully protected and were aware of their option to continue or discontinue participation with no fear of reprisals. Before convening the focus groups, a protocol with a set of focus group questions were developed with follow-up questions (See Appendix H). These were field tested by three teachers who taught in the region of interest and taught AP science to Hispanic high school students there. Each completed a field test participants feedback form, the results of which were used to inform the final interview questions.

One focus group of 12 teachers was convened. It was conducted in a classroom at one of the high schools within the region of interest was located. Initial interactions allowed the establishment of rapport, and the gaining of trust. Teachers were assured that any comments would be held in confidence and reported out only as part of a larger study with no participants identified by name. Data collection took the form of responses to questions that explored how the teachers’ viewed aspects of Advanced Placement as a
method to engage Hispanic science learners. Program practices that participants felt impacted their AP experience were identified in the survey as were barriers to the students’ success. The teachers were aware that the interviews were digitally recorded, with transcription by the researcher to follow.

**Validity and Reliability**

Zamanzadeh (2015), indicates that evidence for the validity of an instrument can be obtained through recommendations of an expert panel. In the study at hand, 11 experts were selected based on their expertise in education. Working independently each was given the instrument and asked to review it and provide feedback. This feedback was incorporated into the final document.

Reliability of the instrument was achieved by using mixed methods wherein quantitative data is observed alongside qualitative data i.e. focus groups. Data analysis was performed by grouping the teachers’ responses in both the Likert surveys and focus groups in terms of themes, which were compared to the study’s purpose and research questions. The literature was also consulted to raise investigator awareness of past themes, and new ones that may emerge. Tables and charts, derived from the data, along with descriptions, added to the analysis, imparting additional insights for the study.

**Quantitative Data Collection**

Quantitative data were first collected using an online survey instrument made available to the sample through laptop computers provided by a cooperating school district. The results were tabulated and reported using the Survey Monkey online application. From the 20 responses received, 12 were selected to form a focus group during which additional questions were asked and follow-up responses sought.
Quantitative Data Analysis

The quantitative data were analyzed by the identification of themes that emerged from the participants’ responses. Participants were asked to respond to statements on a four-point Likert scale indicating whether they Strongly Agree, Agree, Disagree, Strongly Disagree with each. Those responses were then used to determine: a) the extent to which program practices promote the engagement of Hispanic students and improve their learning in high school; b) what barriers were encountered by Hispanic students enrolled in the program; and c) what modifications to existing practice were needed for their success.

Qualitative Data Collection

Xu et al. (2012) suggest that since the researcher play a central role in generating data in qualitative research, he or she is an instrument of that study. At the same time this can become a disadvantage of a qualitative approach is that the researcher brings biases that need to be addressed. In this study, field testing of the approach, and practice focus groups were used to mitigate biases of the researcher.

Patton (2015) describes focus groups as having several advantages. Among these are cost effective data collection, allowance for diverse perspectives, and the possibility of enhanced data from interactions among participants. There are also opportunities to reveal themes through silences and topics that are avoided. The researcher, as facilitator of the focus groups, is able to analyze as the interviews unfold. Some disadvantages that accompany focus groups are the number of questions may be restricted, response times may also be limited, and the skill needed to successfully facilitate this form of data
collection may develop over time. Patton argues that there may be differential data from earlier focus groups as opposed to those held later.

**Qualitative Data Analysis**

The focus group participants were advised that the session was being recorded and that following a two-year period, the recordings would be destroyed. After the focus group was completed, the data were transcribed by a qualified sworn court clerk. Subsequent thematic development using the engagement of a peer researcher to review the coding and bolster the reliability of the analysis was performed. MacPhail et al. (2015) indicate that the reliability of the intercoding approach helps to establish the credibility of the findings. The use of multiple coders is one way to achieve this. In addition, Nvivo software was used to organize and analyze the initially unstructured data generated. According to one source, Nvivo "is a database system designed to facilitate the process of qualitative data analysis" ("Nvivo," 2015, para. 3). It does this by rapidly producing word frequency counts and charting most often used terms. It supported the interview survey responses this research employed by making the process more systematic and organized. Investigators (Welsh, 2002) indicate that Nvivo can “improve the rigour of the analysis process by validating (or not) some of the researcher’s own impressions of the data” (para. 10). This allowed for the coding of the responses, which in turn was used to uncover the meaning of the experiences of members of the sample. This content was in turn analyzed on two levels first using a descriptive account of the data. This was followed by a more interpretive approach seeking to examine what the participants meant or implied in their comments. (Hilal & Alabri, 2013).
Limitations

There were few limitations to the study. Since the research relied on teachers to respond to the surveys in a timely manner, and the number of survey participants and final focus groups participants was small, each individual was needed. The small sample size therefore could have been a limitation.

Teachers may also not be able to attend the focus group due to schedule, illness, or other reason. Another limitation could be responses to the survey and/or focus group that are influenced because of participants discussing their roles in the study with others and substituting those opinions for their own experiences.

Summary

In this chapter, it was explained how relevant data were gathered in response to the research questions. The approach was presented, beginning with a review of the purpose statement and the research questions. Then the research design was presented, the type of data sought, and the rationale for the design, including the contributions of key researchers. The population and sample were described, contextualized from general to the sample level, with a discussion of the characteristics that explain the reason for the selections. The generalizability of the study to the target population was also described. Choice, development and use of instrumentation was discussed, with the connection between the instrument and the literature review established. The process of establishing the reliability and validity of the instrumentation was also explained. Data collection efforts were presented, with a discussion of data scoring, processing, and analysis. This was followed by the limitations of the study, particularly those which are the result of the methodology and will limit the external validity of the study.
In chapter IV, the problem statement will be presented along with the purpose of the study and research questions and methodology. Findings will be presented based upon the data drawn from the instrumentation and focus groups.
CHAPTER IV – RESEARCH, DATA COLLECTION, AND FINDINGS

Overview

Compared to other developed countries, as measured by the Program for Individual Student Assessment (PISA) “the most recent PISA results, from 2015 placed the U.S. an unimpressive 38th out of 71 countries in math and 24th in science. Among the 35 members of the Organization for Economic Cooperation and Development, which sponsors the PISA initiative, the U.S. ranked 30th in math and 19th in science” (Desilver, 2017, para. 2). At the same time, the nation’s second fastest growing student population, Hispanics, who are the majority in some states, including America’s most populous, California, are not being engaged in science. This is evident by their lack of participation in science-related areas.

The problem is that despite their numerical prominence in California, STEM coursework and careers are not being promoted to Hispanics. This represents a threat to the economic viability of the state. The study, then, seeks to find ways to engage Hispanics so that they become science learners at rates which far exceed the present so that the United States benefits from their participation. Of interest to this study is the engagement of those students who are Hispanic and have taken one or more Advanced Placement courses in California’s Central Valley at comprehensive public high schools.

Organization of the Chapter

The chapter begins with an introduction in which the problem statement is presented. This is followed by the purpose statement, research questions, methodology, an explanation of the population and sample, and the presentation of the data. Findings were presented by research questions as stated.
Purpose Statement

The purpose of this mixed methods study was to identify and describe to what extent teacher program practices promote the engagement of Hispanic students in Advanced Placement science. In addition, it was the purpose of this study to identify the barriers experienced by the students in their Advanced Placement science classes.

Research Questions

Research question 1: To what extent does the Advanced Placement Program succeed in promoting Hispanic student engagement and learning in high school science classrooms?

Research question 2: What program practices promote engagement and improve learning among Hispanic Advanced Placement students in high school science classrooms?

Research question 3: To what extent does the Advanced Placement Program present barriers to Hispanic students’ access, learning of science concepts, and course completion in high school science classrooms?

Research Question 4: What do Advanced Placement teachers perceive as changes in practice needed to overcome the identified barriers?

Research Question 5: What program practices do Advanced Placement science teachers recommend to support Hispanic students?

Research Design

This study utilized a mixed methods approach. One challenge in using this process is the amount of effort needed to make sense of the collected information. Discrepancies within the data set may raise other issues that speak to further research. Ivankova (2014) cautions that to achieve quality assurance one method is to proceed from
quantitative investigation to qualitative processes. This researcher advocates for the in-depth exploration allowed through the qualitative process to enhance the overall quality of the study. To help address the complex nature of qualitative data analysis, a specialist in this field was engaged.

The recruitment process began by sending announcements to all superintendents in Stanislaus County, one of the counties within the region of interest to the study. The superintendent of one school district within the region of interest then sent the information to all administrators in the local chapter of Association of California School Administrators with his support. Six superintendents within the Stanislaus and San Joaquin counties granted permission either by email or letter for their AP teachers to be surveyed. These were Modesto City School District, Patterson Unified School District, Turlock School District, Oakdale School District, Riverbank School District, and Stockton School District. Science department leadership in all schools within these districts were contacted, and then the AP teachers. Two rounds of flyers were distributed inviting AP science teachers to participate in both the survey and focus group. Those teachers who responded to the announcement of the study were sent a formal invitation to participate which provided information about the research, its goals and objectives, participants’ bill of rights, and the Consent Form (See Appendices E, F, G). Upon receipt of the form by the researcher, the link for the online instrument was provided, with instructions on how to complete it as well as a survey critique. With this approach, 20 participants were recruited. From this group, 12 teachers agreed to participate in the focus group. The eight teachers who did not participate in the focus group provided quantitative
data that was compared to the 12 who did participate thereby enhancing reliability (Martin et al. 2014).

The survey generated quantitative data that informed the focus group interviews. Teachers who had taught one or more AP science courses during the years 2013-2017 in the region of interest, and who had one or more Hispanic science learners were surveyed. The focus group was digitally recorded and transcribed, with transcription provided by a member of the Stanislaus County Superior Court staff. This document was then reviewed for accuracy by the researcher. All identifiers were changed to codes kept by the researcher. The edited transcript was then delivered to the coding specialist. Using a combination of multiple online consultations and Nvivo 11 qualitative analysis software, the focus group’s data were coded by the researcher and a data coding specialist thereby providing intercoder reliability with a goal of reducing investigator bias (Nvivo, 2015). A detailed report of the themes was generated, after consultation of the two parties (See Appendices J, K).

The data collected from the surveys and focus group was examined for themes which, if present both in quantitative and qualitative data, would assist in validating the understanding gained. These data collection approaches allow the study to explore complex issues and give an opportunity for the participants to share their perceptions (Patten, 2012). Almalki (2016) indicated that a mixed methods approach, using triangulation based on quantitative and qualitative data and results interpreted by the researcher, offers benefits such as design efficiency. Another benefit is to help maintain the research focus with data sets building upon each other. MacNaughton et al. (2012) agree on the function of triangulation in mixed methods approach, while stressing the
need for what he calls “complementarity,” which is described as "using a second method in parallel to provide an enriched understanding of the concept that the first has measured" (p. S59).

**Population and Sample**

According to Mohamad Adam (2017) a “research population is generally a large collection of individuals or objects that is the main focus of a scientific inquiry” (Mohamed Adam, 2017, para. 1). The population for this study consisted of public school Advanced Placement science teachers who have taught Hispanic students in the California’s Central Valley in 2013-2017. Per the College Board (2017) in 2016, California students took 743,280 AP exams. Hispanics took 285,084. Of those, 2,439 took AP science exams (College Board, 2017). The exams included in this statistic were: biology, chemistry, environmental science, physics 1, physics 2, physics C – electricity and magnetism and physics C – mechanics. It is reasonable to assume that nearly all students who take an AP exam have completed the relevant coursework.

Per Buskirk (2017) a “target population provides the overall context and represents the collection of people, housing units, etc. about which inferences, and estimates are desired” (para. 7). For the purposes of this study, the target population consists of the AP science teachers in the Central Valley, a region that is bordered by the Coast Ranges in the west, the Sierras in the east, and includes the San Joaquin, Stanislaus, Madera, Fresno, Kings, Tulare, and Kern counties (University of California Division of Agriculture and Natural Resources [UC Division of Agriculture and Natural Resources], 2015). In this study, Stanislaus County and San Joaquin County were utilized.
One source describes a research sample as being “a group of participants in a study selected from the population from which the researcher intends to generalize” (Brandman University, 2015, p. 18). For purposes of convenience, the sample was selected from teachers working within either the Stanislaus and San Joaquin counties. From these, educators from six districts participated.

The sample consisted of 20 participants, drawn from the population, 12 of whom completed the survey and participated in the focus group. While this many participants may seem like a small number, “if it seems that spending relatively little time with ten to fifteen participants makes sense relative to the phenomenon under investigation, then have ten to fifteen participants” (Vagle, 2014, p. 75). Consultation with Dr. Patricia White of Brandman University indicated that a participant group of 12-16 was acceptable (P. White, personal communication, January 17, 2016.) Those who did not participate in the focus group were designated as the “control group” with their quantitative results compared to those who did the focus group and surveys.

**Presentation of the Data**

The data were organized into the quantitative data from the data collection instruments and the qualitative data from the coding of the focus group’s responses to the interview prompts based on the research questions. As the number of participants was small, despite offering incentives, an approach used by Martin, Friesen, & DePau, (2014) was employed wherein the focus group consisted of the same participants who took the survey. Additional participants took only the survey and served as a control group.

Likert surveys aligned to the research questions were used to collect quantitative data (See Appendix B). All percentages were rounded to the nearest whole number.
Qualitative data on participants’ views as to how well the Advanced Placement Program engages Hispanic science learners was collected through the use of a focus group. The same questions were used in both the survey and focus group. In the focus group discussion, 12 participants were encouraged to expand on their responses from the Likert survey and add additional information they felt relevant to the study. Analysis with a cloud-based online data collection and analysis tool revealed numerous themes. Seven coding reports with 53 subcategories were generated (See Appendix J).

**Research question (RQ1):** To what extent does the Advanced Placement Program succeed in promoting Hispanic student engagement and learning in high school science classrooms?

**RQ1 Quantitative Data**

Survey questions (S) were asked of the focus group. S1-S5 were aligned to RQ1. A review of the Likert surveys showed the following: for S1, 80% of the participants agreed that the AP program promotes Hispanic student engagement in high school science classrooms while 20% disagreed (See Figure 1). In terms of success in engaging Hispanic students in the science classrooms, (S2) 75% agreed, with 25% disagreeing (See Figure 2). S3, the question of whether AP Program succeeds in helping Hispanic students learn science, 85% agreed and 15% disagreed (See Figure 3). The teachers were split on the question of the Advanced Placement Program needing improvement to engage Hispanic students (S4) with 85% agreeing and 15% disagreeing (See Figure 4). Regarding AP Program improvement needed to enhance Hispanic’s learning (S5), the participants were split with 60% agreeing and 40% disagreeing (See Figure 5).
Comparing the focus group/survey participants to the control group yielded the following for RQ1: on S1 they agreed 63% to the focus group's 80%. For S2, the focus group agreed 75%, whereas the control group agreed 50%. S3 the focus group agreed...
85% with the control group agreeing 75%. For S4 the focus group agreed 85% while 50% of the control group agreed. For S5, the focus group agreed 65%, and the control agreed 50%. Overall, the focus group's agreement on questions S1-S5 where substantially higher than the control group (See Appendix I). These discrepancies will be examined more closely in Chapter V.

**RQ1 Qualitative Data**

Focus group question S1, 100% agreed that the AP program promotes engagement and of those, 83% said that this was through recruitment. Twenty-five percent felt that AP retained students during the term (See Figure 6). It was notable that participants raised the issue of test bias as an issue during this discussion. One hundred percent agreed that it was an important concern specifically as it related to vocabulary.

<table>
<thead>
<tr>
<th>Q01-Q03. Engagement of Hispanic students</th>
<th>12</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q01. Promotes engagement</td>
<td>12</td>
<td>100%</td>
</tr>
<tr>
<td>Optional to take AP test</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Recruitment</td>
<td>10</td>
<td>83%</td>
</tr>
<tr>
<td>Retention A.P. students during term</td>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>Test bias - vocabulary issues</td>
<td>12</td>
<td>100%</td>
</tr>
</tbody>
</table>

Figure 6 - Qualitative Theme: Engagement of Hispanic Students—Promotes Engagement coded responses of focus group.

**Research Question 2:** What program practices promote engagement and improve learning among Hispanic Advanced Placement students in high school science classrooms?

**RQ2 Quantitative Data**

On the question of which level of program practices helps Hispanics learn science the most (S6), 65% said the site, with 15% indicating district and 10% each saying federal and state (See Figure 7).
Comparing the focus group’s responses to the control group, 65% of the focus group indicated that the site was the level of program practices that helped to engage Hispanic students the most. The control group said 75% (See Appendix I). This discrepancy will be examined in Chapter V.

**RQ2 Qualitative Data**

S2, asking if the AP program succeeds in engaging, 100% of the participants agreed that this was the case. Of these, 92% felt that the program did this through meeting university standards, and the same percentage felt that AP was successful in engaging through the use of supplementary programs. Thirty-three percent of the participants cited lab activities as a way to engage Hispanic students, with 58% building on student aptitude and motivation (See Fig 8). S3, which explored the question of whether AP helps Hispanics learn science, 100% agreed that it did, with most citing fewer terms and therefore language issues in some subjects such as chemistry and physics. Ninety-two percent said that pre-AP programs help Hispanic students learn science. Fifty percent credited teacher-student engagement with AP to help these students learn science. The supplementary programs mentioned by respondents in the S2 discussion were defined in this conversation as being Advanced Placement Environmental Science and the AVID program, each garnering 33% agreement (See Fig 9). Both high school and middle school AVID were mentioned.

<table>
<thead>
<tr>
<th>ANSWER CHOICES</th>
<th>RESPONSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal</td>
<td>10.00%</td>
</tr>
<tr>
<td>State</td>
<td>10.00%</td>
</tr>
<tr>
<td>Local (District)</td>
<td>15.00%</td>
</tr>
<tr>
<td>Site/School</td>
<td>65.00%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>
When asked if the AP Program needs improvement to engage students, participants cited increased family support (42%) and targeting elementary schools (25%) along with inspiring higher student goals and teachers recruiting students, both 17%. (See Figure 10, 11).

<table>
<thead>
<tr>
<th>Q02. Succeeds in engaging</th>
<th>12</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field of science</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Labs in biology physics</td>
<td>4</td>
<td>33%</td>
</tr>
<tr>
<td>Meeting university standards</td>
<td>11</td>
<td>92%</td>
</tr>
<tr>
<td>Science standards</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Statistics re Modesto City Schools</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Student attitude motivation</td>
<td>7</td>
<td>58%</td>
</tr>
<tr>
<td>Supplementary programs</td>
<td>11</td>
<td>92%</td>
</tr>
</tbody>
</table>

Figure 8 - Qualitative Theme: Engagement of Hispanic Students—Succeeds in engaging coded responses of focus group.

<table>
<thead>
<tr>
<th>Q03. Helps in learning science</th>
<th>12</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>APES Class</td>
<td>4</td>
<td>33%</td>
</tr>
<tr>
<td>AVID program</td>
<td>4</td>
<td>33%</td>
</tr>
<tr>
<td>Calculus</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>College Board practice exams</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Fewer terms in chemistry physics</td>
<td>11</td>
<td>92%</td>
</tr>
<tr>
<td>Medical BioTech Club</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Pre-A.P. programs</td>
<td>11</td>
<td>92%</td>
</tr>
<tr>
<td>Science Olympiad and Science Bowl</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Teacher-student engagement</td>
<td>6</td>
<td>50%</td>
</tr>
</tbody>
</table>

Figure 9 - Qualitative Theme: Engagement of Hispanic Students—Helps in learning science coded responses of focus group.

<table>
<thead>
<tr>
<th>Q04-Q05. AP Program needs improvement</th>
<th>6</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q04. To engage students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional supplementary support</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Increased family support</td>
<td>5</td>
<td>42%</td>
</tr>
<tr>
<td>Inspire higher student goals</td>
<td>2</td>
<td>17%</td>
</tr>
<tr>
<td>Target elementary school students</td>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>Teachers recruiting students</td>
<td>2</td>
<td>17%</td>
</tr>
</tbody>
</table>

Figure 10 - Qualitative Theme: AP Program needs improvement to engage students coded responses of focus group.
Research question 3: To what extent does the Advanced Placement Program present barriers to Hispanic students’ access, learning of science concepts, and course completion in high school science classrooms?

RQ3 Quantitative Data

The issue of the AP Program presenting barriers to student curriculum access (S7) showed that participants did not support that idea by a three to one margin, with 25% agreeing and 75% disagreeing (See Figure 12). The related question of AP presenting barriers to Hispanics learning science concepts (S8) had similar results, with 30% agreeing and 70% disagreeing (See Figure 13). Barriers to Hispanic course completion (S9) also showed 20% agreeing, with 80% disagreeing (See Figure 14).

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Total</th>
<th>Weighted Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased science options in early grades</td>
<td>0.00%</td>
<td>25.00%</td>
<td>65.00%</td>
<td>10.00%</td>
<td>20</td>
<td>1.00</td>
</tr>
<tr>
<td>Increased supplementary support</td>
<td>0.00%</td>
<td>30.00%</td>
<td>60.00%</td>
<td>10.00%</td>
<td>20</td>
<td>1.00</td>
</tr>
<tr>
<td>Requires teacher enthusiasm - buy-in</td>
<td>0.00%</td>
<td>30.00%</td>
<td>60.00%</td>
<td>10.00%</td>
<td>20</td>
<td>1.00</td>
</tr>
</tbody>
</table>
For S7, both the focus group and control group showed that 25% agreed and 75% disagreed. Focus group and control group were similar for S8 with 30% and 70% respectively. On S9, the focus group had 25% agreed and 80% disagreed, whereas the control group was 13% agreed and 87% disagreed. These questions, taken together indicate that the teachers did not support the concept of the AP Program presenting barriers to students for both groups.

**RQ3 Qualitative Data**

All 12 focus group participants cited underachievement on the part of the students as a barrier to access to the curriculum. Explanations included the speed with which the students needed to process information. Ninety-two percent of the focus group indicated that absences due to scheduled school activities as barriers to course completion.

Seventeen percent of participants saw AP as practiced in small school districts presented a barrier to access to the curriculum (See Figure 15). Unfamiliar vocabulary was cited by 33% of the participants as being a barrier to learning of science concepts in AP.

Seventeen percent said that gender issues and generation presented barriers to learning of science concepts in AP (See Figure 16).

---

**Figure 14** – Survey Question 9: To what extent do you agree with the following statement? "The Advanced Placement Program presents barriers to Hispanic students’ course completion in high school science classrooms."

For S7, both the focus group and control group showed that 25% agreed and 75% disagreed. Focus group and control group were similar for S8 with 30% and 70% respectively. On S9, the focus group had 25% agreed and 80% disagreed, whereas the control group was 13% agreed and 87% disagreed. These questions, taken together indicate that the teachers did not support the concept of the AP Program presenting barriers to students for both groups.

**RQ3 Qualitative Data**

All 12 focus group participants cited underachievement on the part of the students as a barrier to access to the curriculum. Explanations included the speed with which the students needed to process information. Ninety-two percent of the focus group indicated that absences due to scheduled school activities as barriers to course completion.

Seventeen percent of participants saw AP as practiced in small school districts presented a barrier to access to the curriculum (See Figure 15). Unfamiliar vocabulary was cited by 33% of the participants as being a barrier to learning of science concepts in AP.

Seventeen percent said that gender issues and generation presented barriers to learning of science concepts in AP (See Figure 16).
Research Question 4: What do Advanced Placement teachers perceive as changes in practice needed to overcome the identified barriers?

RQ4 Quantitative Data

Sixty-five percent of participants agreed that there were changes in practice needed in the AP Program to better engage Hispanic students (See Fig 17). Sixty percent agreed that the AP Program needs to be improved to enhance Hispanic students’ learning (See Fig 18).

Comparing the quantitative data from the focus group and the control group, showed a discrepancy in this area. Sixty-five percent of the focus group agreed that the AP program needed to be improved to better engage Hispanic students (S4) compared to...
50% for the control group. For the question of AP program improvement being needed to enhance Hispanic student’s learning, 60% of the focus group agreed compared with 50% of the control group (See Appendix I).

**RQ4 Qualitative Data**

Under the theme of AP Program improvement, 42% cited the need for increased family support, 25% the need to target elementary schools, and teachers recruiting students and inspiring students to higher goals both received 17% agreement by the participants. Testing issues, most mentioned as a function of language was cited by 42% of the focus group. One participant’s explanation for this was that the AP test questions were written in a style that Hispanic learners were not familiar with (See Figure 19).

<table>
<thead>
<tr>
<th>Q04. To engage students</th>
<th>6</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional supplementary support</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Increased family support</td>
<td>5</td>
<td>42%</td>
</tr>
<tr>
<td>Inspire higher student goals</td>
<td>2</td>
<td>17%</td>
</tr>
<tr>
<td>Target elementary school students</td>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>Teachers recruiting students</td>
<td>2</td>
<td>17%</td>
</tr>
</tbody>
</table>

Figure 19 - Qualitative Theme: AP Program needs improvement coded responses of focus group.

**Research Question 5:** What program practices do Advanced Placement science teachers recommend to support Hispanic students?

**RQ5 Quantitative Data**

The response to this research question is more appropriately explained through the qualitative data.

**RQ5 Qualitative Data**

Twenty-five percent of the focus group recommended that there be increased science options in early grades (See Figure 20). Eight percent recommended increased
supplementary support and noted the value of teacher buy in to teach the AP classes (See Figure 21).

<table>
<thead>
<tr>
<th>Q04. To engage students</th>
<th>6</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional supplementary support</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Increased family support</td>
<td>5</td>
<td>42%</td>
</tr>
<tr>
<td>Inspire higher student goals</td>
<td>2</td>
<td>17%</td>
</tr>
<tr>
<td>Target elementary school students</td>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>Teachers recruiting students</td>
<td>2</td>
<td>17%</td>
</tr>
</tbody>
</table>

Figure 20 - Qualitative Theme: AP Program needs improvement coded responses of focus group.

<table>
<thead>
<tr>
<th>Q05. To enhance learning</th>
<th>4</th>
<th>33%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased science options in early grades</td>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>Increased supplementary support</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Requires teacher enthusiasm - buy-in</td>
<td>1</td>
<td>8%</td>
</tr>
</tbody>
</table>

Figure 21 - Qualitative Theme: AP Program needs improvement to engage students coded responses of focus group.

**Summary**

The purpose of this mixed methods study was to identify and describe to what extent Advanced Placement program practices promote the engagement of Hispanic students and improve their learning in high school science classrooms. Also, the investigation sought to identify the barriers experienced by the students in their Advanced Placement science classes as perceived by their AP teachers.

**Qualitative data** showed that most of the AP teachers surveyed felt that the AP program promotes Hispanic student engagement through recruitment and retained the students once in the class. Meeting university standards was a significant way in which the AP program succeeds in engaging and felt that supplementary programs made a significant difference. Hispanic AP students were helped in learning science through AP environmental science and the AVID Program. Teachers nearly all agreed that those AP courses with less vocabulary helped Hispanics science learners.
Major improvements in the AP program cited as needed by participants to improve student engagement included increased family support, targeting elementary school students, and offering more science options for these learners. According to the participants, inspiring higher student goals and recruiting students were two ways in which teachers could improve the program.

Barriers to access to the curriculum that needed to be overcome as indicated by participants included limitations placed on learners in small school districts, and underachievement by the students themselves. Barriers identified to learning science concepts were unfamiliar vocabulary, gender issues and generational differences in the home. For barriers to course completion, most often mentioned were site-generated absences, family socio-economic issues, and testing issues.

In Chapter V, based on key findings, a set of conclusions that interpret the results is presented. Recommendations for further research that would extend the contributions to the field and assist other researchers are described. Implications for practice as a means to help educators understand and address the needs of the Hispanic AP science learner will be offered.
CHAPTER V: FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Purpose Statement

The purpose of this mixed methods study was to identify and describe to what extent teacher program practices promote the engagement of Hispanic students in Advanced Placement science. In addition, it was the purpose of this study to identify the barriers experienced by the students in their Advanced Placement science classes.

Research Questions

Research question 1: To what extent does the Advanced Placement Program succeed in promoting Hispanic student engagement and learning in high school science classrooms?

Research question 2: What program practices promote engagement and improve learning among Hispanic Advanced Placement students in high school science classrooms?

Research question 3: To what extent does the Advanced Placement Program present barriers to Hispanic students’ access, learning of science concepts, and course completion in high school science classrooms?

Research Question 4: What do Advanced Placement teachers perceive as changes in practice needed to overcome the identified barriers?

Research Question 5: What program practices do Advanced Placement science teachers recommend to support Hispanic students?

Methodology

The study utilized a mixed methods approach. Teachers who had taught one or more AP science courses during the years 2013-2017 were surveyed using a Likert-scale survey. This instrument generated quantitative data that was used to inform a focus
group interview. The data collected from the surveys and focus groups were examined for themes which yielded qualitative data that was subsequently analyzed.

**Population and Sample**

The population for this study consisted of public school Advanced Placement science teachers who have taught Hispanic students in California’s Central Valley in 2013-2017. For purposes of convenience, the sample was selected from teachers working within either Stanislaus or San Joaquin County. The sample consisted of 20 participants drawn from the population, all of whom completed the survey. From that number 12 then participated in the focus group with the remaining eight becoming the control group.

**Major Findings**

The quantitative data showed that the AP science teachers who participated in this study believed the AP Program succeeds in promoting Hispanic student engagement. The qualitative data supported this by showing the engagement happened through recruitment and having the option take the AP examination or not.

The quantitative data showed that showed that the AP Program succeeds in engaging Hispanic students. Through the qualitatively it was found that respondents believed that science axiomatically is of interest to students. Also, students are motivated by lab activities they perform in class, and that the coursework meets university preparation in conformance with College Board standards. Participants cited specific instances as to how the rigor in the AP courses served their students at colleges and universities. It was also mentioned that the AP Program builds on student motivation and supplementary programs help further engage Hispanic students.
The quantitative data also showed that the AP Program helps Hispanic students learn science. The qualitative data supported that assertion. The offering of the newer Advanced Placement Environmental Science has become popular and draws Hispanic students who might otherwise not take a science class. Participants indicated this was because the students perceived that the AP Environmental Science to be a less rigorous course. College Board practice exams and pre-AP courses helped students to learn science. Chemistry and physics draw some Hispanic learners due to the lesser academic vocabulary in those subjects, thereby reducing the burden of academic language acquisition which all participants agreed was a common difficulty for Hispanic science.

On the topic of the need for improvement in the AP Program to better engage Hispanic science students, quantitative data showed that a lesser number agreed on this than the topics above but offered some ways to improve the program. Additional supplementary support was cited, specifically the need to support AVID programs in feeder schools and Science Olympiad and Science Bowl.

The quantitative data showed that the majority of participants agreed that the AP program could be improved to better enhance student learning. Focus group qualitative data suggested to do this, increased science options in early grades. This was consistent with the literature (Roberts, 2014). The data also indicated more supplementary support and the necessity of teacher enthusiasm and buy-in were needed. As with the question of improvement needed to better engage Hispanic students, participants agreed but to a lesser degree than with the ability of the program to promote and succeeds in the engagement of Hispanic science learners.
The issue of which level of program practices help Hispanic students the most, quantitatively the majority cited the site/district. Focus group data indicates less than half of the participants supported that with the same number agreeing with the State of California helping students the most.

Quantitatively, the majority of participants disagreed that the AP program created barriers to Hispanic students in the forms of access to the curriculum and learning of science concepts. Qualitatively, the participants cited access to the AP curriculum being hindered by non-AP factors such as small school districts not offering the courses, and underachievement on the part of the students which all agreed on. Barriers to learning of science concepts were responded to with differences in life experiences that made students unprepared for test items that assumed a different student background. Also noted were gender issues which connected to expectations at home, and as stated above, unfamiliar vocabulary.

Quantitatively, the issue of the AP Program providing barriers to course completion was a contentious one among the participants at a percentage similar to that of the access to the curriculum above. Qualitatively, nearly all participants offered absences due to school activities as a factor, followed by testing issues, and family and socio-economic issues.

**Unexpected findings**

Comparing the quantitative data from those who took the survey and participated in the focus group (participants 1-12) and the control group who only took the survey (participants 13-20) showed some notable differences. The responses to the questions on the AP program promoting Hispanic science student engagement, succeeding in engaging
them and helping them to learn science were notably different. The control group’s responses were 20-50% lower than the survey and focus group.

For the questions describing the need for AP program improvement, both answers were higher by about a third in the survey and focus group than in the control group. For the questions of barriers created by the AP program, both groups had similar numbers with well over half disagreeing. Given the substantial differences between the two groups on the topics of engagement, it is notable that they agreed on the question of barriers caused by AP.

**Conclusions**

Conclusions drawn from the data in regard to RQ1 and RQ2, participants indicated that

- The AP program succeeded in promoting Hispanic student engagement,
- The AP program succeeded in promoting learning among Hispanic science students in these classes.

Conclusions drawn from the data in regard to RQ3 and RQ4, participants indicated that,

- The AP program did not present barriers to access, learning of science concepts and course completion in high school science classes and therefore did not require changes in practice to overcome barriers not identified.

Conclusions drawn from the data in regard to RQ5, most participants indicated that, a number of changes in practice should be made that would better support Hispanic science learners such as,
• Promoting more science in lower grades,
• Promotion of the AVID program in middle grades,
• and specialized enrichment study groups for those Hispanic AP learners that struggle with the language acquisition at the pace required to be successful in the course.

Implications for Action

Implications for action within the delivery of the AP Program include creating an AP science preparation structure that includes vertical articulation with grades K-8 of feeder schools by:

• Enhancing science offerings in elementary grades by working with districts to assure there are properly trained and supported teachers who see science as relevant. This may require a transformational change in district level thinking which may be dedicated to supporting only reading, writing and mathematics. The new Common Core and Next Generation Science Standards may create receptivity to this change although as noted in the literature, Common Core in particular, has drawn criticism from various quarters. Its efficacy remains to be determined.

• Promoting Advancement for Individual Determination (AVID) at the middle school level as well as high school to equip students with the skills to be successful in rigorous AP classes.

• Using AP students as “ambassadors.” These learners would visit elementary and middle schools acting as science demonstrators who would provide enrichment and support of science learning by modeling higher grade students’ passion for the subject. As some participants indicated gender issues with AP science achievement, this approach
would require the thoughtful practitioner to include female AP science students as ambassadors who will exemplify the reality of the program to their younger peers.

**Recommendations for Further Research**

Of the 20 participants, one of the AP science teachers was Hispanic. All members of the focus group were non-Hispanic White. Since all AP teachers in two counties were contacted and made aware of the study on multiple occasions, this may have come from the lack of Hispanic AP science teachers among the two counties surveyed. This percentage of 5% Hispanic in the focus group would be similar to the 6% of STEM jobs being held by Hispanics nationwide.

During the focus group, there was frequent mention of language issues, with some citing English language learners’ difficulties with academic language and the pace of the vocabulary acquisition needed for success in AP courses. While this study did not address these, a future investigation could delve into both topics. Walkui (2010) suggested that increasing the level of challenge would be one way to approach the subject. A future study could investigate how teachers who made AP more challenging results compared with those who take a less rigorous approach. Taking the concept of the AP teacher role further, Mackensie (2014) indicated teacher quality as a significant factor in other nations’ higher testing scores. An investigation of this concept might also provide the basis for a future study. Perhaps the researcher could utilize the approach made by the National Science Board wherein indicators of science teacher quality were defined and measured ("S and E Indicators," 2018).

A future validation study might seek to determine whether differences continue to exist between the control group (survey only) and the group consisting of individuals
who contributed both quantitative and qualitative data. This phenomenon may be unique to this study, and not necessarily apparent to others. Another approach would be to compare results of the participants to a group of AP teachers who were 95% Hispanic and 5% White to look for differences and trends. It may be enlightening to probe more deeply into issues of social justice and SES during that investigation.

Participants indicated the role of the family in the success of Hispanic AP students. A review of the literature showed that familial support was a significant factor in these students’ success (Morgan, 2016). During preparation for this study, Hispanic parents were invited to workshops that taught skills to help them support their children in science classes. Informal discussions arising from these meetings showed these same parents highly interested in helping their children but reporting some levels of helplessness given their educational background. It may be argued that the parents are not experts in science but are experts on their children. Comments made by the focus group supported the role of parents in this regard, noting that parents at home with no college experience were perceived as affecting Hispanic students in AP programs. Comments were made by participants that their students had no college graduate role models in the homes. The literature suggests that Hispanic parents do value college education. According to one study, 86% of Hispanics said that a college degree was extremely important or very important (Renee, 2016). But in practice, few Hispanics attain diplomas. Per another study only 15% of Hispanic adults who had completed degrees in 2012 ("College Completion," 2012). A study could be made to investigate the role of the parents in the child’s science education. This might include examining the
effect of students having no college parent role models or siblings who may be in college and whose parents that are college graduates.

When investigating RQ3, dealing with barriers to access, learning and course completion, the concept of social justice was raised. According to the Center for Economic and Social Justice, "social justice is the virtue which guides us in creating those organized human interactions we call institutions. In turn, social institutions, when justly organized, provide us with access to what is good for the person, both individually and in our associations with others." In this study, there was an absence of data that indicated a concern by the participants for students being denied access. It is possible that the structure of the research questions or the conduct of the focus group by the researcher failed to bring these issues to the surface for examination. A study using the same methods, population and sample numbers, but with a greater emphasis on looking more closely at social justice aspects may reveal themes not yet discovered.

Certainly, the placement of students in AP courses is influenced by school counselors. This was noted by the focus group. A topic for study would be that of the presence or absence of bias in these professionals that in turn influences their placement of students in AP classes and programs. One source acknowledges the presence of bias in college counselors (Patterson, 2017). This may lead to an investigation of the role of bias in AP placement of Hispanic students.

During the recruitment process for this study, it was determined that there were significant differences between schools and the number of AP courses offered. This speaks to inequity of access and may be deserving of further investigation as well.
The issue of the achievement gap between ethnic groups has been discussed in this study. According to NCES, by grade 12, Hispanics performed lower than Asians and Whites but above Blacks ("Science Performance," 2017). Further examination of the reasons for this may be warranted. Comments made by the focus group indicated that they recognized gender performance differences in STEM careers and coursework. According to the literature, there are multiple reasons for these. Else-Quest et al. (2013) note that females are underrepresented in these areas, with student attitudes being strong predictors of achievement. Those researchers found that self-concept, the value of the tasks at hand, along with their expectations of success predicted success possibility the most reliable. The study showed that these three factors were interrelated, and more research is needed to determine the degree to which each played a role. The data did show that females had a more pessimistic view of their success, and the implication was that this affected other factors and thereby, their achievement as a group. In a 12-year study, Lorah and Ndum (2013) found evidence of differences in males vs. females in science, using first-year college biology as the representative STEM course. This study concluded that males performed below females in this course and was consistent with work done by Young in 2001, and Bridgeman & Wendler in 1991. Lorah and Ndum’s explanation for the differences were due to behavioral choices by the males including missing class and not submitting assignments. It may be noted that as of 2017, females outnumbered males in medical school enrollment (Glicksman, 2017).

**Concluding Remarks and Reflections**

From the participants’ comments, it was clear that some changes needed to be made in the science learning environment before students arrived in high school and were
challenged to take AP courses. Participants were in favor of advocacy by parents and AP science teachers for more science education in the elementary grades. Establishment or expansion of AVID programs in the middle grades and high school, along with the establishment of support and study groups for those struggling with academic language in high school AP classes would serve to make the experience more attractive to Hispanic learners. Connecting with local non-governmental agencies dedicated to serving the Hispanic community would offer the possibility of support for the AP Program both on and off campus.
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prosperity-yet-some-politicians-are-demonizing-our-educational-system-for-political-
advantage

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Figure A1 Survey of Advanced Placement science teachers who have taught Hispanic students during 2013-2017.
APPENDIX A CONTINUED

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<td>* 6. What level of program practices help engage Hispanic students' in science learning the most?</td>
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<td>* 7. To what extent do you agree with the following statement? &quot;The Advanced Placement Program presents barriers to Hispanic students' access to the curriculum.&quot;</td>
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</tr>
<tr>
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<td>* 8. To what extent do you agree with the following statement? &quot;The Advanced Placement Program presents barriers to Hispanic students' learning of science concepts.&quot;</td>
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<td>Strongly Disagree</td>
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<td>* 9. To what extent do you agree with the following statement? &quot;The Advanced Placement Program presents barriers to Hispanic students' course completion in high school science classrooms.&quot;</td>
<td>Strongly Agree</td>
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<tr>
<td></td>
<td>Strongly Disagree</td>
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<td>* 10. I am an Advanced Placement science teacher who has taught at least one AP science class during the period of 2013-2017 with Hispanic students in that class in either Stanislaus or San Joaquin County.</td>
<td>Yes</td>
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<td>No</td>
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Figure A1 – Continued- Survey of Advanced Placement science teachers who have taught Hispanic students during 2013-2017.
APPENDIX B

<table>
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<th>Research Questions (RQ)</th>
<th>Survey Questions (S)</th>
<th>Interview Questions (IQ)</th>
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<tr>
<td>RQ 1 - To what extent does the Advanced Placement Program succeed in promoting Hispanic student engagement and learning in high school science classrooms?</td>
<td>S1 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program succeeds in promoting Hispanic student engagement in high school science classrooms.&quot;</td>
<td>IQ1 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program succeeds in promoting Hispanic student engagement in high school science classrooms.&quot;</td>
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<td>S2 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program succeeds in engaging Hispanic students in the science classroom.&quot;</td>
<td>IQ2 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program succeeds in engaging Hispanic students in the science classrooms.&quot;</td>
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<td>S3 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program succeeds in helping Hispanic students learn science in high school classrooms.&quot;</td>
<td>IQ3 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program succeeds in helping Hispanic students learn science in high school classrooms.&quot;</td>
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<td>S4 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program needs to be improved to better engage Hispanic students.&quot;</td>
<td>IQ4 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program needs to be improved to better engage Hispanic students.&quot;</td>
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<td>S5 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program needs to be improved to better enhance Hispanic students' learning.&quot;</td>
<td>IQ5 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program needs to be improved to better enhance Hispanic students' learning.&quot;</td>
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<td>RQ3 - To what extent does the Advanced Placement Program present barriers to Hispanic students' access, learning of science concepts, and course completion in high school science classrooms?</td>
<td>S7 - To what extent does the Advanced Placement Program present barriers to Hispanic students' access to the curriculum?</td>
<td>IQ7 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program presents barriers to Hispanic students' access to the curriculum.&quot;</td>
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<td>S8 - To what extent does Advanced Placement Program present barriers to Hispanic students' learning of science concepts?</td>
<td>IQ8 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program presents barriers to Hispanic students' learning of science concepts.&quot;</td>
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<td>S9 - To what extent does the Advanced Placement Program present barriers to Hispanic students course completion in high school science classrooms?</td>
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Table 1 Alignment of research, survey, and interview questions.
Table 1 Continued Alignment of research, survey, and interview questions.

<table>
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<th>Research Questions (RQ)</th>
<th>Survey Questions (S)</th>
<th>Interview Questions (IQ)</th>
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<td>RQ4 - What do Advanced Placement teachers perceive as changes in practice needed to overcome identified barriers</td>
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<td>IQ8 - To what extent do you agree with the following statement? &quot;The Advanced Placement Program presents barriers to Hispanic students' course completion in high school science classrooms.&quot;</td>
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<td>RQ5 - What program practices do advanced placement science teachers recommend to support Hispanic students?</td>
<td></td>
<td>IQ4 - To what extent do you agree with the following statement: The Advanced Placement Program needs to be improved to better engage Hispanic students. IQ5 - The Advanced Placement Program needs to be improved to better enhance Hispanic students' learning.</td>
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APPENDIX C

Field Test Participant Feedback Questions

After the field test participants have engaged in the practice focus group, each will be asked a series of questions designed to provide input for improving the interviews with research subjects. The responses would be documented. The goal is to improve the interview questions and process.

1) How did you feel about the interview?

2) Do you think you had ample opportunities to describe what you have learned about the extent that the Advanced Placement program promotes the engagement of Hispanic students and their learning in high school science classrooms?

3) Do you think you had ample opportunities to describe what you have the extent any barriers that your Hispanic AP students may have experienced while learning science in high school science classrooms?

4) Do you feel the amount of time for the interview was OK?

5) Were the questions by and large clear or were there places where you were uncertain what was being asked?

6) Can you recall any words or terms being asked during the interview that were confusing?

7) And finally, did I appear comfortable during the interview? (I am pretty new at this.)

Figure C1 – Field test participant survey
APPENDIX D

Figure D1 – Institutional Review Board approval to conduct the study.

From: Institutional Review Board <my@brandman.edu>
Date: Sat, Jan 13, 2018 at 11:29 AM
Subject: BUIRB Application Approved: David Menshew
To: mens5301@mail.brandman.edu
Cc: ddevore@brandman.edu, mabrams@brandman.edu, buirb@brandman.edu

Dear David Menshew,

Congratulations! Your IRB application to conduct research has been approved by the Brandman University Institutional Review Board. Please keep this email for your records, as it will need to be included in your research appendix.

If you need to modify your BUIRB application for any reason, please fill out the "Application Modification Form" before proceeding with your research. The Modification form can be found at IRB.Brandman.edu

Best wishes for a successful completion of your study.

Thank You,

BUIRB
Academic Affairs
Brandman University
16355 Laguna Canyon Road
Irvine, CA 92618
buirb@brandman.edu
www.brandman.edu
A Member of the Chapman University System
Brandman University Research Study Participant Invitation

1-16-18

Dear Potential Study Participant,

I am an educator, in the School of Education at Brandman University, and am conducting a study on the use of Advanced Placement Programs as a means to engage Hispanic science learners within California’s Central Valley. It is hoped that the data from this study will add to the body of information of how to best meet the needs of this group of learners and thereby develop approaches that result in improved educational outcomes.

I am asking your assistance in the study by participating in a brief online survey which will take about five minutes, and if called, a focus group/interview of approximately one hour. Both experiences will be compensated with payments of $100 for the survey and $100 for the focus group. The survey may be taken at your convenience, and the focus group/interview will be set up at a time convenient for you. If you agree to participate in the interview, you may be assured that it will be completely confidential. No names will be attached to any notes or records from the interview. All information will remain in locked files accessible only to the researchers and will be transcribed and the records destroyed after three years. No employer, supervisor, agency, or other organization will have access to the information. You will be free to stop the survey, or focus group/interview and withdraw from the study at any time. Further, you may be assured that the researcher is not in any way affiliated with the administration of your organization or acts in a supervisory capacity above you. You can contact me, the researcher Dave Menshew at mens8301@brandman.edu or by phone at (209) 222-1265. You can also contact the Research Director, Dr. Marv Abrams, (Dissertation Chair) at mabrams@brandman.edu or by phone at (949) 562-1758 to answer any questions you may have.

Should you choose to participate you will receive additional forms which will include contain a Participant’s Bill of Rights and other documents as required by Brandman’s Institutional Review Board.

Your participation would be greatly valued and will allow this study to move forward.

Sincerely, Dave Menshew, M.A.Ed. Ed.D. Candidate, Brandman University

Figure E1 – Participant invitation letter
APPENDIX F

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

Figure F1 – Research participant’s bill of rights
APPENDIX G

Brandman University Research Study - Informed Consent Form

Information about: Understanding the engagement of Hispanic science students of California’s Central Valley.


Purpose of Study: You are being asked to participate in a research study being conducted by Dave Menshew, a doctoral student from Brandman University. The purpose of this phenomenological study is to explore the experiences of Hispanic Advanced Placement science students to discover to what extent do program practices promote the engagement of these students and improve their learning in secondary science. It is also to examine what barriers were encountered by these students while enrolled in the program, and explore what modifications to existing program practice were needed for their success. This study will fill the gap in what is known about Hispanic science student engagement in the Central Valley. The results of this study may help to assist school districts to align or redesign science instruction programs to the benefit of Hispanic science learners. It may also inform the classroom instruction of teachers and allow for improved engagement of the target population.

Participation: By participating in this study, I agree to participate in an initial survey using Survey Monkey which will take approximately 8-10 minutes to complete. A small focus group interview will last about one hour and will be conducted in person, by phone, or electronically.

I understand that:

a) There could be unforeseen minimal risks associated with participating in this research. I understand that the investigator will protect my confidentiality by keeping the identifying codes and research materials in a secure place that is available only to the researcher.

b) The possible benefit of this study to me is that my input may help add to the research regarding how best to engage Hispanic science students to improve their grasp of core science concepts. The findings will be available to me at the conclusion of the study and will provide new insights about the Advanced Placement coursework experience in which I participated. I understand that I will not be compensated for my participation.

c) If you have any questions or concerns about the research, please feel free to contact the principal investigator, Dave Menshew at menshew@brandman.edu or by phone at (209) 222-1265; or Dr. Marv Abrams (Dissertation Chair) at mabrams@brandman.edu or by phone (949) 582-1758

d) My participation in this research study is voluntary. I may decide not to participate in the study and I can withdraw at any time. I can also decide not to answer questions during the interview if I so choose. I understand that I may refuse to participate or may withdraw from this study at any time without any negative consequences. Also, the investigator may stop the study at any time.

e) No information that identifies me will be released without my separate consent and that 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. I understand that if I have

Figure G1 – Informed consent form
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.

________________________________________
Signature of Participant or Responsible Party, Date

________________________________________
Signature of Principal Investigator, Date

Figure G1 – Continued informed consent form
APPENDIX H

Interview Protocol

My name is Dave Menshew, teacher in the Forensic Biotechnology Program at Enochs High School and Adjunct Professor at Brandman University. I am also a doctoral candidate at Brandman University in the area of Organizational Leadership. I am conducting research to determine the extent that the Advanced Placement Program engages Hispanics to learn science and what barriers (if any) they experience.

I will be conducting focus group of 8-10 Advanced Placement teachers like yourself. The information you give, along with the others, hopefully will provide a clear picture of the experience Hispanic AP science students have here in the Central Valley and will add to the body of research currently available.

Incidentally, even though it appears a bit awkward, I will be reading most of what I say. The reason for this to guarantee, as much as possible, that my interviews with all participating AP teachers will be conducted in the same manner.

Informed Consent (required for Dissertation Research) will be distributed in hard copy.

I would like to remind you any information that is 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 electronic mail 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 you via email? Do you have any questions or need clarification about either document?

We have scheduled an hour for the interview. At any point during the interview you may ask that I skip a particular question or stop the interview altogether. For ease of our discussion and accuracy I will digitally record our conversation as indicated in the Informed Consent.

Do you have any questions before we begin? Okay, let’s get started, and thanks so much for your time.

Interview Questions

1) What Advanced Placement Program practices succeed in promoting Hispanic student engagement and improve learning in the science classroom?
   a. Probe question – What do you believe is most effective?
2) What Advanced Placement Program practices do you recommend to support Hispanic science learners’ understanding the science concepts?
   a. Probe question – What helps them understand often difficult concepts?
3) What barriers does the Advanced Placement Program have that limits Hispanic students learning the AP science curriculum?
   a. Probe question – Do you see barriers that seem to limit Hispanic students from learning the AP curriculum?

Figure H1 – Interview protocol
4) What do you perceive as changes in practice needed to overcome identified barriers to Advanced Placement course completion?
   a. Probe question – Are there changes needed? Where would they come from?
5) What Advanced Placement Program practices do you recommend to support Hispanic science learners’ course completion?
   a. Probe question – What practices might be particularly effective?
6) What advanced Placement Program practices do you recommend to support Hispanic science learners access to the curriculum?
   a. Probe question – How might these students be helped to access the AP curriculum?
7) What Advanced Placement Program practices succeed in promoting Hispanic student engagement and improve learning in the science classroom?
   a. Probe question – Engagement can be challenging – what seems to work for you?
APPENDIX I

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AP Teacher

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P13-20 Data

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Table 2 – Quantitative data from Likert surveys
APPENDIX J

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Figure J1 – Node listing of coding reports
## APPENDIX K

### Table 3 - Report of responses to themes

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### Table 3 – Continued - Report of responses to themes

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<th>P3</th>
<th>P4</th>
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<th>P9</th>
<th>P10</th>
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APPENDIX K CONTINUED