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An assessment of factors relating to high school students' science self-efficacy

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AN ASSESSMENT OF FACTORS RELATING TO HIGH SCHOOL STUDENTS' SCIENCE SELF-EFFICACY

A dissertation submitted in partial satisfaction

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Doctor of Education in Organizational Leadership

by

Jakeisha Jamice Gibson

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This dissertation, written by

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under the guidance of a Faculty Committee and approved by its members, has been submitted to and accepted by the Graduate Faculty in partial fulfillment of the requirements for the degree of

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DEDICATION

This dissertation is dedicated to all students with a dream. Never let anyone tell you something is impossible, everything is possible with the right attitude! Continue to strive for greatness.

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VITA

Jakeisha Gibson

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UNIVERSITY OF CALIFORNIA, LOS ANGELES 2005

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Minor in Education

Specialization in the Diversified Liberal Arts Program

NOGALES HIGH SCHOOL 2001

High School Diploma

WORK EXPERIENCE

Los Angeles Unified School District 2006–Present

Elementary School Teacher

Grade Level Chairperson

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Chairperson of the Coordinated Health and Safety Committee

Technology Coordinator

Lead Science Teacher

Member of the Local School Leadership Team

Member of the School Site Council

Academic English Mastery Teacher Facilitator

Team Lead for UCLA's Teacher Initiated Inquiry Project.

SPECIALIZED SKILLS

Elementary Math Certification from University of California, Los Angeles Math Department

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Adaptive Schools Trained (Tools for developing collaborative groups)

New Hire Coach/ New Teacher Support Provider

ABSTRACT

This mixed-methods case study examined two out-of-school (OST) Science, Technology, Engineering and Math (STEM) programs at a science-oriented high school on students' Self-Efficacy. Because STEM is a key for future innovation and economic growth, Americans have been developing a variety of approaches to increase student interest in science within the school curriculum and in OST programs. Nationwide, many OST programs are offered for students but few have engaged in an in-depth assessment.

This study included an assessment of two different types of OST programs and direct observations by the researcher. This study involved two advisors (one male, one female), 111 students, and their parents during 2016. Student participants completed two standardized surveys, one to determine their Science Self-Efficacy and another to assess their engagement in science during their OST programs. Parents described their parental involvement and their child's interest in the OST program(s). The OST program advisors participated in lengthy interviews. Additionally, the advisors rated their perceived interest level of the enrolled students and recorded attendance data.

Bandura's Social Cognitive Theory (1997a) provided the theoretical framework. This theory describes the multidirectional influence of behavioral factors, personal factors, and environmental factors have on a student's Self-Efficacy. Compiled data from the teachers, students, and parents were used to determine the relationship of selected variables on Science Self-Efficacy of students. A correlational analysis revealed that students who participated in these OST programs possessed a high Mindset for the Enjoyment of science and that teacher ratings were also positively correlated to Mindset and Enjoyment of Science. Descriptive analyses showed that (a) girls who chose to participate in these OST programs possessed higher school grades in their in-school coursework than boys, (b) that parents of girls participated in more parental activities, and (c) the teachers rated student's interest in the science OST programs as high. Student comments on the survey and the qualitative analysis by trained coders revealed that success of the program was related to the collaborative and hands-on activities/projects of their OST program. In addition, students felt more involved in projects during after-school and weekend activities than in OST lunch break programs.

Chapter 1: Overview of the Problem and Study

Introduction to the Problem

Results from the Program for International Student Assessment (PISA) assessments show that children in the United States are low-performing in comparison to the rest of the world in the science, technology, engineering, and mathematics (STEM) fields (PISA, 2012). Additionally, the state of California performs near the bottom of the 50 US states on the science assessments for eighth grade students (National Center for Education Statistics, 2012). Such results are a cause for concern to educators, and, as a result, issues related to STEM education have achieved importance among policymakers and educators in recent years. The STEM fields have been shown to produce the innovation required to meet the needs of a rapidly changing world. The US has seen stagnant and in some cases declining number of students pursuing degrees in STEM areas. Therefore, not enough graduates enter the STEM workforce (Carnevale, Smith, & Melton, 2011; Clough, 2008; National Academy of Sciences, 2007, 2010; Subotnik, Tai, Rickhoff, & Almarode, 2010). Carnevale et al. (2011) estimate that 2.8 million science and technology jobs will have openings in 2018. Successfully teaching and integrating STEM subjects has been a concern for teachers. There is an urgent need for the US to develop a workforce capable in STEM fields, especially coding and robotics. The school day may not allow for comprehensive programs to take place so an out of school program may be desirable.

In California, 4 in 10 elementary teachers claim to spend less than one hour a week teaching science (Blank, 2012; Dorph, Shields, Tiffany-Morales, Hartry & McCaffrey, 2011). Fourth grade teachers spend an average of 27 minutes teaching science per day (Blank, 2012). Many teachers cite lack of time and lack of materials for teaching science, technology, and engineering (Dorph et al., 2011; Hartry, Dorph, Shields, Tiffany-Morales & Romero, 2012). Many schools and teacher credentialing programs place high priority on reading and math skills because these skills are assessed on a national level throughout a student's educational career, which begins in the primary grades (Cobern & Loving, 2002). Only 10% of students engage in science practices that include learning by participating in hands-on activities and analyzing data (Dorph et al., 2011). Such limited exposure to science content in their early school years may squelch students' interest in STEM activities and reduce their future interest in STEM careers. Between 2003 and 2009, about 28% of student's chose a STEM major for their bachelor's degree and nearly one half chose a different, non-STEM major by Spring 2009 (Chen, 2013).

There is an overwhelming body of evidence that supports teaching students in STEM subjects to students at an early age in order to pique their interest (Bers, 2008; Epstein & Miller, 2011; Gelman & Brenneman, 2004). Research has shown that engaging students in STEM subjects early on in their education can build an interest and desire to remain in STEM fields (Belden, Lien, & Nelson-Dusek, 2010; National Research Council, 2012). Early interest and involvement in STEM subjects can increase student achievement as well as get students excited to enter more advanced science fields (Bers, Flannery, Kazakoff, & Sullivan, 2014; Epstein & Miller, 2011). Promoting an early interest may also assist in getting more women and underserved minorities into the STEM pipeline. Limited research shows that mentoring partnership programs or Out of School Time (OST) STEM programs can increase student Science Self-Efficacy (Barker & Ansorge, 2007); this approach was a focus of the present study. A review of the literature in the area of STEM education suggested a need to examine how science education could be used to increase the motivation in students, especially in school-aged girls.

Across the US, states are promoting new teaching and learning standards aimed to make students college- and career-ready; however, many schools are left with curriculum that no longer meets the current standards (Common Core State Standards Initiative, 2016). Students are always tested on the current state standards while teachers may continue to teach an outdated curriculum. In light of this dilemma, there are two major reasons that may explain why teachers may lack skills to teach STEM. First, teachers are required to modify their district-adopted curriculum to become aligned with the current set of Next Generation Science Standards (NGSS) without sufficient training (Dorph et al., 2011). Second, when teachers are handed a new set of standards, but do not possess the necessary knowledge and skills to meet these requirements, teachers ignore the new requirements and continue to teach using their prior knowledge and skills (Goodlad, 1969; 1984). In some cases, teachers engage in self-study in an attempt to teach themselves (Davis & Krajcik, 2005; Grossman & Thompson, 2008).

In addition to the at-school limitations in STEM activities, parents feel less competent and uncomfortable working with their children on STEM-related topics when compared to other content areas taught in schools, such as reading (Freiberg, 2004; Shymansky, Yore, & Hand, 2000). With a lack of educational activities occurring during the school day and at home, there is a need for STEM mentoring programs and OST programs, particularly for girls. A program sponsored by a local university or community businesses might fulfill the need to teach science at the high school level by qualified people. Such a program does not infringe on the teacher's limited knowledge of the STEM subjects or require extra planning time. An ongoing mentorship program provides an opportunity for students to gain an interest in STEM.

Background of the Study

The current study will focus on two long-term OST mentoring programs which support high school students at the Einstein Science High School (DVS). In the first program called The Society of Women Engineers (SWE), high school girls mentor girls in grades K–8. The second program is called For Inspiration and Recognition of Science Technology (FIRST), and students are given a challenge of designing a robot that can accomplish certain tasks.

Science education is an important part of learning how to think logically and problem solve. Many teachers find it difficult to teach science for various reasons including lack of time, preparation, limited content knowledge, and/or insufficient materials (Dorph et al., 2011). One study noted that students in low-income schools get science education for less than 27 minutes per day (Blank, 2012). This study will highlight an alternative way to promote STEM education that does not place additional stress on the teacher but could possibly increase overall student achievement.

Evidence suggests that learning in STEM subjects may lead to increased student achievement in other areas as well (Bencze, 2010). The current study has the potential to provide insights that may help narrow the achievement gap at an increased rate. The OST FIRST Program provides opportunities for students to learn about coding and robotics in a relaxed atmosphere that focuses on collaboration and having fun while SWE allows older girls to mentor younger girls in engineering activities.

Exploring ways to increase student engagement with STEM subjects leads to more students entering the STEM pipeline and choosing careers in STEM fields (Sanders, 2009; U.S. Department of Commerce, 2011). Getting new perspectives in STEM fields may be the key to economic innovation that the US needs.

Statement of the Problem

The problem of this study is that limited research has been conducted to assess the effectiveness of OST programs.

Purpose of the Study

The purpose of this study was to examine how these OST STEM programs have an effect, if any, on students' Science Self-Efficacy. The study focused on the effects of student Science Self-Efficacy of students attending the SWE OST STEM program and FIRST OST STEM program. Establishing interest in science early on is one way to get more students into the STEM pipeline. High school has been chosen as the focus of this study because research has shown that interest in science declines sharply once students enter middle school (Archer et al., 2010; Rice, Lopez, & Richardson, 2013). It is hoped that a study like this could help students regain an interest in science.

Some of the unfavorable attitudes towards science can be attributed to boredom and/or the work being too challenging (Cuevas, Lee, Hart, & Deaktor, 2005; Hong, Lin, Chen, Wang, & Lin, 2014; Lloyd, Neilson, King, & Dyball, 2012; Paris, Yambor, & Packard, 1998). These OST STEM programs have the propensity to teach crucial 21st century skills that students need to thrive in this information age, such as critical and creative thinking, decision-making, collaborating, communicating, technological literacy, flexibility, social skills, and innovation skills. Data collected from this study provided valuable feedback to the school on how to adapt this program to better meet the needs of the students being served.

Theoretical Framework

The researcher has selected Bandura's (1997b) social cognitive theory as the theoretical basis for this study. More specifically, this study is based on Bandura's reciprocal determinism system, which posits that behavioral factors, environmental factors, and personal factors each influence one another in a multidirectional fashion as demonstrated in Figure 1 (Bandura, 1997b). Each influence is multidirectional, and the interaction of environment, personal factors, and behavior is reciprocal determinism. Reciprocal determinism views interactions from a social learning perspective (Bandura, 1977). Each of these components work together to generate a person's self-efficacy. The main idea is that all behaviors have certain consequences and these consequences can further influence future behaviors. Reciprocal determinism is an interaction of many different influences.

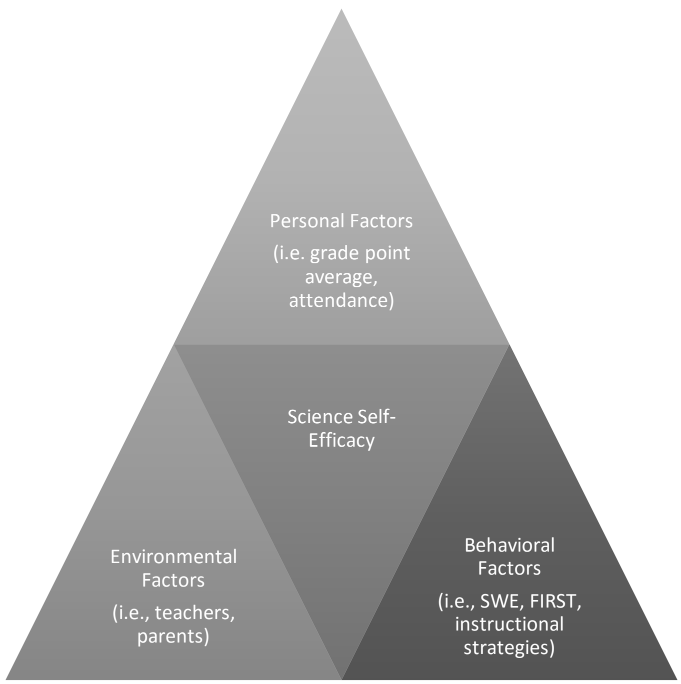

Figure 1. Study's factors placed within Bandura's reciprocal determinism model.

In the study of the OST programs, Bandura's reciprocal determinism system applies. Each factor influences the other two factors, which leads to the student's Science Self-Efficacy in the mentoring program and initial interest in joining the program (Pajares, Britner, & Valiante, 2000). Self-efficacy influences the amount of effort a person will put into a task (Pajares, 2005).

Self-efficacy influences what affects people's willingness to act in a particular situation (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996). Bandura (1977) asserted that people play a role in determining their self-efficacy. This study will use data gathered from a survey to measure each student's Science Self-Efficacy after participating in an extended OST STEM program.

Personal factors include thoughts, conceptions, beliefs, and self-perceptions about a given topic (Bandura, 1977). Personal factors for students involved include an interest in STEM and completing the required application necessary to apply for the program. Students with higher overall grade point averages (GPA) may have a higher Science Self-Efficacy. Another personal factor is participation in the workshops given by the mentors which allows students to learn more about STEM career paths. Students' expectations about any given task will affect their actions on the best way to complete the task as well as their expectations on the possibility of being successful. When a person chooses to participate in certain activities, those activities can in turn help to shape that person's personality and/or interests. Attendance at meetings may also indicate a higher Science Self-Efficacy. Students in the FIRST OST program must believe that they can design a build a robot that meets the current year's challenge. For the 2015–2016 school year, the robot had to climb towers and shoot a basketball through a window at the top of the tower.

Environmental factors are external factors that can influence a person's behavior (Bandura, 1977). Environmental factors can be divided between physical and social aspects. For the purposes of this study, the social environment is discussed. Most of the physical environments of interest to the present study are high school classrooms, but occasionally the workshops may be held in other venues. One's personality influences the type of environment a person may choose to be a part of. In the mentoring program, some environmental factors include parents' support, peer interactions, and various support from mentors while working in the program. Seeing other people successfully perform a task in the immediate environment can add to a person's self-efficacy (Pajares, 2005). Positive encouragement also aids in boosting a person's self-efficacy, which can also affect the personal factors, such as beliefs a person has (Pajares, 2005). In this study, teachers provided their judgment of each student's interest in STEM. Parents also described their participation with the OST STEM program and any STEM-related activities they have engaged in with their children.

Behavioral factors include a person's skills and actions (Bandura, 1977). Behavioral factors can be observed during the activities that are planned for students, such as the Femineer's Day workshop sponsored by the Society of Women Engineers. For the purposes of this study, the behavioral factors include the instructional strategies that took place during the OST STEM program. The aim of these workshops are for girls in grades K–8 to participate in activities to assist in building awareness of our carbon footprint. The students participating in the FIRST OST STEM program learned to specialize in a particular area like designing, manufacturing, and outreach. Bandura (1977) believes that observational learning is the result of behavior learned from the environment.

In an effort to improve STEM education through the use of the Einstein OST programs, it is important to evaluate the level of confidence, or self-efficacy, that students have in science subjects. Studying Science Self-Efficacy can be a way to improve student achievement and engagement (Britner & Pajares, 2006; Pajares et al., 2000).

Significance of the Study

This study (a) contributes to the valuable efforts to promote increased student Science

Self-Efficacy and interest in STEM fields, and (b) adds to the body of literature on ways to encourage students to enter and remain in the STEM pipeline. Many studies have shown a positive correlation between time spent learning science and science achievement, but few studies have looked at the actual content that is being taught (Blank, 2012; Sanders, 2009). This study looked at one OST STEM programs that teaches and supports girls in understanding STEM subjects and another program that promotes collaboration to accomplish a robotics challenge. The results of this study provide valuable information on best practices for teaching STEM subjects. The results of this study could also drive policy changes and possibly encourage the allotment of money to schools to provide similar mentoring support to those students who need it most. The results of this study may be used to create improved school plans to encourage and maintain student interest at all levels in the educational process. This study is intended to add to what is known about STEM education to high school aged students, especially with students that are typically underrepresented in the STEM pipeline and possibly reduce the achievement gap.

The intent of this research study is to use the findings to:

1. Support schools with creating and sustaining an ongoing and engaging mentoring program to increase science knowledge.
2. Improve students' research skills.
3. Increase college and career readiness among students.
4. Increase engagement in school activities.
5. Improve student attendance.

At the current rate of students interested in STEM education, there are not enough qualified candidates to fill available job positions. The programs at this school are intended to stimulate STEM interest and awareness in the targeted student populations. The Einstein organization recognizes the need to offer more comprehensive learning opportunities—especially for girls in science. Ensuring that more students are adequately prepared for the job market is important for the future of the US economy (Bonvillian, 2002). The potential effect of OST STEM programs in education necessitated this study as a means of improving the U.S. economy. We need more thinkers and innovators in the US to meet the demands of our future society and the input from females is invaluable. The programs offered at Einstein Science High School signal a determination to bring essential STEM skills to high school students, who are at the age where math and science skills have been shown to open up college and career pathways (Ralston, Hieb, & Rivoli, 2012). These programs may have the potential for increasing access to the STEM pipeline for more students, especially for girls.

Definition of Terms

For the purposes of this study, the following definitions are used:

- Enjoyment: A feeling of pleasure caused by doing or experiencing something you like (Merriam-Webster, 2017).
- FIRST: For Inspiration and Recognition of Science and Technology, a nonprofit, international youth group.
- Mentor: A more experienced person who assists, or teaches, a less experienced person into a particular way of life using one-to-one interactions (Parkay, 1988). Sometimes the mentee, or less experienced person, is called the protégé.
- Mindset: Differing beliefs about intellectual abilities. Some may think abilities are fixed, or unchangeable, while others believe abilities are malleable, or can be changed (Dweck, 2000).

- Parent: Any person living with the child acting in a parental role. This could be a guardian, grandparent, or sometimes an older sibling according to the California Education Code, sec. 26.002 (Findlaw, n.d.).
- Program advisor: Classroom teachers that assist students with an OST program.
- OST: Out of School Time programs that occur outside of the typical instructional school day.
- Self-Efficacy: Student’s self-assessment of their ability to perform, especially in challenging situations (Bandura, 1997b; Britner & Pajares, 2006).
- STEM: Science, math, engineering and technology education. The acronym STEM has many variations, but most people agree that a true STEM education integrates the subjects as opposed to teaching each subject in isolation (Gonzalez & Kuenzi, 2012; Reeve, 2015).
- Student: High school aged student in grades 9–12 participating in the programs.
- SWE: Society of Women Engineers, a group that promotes women in engineering.

Research Questions

The purpose of this study is to examine whether an ongoing OST program can improve student Science Self-Efficacy and spark interest in STEM education. As a means to examine students’ Science Self-Efficacy, this study used the following research questions:

1. How does the degree of parent participation correlate to a student’s Science Self-Efficacy?
2. How does the teacher rating of student interest correlate to student’s Science Self-Efficacy?
3. How does overall GPA affect a student’s Science Self-Efficacy?

4. How does student attendance at an OST STEM program affect a student's Science Self-Efficacy?
5. How does student participation in instructional activities in SWE affect a student's Science Self-Efficacy?
6. How does student participation in instructional activities in FIRST affect a student's Science Self-Efficacy?

This study posited the following two null hypotheses:

1. There is no significant correlation between any of the following factors and a female student's score on the Science Self-Efficacy Survey:
   - High school GPA.
   - Attendance at OST FIRST.
   - Attendance at OST SWE.
   - Teacher rating of student interest in science.
   - Parent level of support in OST science.
   - Student score on Instructional Activities Survey.
2. There is no significant correlation between any of the following factors and a male student's score on the Science Self-Efficacy Survey:
   - High school GPA.
   - Attendance at OST FIRST.
   - Teacher rating of student interest in science.
   - Parent level of support in OST science.
   - Student score on Instructional Activities Survey.

Delimitations

This study was exploratory and limited to one school site and two specific OST STEM programs. This study looked at a small target population at one school in a moderately sized school district. This school is a part of four small, college-preparatory public charters schools in Los Angeles dedicated to real-world, project-based learning. The target population is high school students aged 14–18 years old. The time period of the study coincides with the nine months of the academic school year.

Assumptions

This study is based upon the following assumptions:

1. Students respond to questions honestly and accurately.
2. An OST program in STEM can affect a student's Science Self-Efficacy.
3. The score on the Science Self-Efficacy Survey will accurately reflect the student's Science Self-Efficacy.

Timeline for Study

The FIRST Program began in 2010 while the SWE Program began in 2011. Data was collected in the winter of the 2016–2017 school year from participating students. Surveys were sent to all participating students and their families via email from their teacher's address.

Organization of the Study

The study description is presented in five chapters. Chapter 1 provided background information, statement of the problem, purpose of the study, significance of the study, definition of key terms, theoretical framework, research questions, limitations, delimitations, and assumptions inherent in the study. Chapter 2 provides a review of the literature including a brief history of the schooling system, STEM education, education reform, and the status of parental involvement. Chapter 3 describes the methodology used for this research study and includes the selection of participants, instruments, data collection, and procedures for analysis. Following data collection, Chapter 4 will provide complete data analyses and describe the study's findings according to the stated research questions and the results of the data analyses for the research questions. Chapter 5 includes a summary of the study conducted, a discussion of key findings, implications of the findings for theory and practice, recommendations for future research, and conclusions.

Chapter 2: Review of the Literature and Research

Overview

Concern regarding student knowledge in STEM fields is an increasing concern among policymakers and educators in the United States. The greatest concern is the achievement gap among minority students and their White counterparts (Bohrnstedt, Kitmitto, Ogut, Sherman & Chan, 2015). In this regard, the term *achievement gap* describes the discrepancy in achievement in standardized tests between minority students and their White counterparts. However, the comparison of the United States with other developed and technically advanced countries indicates that the United States ranks 20th out of 30 in science and 27th out of 34 in math according to 2012 data from PISA (PISA, 2012). In this regard, the achievement gap is also an issue on the international level.

Chapter 2 explores the literature and research related to the research study. This chapter provides a brief history of education in the US, which leads to the historical context of the problem under discussion. Following this, the history of STEM education as well as educational reforms are described. Concerns about the achievement gap, gender gaps, and teacher preparation as well as Science Self-Efficacy are highlighted. The importance of family involvement is also discussed in this chapter. The chapter concludes with information about robotics programs and the current program being researched. These various topics were selected because they are associated with the implementation of a STEM curriculum that may meet the needs of the new national state standards for student learning assisted by the community, namely a local university and parental involvement.

Search Process

The search for this literature review was performed using electronic databases such as ERIC, JSTOR, EBSCOhost, and PsycINFO. Search engines such as Google and Google Scholar were also utilized to a certain degree. Terms such as *science, technology, engineering, and mathematics*, *STEM education*, *STEM pipeline, mentoring, family involvement, parent involvement, Science Self-Efficacy, gender differences in STEM*, *STEM,* and *science education* were used as keywords in the initial searches to explore the topic. These resources were studied to identify the best practices for implementation of a science program that meets the needs of diverse learners.

Historical Context of the Problem

The idea of free compulsory education began in the 19th century after the American Revolution when the colonists won their freedom from Great Britain (Katz, 1976). Free compulsory education was originally suggested as a way to educate the members of the newly formed country (Katz, 1976). Thomas Jefferson thought all children should be afforded a basic public education in order to build a strong nation of thinkers (Katz, 1976). However, the concept of free compulsory primary education for every child in the nation gained little support until it was promoted by Horace Mann and Henry Barnard (Katz, 1976). Mann argued that a common school was the key to political stability and social harmony in the newly formed nation. He also played a crucial role in the development of training schools for teachers, and he created an easy-to-implement school plan termed the *graded school*, an advance from non-graded schools. Horace Mann thought schooling would help immigrants to the US assimilate. Henry Barnard, an educational reformer, helped create a state board of common schools and a teachers' institute. Together these reformers' ideas and work revised the U.S. educational system (Katz, 1976).

During the 19th century, only a basic education was needed to enter the workforce. Most people did not need to continue school past eighth grade in order to the meet criteria to find a job. Most jobs available were mundane and routine during the early industrial revolution and required very little thinking on the part of the employee. Machines were beginning to replace people in the workplace for many of the routine tasks, and these machines would transform tasks into small repetitive jobs. Workers no longer got to see an item produced from start to finish. The US began to need fewer skilled craftsmen and while more people were required for assembly line production. During this time period, schooling was systematically set up to mimic the need for developing workers who were adept at following directions and performing repetitive tasks. The division of labor in the factory was very similar to the division of labor in education. In school, the student was the raw product, and the product was a worker able to follow directions.

The public school system was originally designed in a slow-changing environment with few technological advances. The school was expected to produce consistent results year after year to maintain the constant needs of the job market and of society. Most students were motivated to get an education and enter the workforce during the industrial revolution in order to provide for their families. There was a trend of students leaving the classroom earlier and earlier to earn a living. Child labor laws and compulsory education laws were enacted to help keep young children from joining the workforce too early to enforce the importance of an education.

During this time, the one-room schoolhouse transformed into one with rooms based on age, which reflected Horace Mann’s model of a graded school. With students separated by age, teachers could deliver a unified curriculum to a batch of students that had similar developmental needs. This type of schooling was also able to handle increased numbers of enrollees. Each teacher played a role in developing the final product, the student who is ready to be an employee. This method of assembly line education is often called the factory model of education (Leland & Kasten, 2002).

Without compulsory education laws, many children were forced into child labor instead of schooling. However, by 1918, every state had passed child labor laws that imposed penalties for not attending school. By the 1920s, the use of standardized tests in the education field became popular. The factory model of education uses standardized testing as a means of quality control, and the assessments are viewed as a measurement of the quality of each student. A school was seen as an institution for training (Serafini, 2002). The answers that students placed on the assessment were also a product of the factory model of education. Many of the standardized tests consist of multiple-choice questions, with one correct answer, scored by a machine. While multiple-choice assessments can be quick to score, some students are not good test takers and could benefit by opportunities to showcase their learning in other ways.

Although compulsory education laws were in effect in many parts of the country during the last quarter of the 19th century, they were very difficult to enforce. At this time, fewer than 15% of all school-age children were enrolled in school (Katz, 1976). By the year 1918, all American children were required to attend elementary school, and the statutes were more effective, which resulted in increased attendance. During the first quarter of the 20th century, attendance offices were established, and money from the state began to be tied to the presence of the students.

Both Barnard and Mann believed it was the job of the teacher to educate the students. The assumption was that parents could not devote the appropriate amount of time and probably did not have the skills needed to help their children. As schools began to change, parents were not seen as vital components to the academic education of their children. Barnard and Mann became some of the first educational reformers with their vision of creating a public school system.

Over the last 100 years, the factory or industrial model of education has remained particularly consistent, while the skills for the workforce have changed dramatically. The advent of new technologies has made advancement in the educational process necessary for the country to prosper and prepare people for jobs of the 21st century. For example, being an automobile mechanic now requires many technological skills that were not needed in the past. In the 21st century, auto mechanics need the basic skills of reading and writing as well as computer literacy skills. As cars and car production become more computer-dependent, the skills required to build, manufacture and maintain them includes knowing how to program and reprogram these machines. The current way of educating students is no longer sufficient for producing a competitive workforce.

The vast majority of 21st-century jobs and careers require knowledge that cannot be taught using the factory model of education. Many of the problems that students will face in their futures may not exist during their school-aged years, so there needs to be a greater emphasis placed on problem solving, group work, and critical thinking skills to help ensure that students are better prepared to handle novel challenges (Lantz, 2009; Nourbakhsh et al., 2005). The factory model of education is not conducive to producing the types of skills that are required to be successful in the 21st century. The factory, or industrial, model of education creates a large population of people ready to follow instructions so they do not mess up their part in the assembly line. This model of teaching conditions people to stay inside their narrow box, whereas problems of the future require a great deal of thinking outside the box. Jobs of the future, and not simply those related to high technology, require a much greater knowledge of STEM (Lockard & Wolf, 2012).

A Nation at Risk and School Reform

President Reagan commissioned the National Commission on Excellence in Education which wrote “A Nation at Risk,” detailing some of the issues in our current education system. It describes the US as failing and producing academic underachievement (Gardner, 1983). This report was issued after a 30-page report was compiled reviewing US public schools, highlighting declining student achievement, along with poor teacher preparation and pay. There was a fear that other nations would surpass the US as the world leader in mathematics and technology. Since then, many educational reform efforts such as the No Child Left Behind Act of 2001 (2002) and the Every Student Succeeds Act (2016) have attempted to address the same issues. Each of these reform efforts have attempted to increase the rigor of teaching and testing in school, especially in the area of math and science, as well as promote a greater sense of community among families and school staff.

With student achievement at the forefront for policymakers and educators alike, there have been some shifts in the educational process, mostly in the form of revised student achievement standards. Recently, many states have adopted a set of common standards to promote increased rigor in the classroom and college readiness entitled the Common Core Standards. The Common Core Standards cover the core content areas of reading, writing, and mathematics. These grade level standards describe what students should know and be able to do at the end of each grade level. Additionally, many states have taken part in developing national science standards called Next Generation Science standards which focus more on an inquiry-based approach to teaching science versus only reading from a textbook (California Department of Education, 2015a). The science framework was developed by states and used by teachers to guide instruction. The aim of these standards is to provide a roadmap teachers can use to guide students to a quality education that will make them college ready and career ready by the completion of high school.

STEM Education History and Definition

STEM education has been of national interest since the founding of the US. There was vigorous debate among representatives of the 13 founding states about the importance of science. On August 18, 1787, the members of the convention tried to determine if the federal government should create learning location for arts, sciences and literature (Madison, 1987). The value of STEM education became of utmost import after the Sputnik satellite was developed and launched by the Soviet Union on October 4, 1957. The USSR's success in launching Sputnik set off the space race as well as the US desire to catch up to and surpass other countries (NASA, 2007). Teachers realize there is great value in STEM education for the continued wellbeing of our society (Brown, Brown, Reardon, & Merrill, 2011).

Prior to the use of the acronym STEM, the acronym SMET was widely in use (Cavanagh & Trotter, 2008; Sanders, 2009). The acronym STEM is used to represent the teaching and learning of science, technology, engineering, and math (Gonzalez & Kuenzi, 2012; Reeve, 2015). This acronym does not suggest that there is an interaction between these four items (Sanders, 2009). The California Department of Education (2015a) describes STEM as courses, possibly in sequence or taken individually, or any activities relating to science, technology, engineering, or mathematics. The four elements of STEM are defined as follows:

- Science is the study of the natural world, including the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines. Science is both a body of knowledge that has been accumulated over time, and a process—scientific inquiry—that generates new knowledge. Knowledge from science informs the engineering design process.

- Technology comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves. Throughout history, humans have created technology to satisfy their wants and needs. Much of modern technology is a product of science and engineering, and technological tools are used in both fields.
- Engineering is both a body of knowledge—about the design and creation of human-made products—and a process for solving problems. This process is design under constraint. One constraint in engineering design is the laws of nature, or science. Other constraints include such aspects as time, money, available materials, ergonomics, environmental regulations, manufacturability, and reparability. Engineering utilizes concepts in science and mathematics as well as technological tools.
- Mathematics is the study of patterns and relationships among quantities, numbers, and shapes. Specific branches of mathematics include arithmetic, geometry, algebra, trigonometry, and calculus. Mathematics is used in science and in engineering. (Council, 2009, p. 17)

Although STEM is a topic of enduring interest in the realm of education, Brown et al. (2011) found that many educators at school sites do not share a clear understanding of STEM education. Studies have showed that teachers spend very little time teaching science, due to their discomfort (Howitt, 2007; Westerback, 1984). To other researchers, teachers' lack of understanding regarding STEM education equates to students missing critical content essential for economic growth (Bybee, 2010; Reeve, 2015). Teachers find it difficult to adequately prepare students in subjects they are not themselves confident about. Raising more awareness about STEM education among educators is critical for schools wishing to create a strong STEM pipeline (Brown et al., 2011). The STEM pipeline is a metaphor used to describe the pathway a student takes towards earning a STEM degree and entering the work field in a STEM career.

The STEM pipeline is often referred to as *leaky* because many students prematurely exit the pipeline. Clark Blickenstaff (2005) offered some examples of leaks in the pipeline that include a person changing the area of study after starting college, change the area of study in college, or getting a STEM degree but working in a different field. After a general consensus is made about the definition of STEM education, further steps can be made for planning the appropriate curriculum. Each state adopts its own standards for student learning that tells what students should know and be able to do at the end of each school year.

Standards for learning. The National Research Council and the American Association for Advancement in Science cite drastic changes in our lives for the rationale behind new standards for student learning. The need for new standards arose from the idea that the US is losing its economic competitiveness with other countries and more students need to be educated for STEM jobs (California Department of Education, 2015b). Additionally, many states have begun adopting rigorous common standards for math and language arts to better prepare students for college. In both cases, standards are being modified with a greater focus on increasing student knowledge by promoting essential skills that students need to know and understand to be successful.

STEM education in the US has been on the minds of many, including presidents, policy makers, and educators (Reeve, 2015). During the third annual White House Science Fair in April 2013, President Obama said, "One of the things that I've been focused on as President is how we create an all-hands-on-deck approach to science, technology, engineering, and math….We need to make sure this is a priority to train an army of new teachers in these subject areas, and to make sure that all of us as a country are lifting up these subjects for the respect they deserve" (The White House, 2013, para. 5). The Educate to Innovate initiative began in November 2009 as a way to increase the standing of US students in STEM learning (The White House, Office of the Press Secretary, 2009). The idea is to give the students the skills they need to critically work through and solve the problems of tomorrow. President Obama understands that education in the STEM fields is vital for the United States to continue to flourish and innovate.

Achievement Gap

Even with compulsory education, the US has long been plagued with the notion of an achievement gap. There are two levels of achievement gap under discussion, national and international levels. At the national level, an achievement gap occurs when there is a large disparity in achievement based on standardized test scores between minority students and their White counterparts. The achievement gap has lessened a bit over time (Bohrnstedt et al., 2015), but there is still a marked lag in achievement for underserved and diverse student populations. In 2007, Black students in fourth grade showed a narrowing gap in mathematics scores in 15 states and a narrowing gap in reading in three states. A similar trend can be seen with Hispanic students, and eight states have showed a decreased gap in math and six states have showed a decrease in reading.

According to the Bohrnstedt et al. (2015), by eighth grade, Black students showed a narrowing gap in math in four states and there was no change in score gaps for reading assessments. In 2009, for Hispanic students in two states had a gap that narrowed, one state had a gap that widened, and 45 states showed no change. Reading scores for Hispanic students showed no change in the achievement gap for 39 states, and three states showed a narrowing of the gap (Bohrnstedt et al., 2015). The achievement gap appears to persist as students progress through the grade levels (National Assessment of Educational Progress, 2013). In fact, one study showed a significant gap in science achievement that occurs within the first two years of formal schooling (Curran & Kellogg, 2016).

According to the College Board survey, Advanced Placement curricula in computer science is only available in 5% of high schools, and of that amount, only 19% enrolled are girls, and a mere 4% are Black, and 8% are Hispanic, while 54% are White (College Board, 2014). This further confirms that students, especially those students who are typically underserved, are not entering or remaining in advanced science courses. This situation leads to students who will not be eligible for high paying jobs and technological leadership roles.

Researchers have varying views on the causes of the achievement gap evident in science and mathematics education. Students with limited science knowledge may have difficulty comprehending public policy issues like climate change (Morgan, Farkas, Hillemeier, & Maczuga, 2016). The achievement gaps in science are evident even by the time students enter kindergarten (Morgan et al., 2016). Brooks-Gunn and Duncan (1997) believe poverty plays a role in the gap. Häkkinen, Kirjavainen, and Uusitalo (2003) believe the educational level of the parents plays a role in the gap. Other researchers believe that parent involvement is at the core of student achievement (Barnard, 2004; Lee & Bowen, 2006). Still others believe that increased parental involvement could be the key to narrowing the achievement gap that exists between minority students and their White counterparts (Colombo, 2006). However, researchers are not in agreement on the reasons as to why this achievement gap persists.

Standardized testing is a factor in the decisions the federal government makes when deciding how to issue money to various schools. Since the reauthorization of The Elementary and Secondary Education Act of 1965 (ESEA) with the No Child Left Behind Act of 2001, time spent teaching language arts and math has increased, while time spent teaching science has decreased (Dorph et al., 2011). While science is tested in fourth and eighth grades, the scores only account for 5.9% of a school's adequate yearly progress score (Dorph et al., 2011). The school's test scores are used to determine interventions needed to improve performance.

Several types of schools have emerged over the years to better educate students to meet the ever-changing needs of society. Some parents have chosen to homeschool their students, which allows for total control on the delivery of instruction. Other parents have decided that private schools will best fit their idea of an ideal education that prepares their students for the future. More recently, parents have been given an option called Public School Choice. With this option, parents can choose to move their students from their designated school if it is failing, to another public school if there are available spots. Still other parents may prefer other specialized schools. Numerous organizations have made suggestions on how to improve STEM education in the US. A report from the National Research Council (2012) suggests that STEM goals could be achieved by having specialty schools with a STEM focus. At each of the schools, students would need to apply for admission.

It is very important to get more minorities currently living in the US into the STEM pipeline. The 2010 Census demonstrated that Hispanics are a rapidly growing segment of the US population, now representing about 16% of the entire population. Blacks represent about 12% of the total US population (U.S. Department of Commerce, 2011). With the rate of minority students increasing, it is important to meet the needs of these learners. The students in the STEM pipeline are not representative of the current or projected future minority students in school.

At the international level, an achievement gap is also occurring. There is currently a shortage in qualified individuals for STEM careers. As a result, the United States has many foreign-born scientists and engineers (Wright, 2013). According to the Census Bureau, more foreign-born students are earning degrees in STEM fields (Gambino & Gryn, 2011). This further suggests that US-born students are not being sufficiently prepared to enter STEM fields. More research needs to be done to better understand why these gaps exist and what can be done to lessen the gaps.

Specialized Schools

Many specialized science magnet schools have appeared to meet the growing need for science education. These schools are also highly competitive and selective. Magnet schools originally began in the 1970s as a way to desegregate schools. Now, magnet schools are seen as a more elite version of a public school due to the particular focus or area of study that a magnet school may have. Magnet schools tend to have an approach to learning that has a heavy emphasis on inquiry (Leiding, 2008). Magnet schools that focus on STEM subjects could play a vital role in ensuring that more students enter the STEM pipeline (Casey, 2012; Kesidou & Koppal, 2004; Olson & Labov, 2009).

Charter schools are another type of school that has gained prominence in the world of education. Charter schools have the unique advantage of being able to adjust their curriculum to meet the needs of their learners. Charter schools are afforded the opportunity to be innovative with their curriculum while not charging students tuition, are available to all students, and do not have entry requirements. Many Charter Schools are competitive and have a selection process for students.

STEM Education Reform

Proponents of STEM education favor establishing a pipeline that is strategically set up to direct students towards careers in one of the STEM fields (Ralston et al., 2012). The pipeline would begin with exposure to STEM subjects in elementary school. This can be done by classroom teachers providing supplemental curricula, after school programs focused in STEM areas, or even summer camps for students to engage in hands-on activities in STEM areas. These programs would be taught as units that focus on solving real world problems such as climate change (Bybee, 2010). Similar programs would continue in middle school and high school to continually support and maintain the interest of students. An effective STEM pipeline would also provide professional development for classroom teachers.

The STEM pipeline is referred to as being *leaky* when students exit the path towards STEM education and careers for various reasons (Allen-Ramdial & Campbell, 2014). Students are said to exit the STEM pipeline for many reasons, including discrimination and lack of interest in pursuing jobs related to STEM fields. Bidwell (2015) suggests that a better alternative to fixing the leaky pipeline is to get to the root of the issue and get more students interested in STEM subjects. The President's Council of Advisors on Science and Technology noted that increasing proficiency as well as increasing interest in STEM fields is important for students (Holdren, Lander, & Varmus, 2011; Sanders, 2009), and to that end it is critical to strengthen STEM education across the grade levels.

In 2009, President Obama introduced the President's Council of Advisors for Science and Technology (PCAST). This group features a group of leading engineers and scientists tasked with the goal of making policy recommendations to the President (The White House, Office of the Press Secretary, 2009). Previous presidents maintained similar committees to provide scientific and technical advice to the president. This committee released the Undergraduate STEM Education Report to the President (Olson & Riordan, 2012), which recommended an improvement for STEM during the first two years of college, ensuring that students had the appropriate tools to be successful. It called for various pathways to obtain STEM degrees (Olson & Riordan, 2012). Furthermore, PCAST suggested that a Presidential Council on STEM Education be created to assist with implementation of these recommendations.

The STEM Education Caucus was created as a response to the need to improve STEM education at all levels. This caucus presented ideas to help fill a void associated with the need for STEM learning necessary to acquire many jobs of the future as well as to increase the overall human intelligence capital. The STEM Education Caucus maintains that people literate in STEM will provide various types of intellectual capital for the economy that includes students prepared to work as researchers, technologically proficient workers, and voters who understand statistics. In general, when compared to other academic areas, students tend to view science and math in a negative light and choose to not pursue these subjects past the required courses (Rice et al., 2013).

Legislation

Legislation plays an important role in how education is carried out at the school level. ESEA was the first major federal law to target the improvement of education for students from lower income areas. Under the leadership of President George W. Bush, the NCLB was an attempt "to close the achievement gap with accountability, flexibility, and choice, so that no child is left behind" (Public Law 107-110, para. 1, 2002). NCLB was the seventh iteration of ESEA meant to improve the educational outlook of underserved students and provide for greater accountability. This new law called for improving achievement for disadvantaged students, increasing the quality of teachers and principals, creating 21st century schools, and improving parental involvement. Some additional requirements included annual assessment and highly qualified teachers and administrators.

The NCLB legislation also offered measures for schools that do not make adequate yearly progress based on the standardized test scores. Some of these corrective measures include allowing students to transfer schools and pursuing a major corrective action at the school site. The Academic Performance Index is a result of the 1999 Public Schools Accountability Act passed by the state legislature. The Academic Performance Index measures students' academic progress and performance at schools across the US; it ranges from 200 to 1000. Adequate Yearly Progress is a measure that holds schools accountable under the Title I section of NCLB and measures the progress toward meeting academic content standards; scores represent the number of students at or above proficiency in a certain area. This measure was first put into legislation in the 1994 reauthorization of ESEA. Each of these measures disaggregates the data according the school population and different subgroups of learners, such as those who are socioeconomically disadvantaged, racial or ethnic minorities, or disabled students. Students are assessed in third through eighth grades and one year in high school.

NCLB specifically calls for the entire community to "share the responsibility for improved student academic achievement and the means by which the school and parents will build and develop a partnership to help children achieve the state's high standards" (Davis, 2005,

p. 18). Adequate yearly progress was the measure used to determine quality of the student's education based on a standardized test score. Schools that do not meet the growth targets are forced to make drastic changes to their educational plan, which could include an overhaul of administration and/or teaching staff.

In President Obama's 2016 State of the Union address, he called for computer science for all students. President Obama noted that progress should continue by "offering every student the hands-on computer science and math classes that make them job-ready on day one" (Obama, 2016, para. 15). The STEM Education Act of 2015 acts as a starting point for preparing students for the future.

The STEM Education Act of 2015 includes the following:

> [the legislation] requires the Director of the National Science Foundation (NSF) to continue to award competitive, merit-reviewed grants to support: (a) research and development of innovative out-of-school STEM (science, technology, engineering, and mathematics) learning and emerging STEM learning environments; and (b) research that advances the field of informal STEM education. (STEM Education Act, 2015)

Funding is available for schools and organizations that have the resources to write the necessary grants. The NGSS were adopted by the state of California in 2013 as a means of getting students to be college ready and career ready (California Department of Education, 2015b).

President Obama's reauthorization of the ESEA includes having family involvement integrated throughout the educational process, and not simply mandated as a set of discrete items (Every Student Succeeds Act of 2015, 2016). The Senate passed the Every Student Succeeds Act of 2015 (2016), which put an end to No Child Left Behind in 2015. The Every Student Succeeds Act of 2015 (2016) gives the state opportunities to test for accountability and is viewed as an improvement over NCLB because students are given fewer standardized tests and allowed other measures of assessment, such as portfolios. This bill is a reauthorization of the ESEA aimed to end the failures of NCLB. Sections 11500–11506 of the Federal Education code describe the importance and value that parental involvement has on increasing the achievement of students, especially those in large urban areas. In fact, parents are seen as key parents to their students' education in the eyes of the federal government (Programs to Encourage Parental Involvement, 1990). These sections continue by describing how parents should be involved at the local level and further describe the value that parental involvement creates with students.

A Call for STEM Literacy

STEM education is very important for the future of the US's economy and innovative problem solving (Lantz, 2009; Nourbakhsh et al., 2005). At the elementary level, the focus should be on getting students excited about the possibilities that STEM can bring. Once students are excited about STEM, it is important to maintain their enthusiasm for the remainder of their educational career. Oftentimes, students get discouraged by a bad experience and never regain interest in that particular field again. Beginning in middle school, interest in science and math begins to decline (Rice et al., 2013). This is typically the point in a student's education that the student leaves the self-contained classroom with one teacher and enters the realm of different teachers for each content area.

To a certain extent, STEM education is being used across the nation, but each component of STEM is isolated and unconnected with the others (Sanders, 2009). Donovan, Mateos, Osborne & Bisaccio (2014) worried that with such a heavy emphasis on tests, many isolated facts and figures are presented to students to get high scores on the tests that are needed to move them to the next test, without ensuring that students understand these subjects conceptually and in relation to each other. Research shows that learning occurs best through interdisciplinary units that integrate various content areas (Reeve, 2015). Additionally, retention of learning is greater when more care is taken to align teaching along big ideas that transcend time and content areas (Hoachlander & Yanofsky, 2011; Sanders, 2009).

There are resources available online for educators to improve their practice. The *You for Youth* is a website promoted by the Department of Education as a source for providing curriculum for afterschool programs (About You for Youth, n.d.). Educators can find resources that support 21st century learning. Some of the major topics addressed on the website are STEM, problem-based learning, and family engagement. Research suggests that problem-based learning is a great way to promote inquiry while solving real world problem in STEM fields (Sanders, 2009).

Bringing more diversity into STEM fields creates more diversity in innovation and advancement in society (Daily & Eugene, 2013). Stevens, Plaut, and Sanchez-Burks (2008) argue that while diversity is deemed positive, there is more potential for conflicts. In order to reduce some of these conflicts people must have ample opportunities to collaborate with others who come from diverse backgrounds before they enter the workforce. A school setting seems like an ideal place to practice working in groups that contain individuals with differing perspectives. Research shows that student interest in science tends to decline around the middle school age with students believing science is not interesting or relevant (Basu & Barton, 2007). Getting students to realize their Science Self-Efficacy at an earlier age may boost or sustain their interest in science as they get older (Bers, 2008; Gelman & Brenneman, 2004).

Perceived feelings of support from parents, teachers, and peers greatly improve the achievement of students. A study by Rice et al. (2013) concluded that when students feel supported, they have a better attitude towards math and science, which in turn creates increased achievement in these areas. The academic achievement comes from feelings of self-efficacy that students feel from having great support from influential people in their lives.

Teacher Preparation

A complete STEM education prepares all students to become successful citizens who are ready for employment in our technological world, and this is an issue of high importance (Gonzalez & Kuenzi, 2012; Obama, 2016). In the general education classroom, STEM education could be improved by spending more instructional time on curricula that focuses on essential topics (Sanders, 2009). However, many teachers seem to lack a clear understanding of what STEM education entails, and many of these failures in understanding reach back to their teacher preparation courses (Brown et al., 2011). Epstein and Miller (2011) cited issues with STEM education that begin in elementary school and stated that a strong foundation must be set during these crucial years. Many elementary school teachers feel uncomfortable and unprepared teaching science, which equates to students not getting the education they need (Howitt, 2007; Westerback, 1984). Teacher credentialing programs do not adequately address the need for teaching math and science in an integrated way (Kurt & Pehlivan, 2013).

Another issue facing teachers is their limited knowledge about how to teach science in a way that meets the cultural and linguistic needs of their students (Bravo, Mosqueda, Solís, & Stoddart, 2014). Research shows that the attitudes teachers have about science can be transferred to their students (Baker et al., 1992; Krajcik, Czerniak, Czerniak, & Berger, 2003; Ramsey & Howe, 1969). When teachers are not comfortable with teaching and do not feel adequately prepared, they will not teach science or may do a poor job (Crosby, 1997; Riggs, 1991).

The issue of teachers being prepared to teach science may start with the required teacher preparation courses in the credentialing program. Elementary school teachers are generalists by nature because they teach all subjects, but many teachers feel especially anxious teaching science (Crosby, 1997; Riggs, 1991). Most teacher credentialing programs mimic the standardized tests by placing a heavy emphasis on reading, writing, and mathematics (Cobern & Loving, 2002). Some pre-service elementary school teachers take their science courses in a lecture style environment with the rest of the students at the college, meaning these courses are not specifically geared towards educators (Bergman & Morphew, 2015). Training for pre-service teachers that provides only limited amounts of time to engage in science pedagogy can produce teachers who are hesitant to delve into this subject area once they get their own classrooms (Casey, 2012; Olson & Labov, 2009). Many teachers feel uncomfortable teaching science and these feelings of uneasiness can transfer to the students (Baker et al., 1992; Krajcik et al., 2003; Ramsey & Howe, 1969). However, when teachers learn more about how to teach science and math, their anxiety levels decrease and they are more likely to teach science (Cady & Rearden, 2007).

Another critical component of teacher preparation courses should be examining potential unconscious biases. Teachers may subconsciously promote the idea that boys are best suited for science and math (Furnham, Reeves, & Budhani, 2002). One study found that teachers and boys have more interactions with each other versus the interactions of the teachers and girls (Campbell & Storo, 1996). Peltz (1990) asserted that boys have more access to lab equipment during science courses. Another study showed that teachers provide more coaching for boys to get the correct answer and hold boys to a higher standard of academic quality in their work (Clark Blikenstaff, 2005). Hill, Corbett, and St. Rose (2010) found that teachers can encourage girls to have more of an interest in science. Some of this encouragement can happen increasing the science identity of girls and providing more opportunities to behave as a scientist in tasks that mimic real-world scenarios (Riedinger & Taylor, 2016).

Sanders (2009) suggested that ongoing professional development that allows for cross-curricular planning is beneficial when planning learning modules that will actively engage students. STEM subjects need to be taught in a way that demonstrates the connectedness of each area (Cook & Bush, 2015; Reeve, 2015). An integrated approach to teaching STEM subjects appears to be a possibility for reducing this issue (Sanders, 2009). For example, the integration of math and science has been shown to increase student achievement in these subject areas (Kiray & Kaptan, 2012). Using inquiry as a starting place for teaching science has also proven to be very effective as students practice the process of being inquirers (Chen, Wang, Lin, Lawrenz & Hong, 2014; Kim, Tan, & Talaue, 2013).

Reeve (2015) suggested that in preparation for teaching STEM subjects, teachers should take the time to engage in their own STEM thinking by challenging themselves to share with students how STEM is related to their lives. STEM thinking can be defined as "purposely thinking about how STEM concepts, principles, and practices are connected to most of the products and systems we use in our daily lives" (Reeve, 2015, p. 8). Teachers can then take these novel experiences back to their students and create a new learning experience for them. The students can learn from their teacher's experiences and gain a better understanding of the importance of STEM.

OST programs. One way to answer the call for STEM literacy is to provide high quality OST programs for students (Jackson, 2013). OST programs provide optional extended learning opportunities for students while not taking time away from the regular instructional day. These can be great opportunities for students to catch up on or acquire new skills. Because these programs are optional, usually offered by the school site, and free, oftentimes families choose to not enroll their children while other families may find their children on a waiting list to get in. After-school programs can be beneficial, but they generally do not reach the entire student population. The availability of OST programs varies greatly between school sites and are heavily dependent upon funding.

OST programs that focus on STEM learning often teach students how to learn in cooperative group settings while learning in a hands-on way (Hussar, Schwartz, Bioselle, & Noam, 2008). Hands-on learning has been shown to have the students think more critically as they manipulate the objects they are studying in a real-world application. This style of teaching has also been linked with increased student achievement (Burton, 2014; Ekwueme, Ekon & Ezenwa-Nebife, 2015). OST programs allow opportunities for students to engage in high interest activities that enhance STEM learning (Hoachlander & Yanofsky, 2011). Much of the allure of OST programs comes from the lack of traditional tests and assessments, so it may be difficult to measure the effectiveness of the program (Barker, Nugent, & Grandgenett, 2014).

Parent and Family Involvement

Students may spend more of their waking hours with their teachers, but parents still remain the most important influence in a student’s life (Shonkoff & Phillips, 2000). Parent and family involvement is assistance given to a student by a family member or caretaker either at home or at school. LaRocque, Kleiman, and Darling (2011) defined family involvement as an “investment in the education of their children” (p. 116). The most crucial part in getting families involved in the education of their students is school officials building strong relationships with the families (Lopez, Scribner & Mahitivanichcha, 2001). Building these types of relationships with the community allows family members to gain opportunities to learn more about ways of getting involved in their student's education.

Numerous studies have shown that students achieve more in an academic setting when family members are involved in the educational process (Barnard, 2004; Desforges & Abouchaar, 2003; Epstein, 1994; Hara & Burke, 1998; Hiatt-Michael, 2001; Jeynes, 2005). A study conducted by Keith and Keith (1993) found that parental involvement yields academic increases across all subject areas and the greatest impact happens when parents assist with homework. Part of the increased achievement on the part of the student can be attributed to seeing adults actively engaged in their education (Hara & Burke, 1998; Mapp, 2003). Research also suggests that parental involvement decreases as students move on to higher grade levels (Epstein, 1995). The issue of parental involvement can be seen as an equity issue, in which students living in lower socioeconomic settings are not afforded the same benefits as those with higher socioeconomic statuses, and this bifurcation further perpetuates the achievement gap (Smith, 2006). Efforts to address this issue have yielded success, such as studies done by Tang, Dearing, and Weiss (2012) found parental involvement to be very important for increasing literacy for Spanish speaking low-income families that may have had previous difficulty.

Viewing parental involvement as a means of increasing student achievement is not a new idea. Right before and right after the US was deemed to be "at-risk," some researchers clearly understood the importance of building stronger relationships that bridge home and school for the sake of student achievement (Bronfenbrenner, 1979; Hobbs, 1984). Hoover-Dempsey, Bassler, and Brissie (1987) suggested that teacher efficacy, the belief that the teacher has the ability and resources to educate the child, contributed to high rates of parental involvement.

Education reform around parental involvement. Lawmakers have noted the importance of parental involvement with educational reforms, as evidenced by numerous laws and policies that incorporate parental involvement. Head Start programs were the first federally funded programs that focused on parental involvement. The creation of Head Start programs in 1964 put parental involvement at the forefront of a child's education, as parents were required to participate in activities at school. Head Start programs were designed to support low-income families with various services. One aspect of the services provided include assisting with the transition to school by providing access to preschool. The guidelines for Head Start programs have a heavy emphasis on getting the parents involved in the education of the child (Schumacher, 2003). Epstein (1995) believed that the Head Start programs set the stage for the importance of parental involvement in education. Many other early education programs started as a result of Head Start.

Another policy entitled Goals 2000: The Educate America Act was signed into law on March 31, 1994. This legislation proposed eight national goals to be achieved by the year 2000, one of which was to increase parental involvement. Federal funding was provided for schools to assist in meeting the goals. More recently, was the enactment of Title I, a federal program intended to improve the student's level of reading and math through parental involvement. Title I schools receive money to improve parental involvement in low-income schools. In fact, Title I is part of the NCLB federal legislation aimed at reducing the achievement gap among disadvantaged students, and one of the strategies listed was to increase the family involvement in the student's education. Additionally, under NCLB, parents were given the option of removing their child from a failing school.

The Parent Teacher Association (PTA) is an organization that also seeks to increase parental involvement (Levine, 2010). The National Parent Teacher Association website mission states that “The overall purpose of PTA is to make every child’s potential a reality by engaging and empowering families and communities to advocate for all children” (National Parent Teacher Association, n.d., para. 1). As the name implies, the PTA is a way to connect parents and teachers with the goal of better educating each student. The PTA website lists six standards for parental involvement programs: welcoming all families into the school community, communicating effectively, supporting student success, speaking up for every child, sharing power, and collaborating with community. These standards are modeled off of Epstein’s levels of parent involvement.

Six types of involvement. There are various ways that parents and other family members can participate in the student’s education. Dr. Joyce Epstein (2001) described the six ways of participation as being: parenting, communicating, volunteering, learning at home, decision-making, and collaborating with the community (Epstein & Hollifield, 1996). These categories show the various aspects of participation and how parents can be involved both in and out of the school setting. School officials can use these six ways of participating to plan and coordinate events for true family involvement.

While the Epstein model of parent involvement (2001) is widely used, there are criticisms. One criticism is that fact that the Epstein model does not take into account the cultural differences of families or account for other ways parents may be highly involved (Bower & Griffin, 2011). Table 1 gives a brief explanation of parental involvement as well as challenges and expected results (Epstein & Hollifield, 1996).

Table 1

Summary of Epstein's Six Types of Parent Involvement

Type and description	Some challenges	Expected results
Parenting: help with parenting skills and understanding development of student	disseminating information to parents who cannot attend	increased confidence level among parents
Communicating: communication about student progress and school events	ensuring communications are understood by all education levels	increased interactions
Volunteering: involving parents to support school programs	making everyone feel welcome	increased number of volunteers
Learning at home: involvement in academic activities related to schoolwork	maintaining a regular schedule of work that can be interactive	improved grades
Decision-making: participation in school policy making	ensuring parent makeup reflects the diversity of the school	parents have more input
Collaborating with community: coordinating community resources	few resources in the community means sharing is largely one-way	increased knowledge and available resources

Epstein (1995) also created a model to demonstrate the interaction of school, family, and community that she calls *spheres of influence*. Each sphere can be manipulated to vary the amount of overlap to illustrate how some things are accomplished together, with a partner, or alone (Epstein & Hollifield, 1996). The idea is that students hear a consistent message about doing well in school from all three spheres, based on the notion that schools can build their community to promote caring and increased parental involvement (Epstein, 1995).

Epstein and Hollifield (1996) agreed that strong parent involvement will have instrumental effects on education. One key effect is the increased focus and motivation of students. Epstein and Hollifield (1996) also suggested that the most important form of parental involvement may be the involvement that takes place in the home, because of the impact on attendance and behavior. Parents also benefit from increased engagement by obtaining a better understanding of what their child is learning in the classroom, thereby being more capable of assisting.

Schools that have programs that successfully engage parents will notice gradual increases in the number of families that participate, with three years being the amount of time needed to truly witness the growth (Epstein, 1995). Hoover-Dempsey and Sandler (1995) offered another framework for viewing parental involvement, consisting of five levels: parental involvement decision, parents' choice of involvement forms, mechanisms through which parent involvement influences student outcomes, mediating variables, and student outcomes. Parents are more likely to become involved in their child's education if (a) they feel that part of parenting involves assisting in the academic area, (b) they believe they can have a positive impact on educational outcomes, and (c) there are various opportunities to participate (Hoover-Dempsey & Sandler, 1995).

Parental involvement in STEM areas. Parental involvement is a strong predictor of future interest in math and science (Turner, Steward, & Lapan, 2004). Parents also play a key role in a student's attitude about science (Miller, 1989). It is important to understand various ways of getting more family involvement in students' educations; however, many policymakers are not truly meeting the needs of minority populations (Delgado-Gaitan, 1991). While parental involvement is viewed as necessary for the improved education of the students, many minority and low-income parents feel marginalized at their children's schools (Abrams & Gibbs, 2002). Parents are important members of the school community and they should be treated as such.

The refrigerator door is often seen as an area to display important student work. Researchers have found that most work displayed on the refrigerator door is either language arts or visual arts (Shymansky et al., 2000). These researchers go on to state that science is rarely the topic of family discussions throughout the day (Shymansky et al., 2000). Within STEM subjects there is a greater support from the parents for math versus science (Rice et al., 2013). This effect may be due to the fact that math concepts are clearly illustrated in daily life, whereas daily implications for science education may be overlooked or not as immediately obvious.

Family involvement in science and other subject areas can be increased when school staff members are able to provide a hands-on learning experience that is purposeful (Solomon, 2003). Kaya and Lundeen (2010) recommended beginning science education early on as a means to encourage student learning. Some schools offer family nights based on themes such as science, math, or literacy. Families are invited to the school campus to engage in set activities with their students.

Barriers to Parental Involvement

Parents are often described as being marginalized in school settings. Schools typically mirror middle class society and parents may not feel comfortable there. Murphy and Pushor (2004) argued that the intentions of parental involvement activities serve the mission of the school and thus view parents from a deficit perspective. Some parents may internalize this feeling and consciously choose to not participate in educational events. Oftentimes parents are blamed for not participating in school activities, yet the school does not get evaluated on the methods for communicating with parents (Murphy & Pushor, 2004). School staffs that do not take adequate measures to successfully involve parents may be sending a subtle message that the knowledge of the parents is not valued.

School culture vs. home culture. The actual culture of the school may be a barrier for parental involvement. Research suggests that school culture mimics that of a middle class society, whereas schools today often serve heterogeneous population (De Gaetano, 2007; Lareau & Benson, 1984). Families are vital to the transmission of culture to the students. The differing cultures of schools and families can lead to a communication breakdown, whereby families are viewed as uninterested in the education of their child. Family members may not be aware of how to get involved in their child's education (LaRocque et al., 2011). In some cultures, it may be considered rude by the parent to question the teacher's authority, or parents may feel they will obstruct their children's academics by their involvement (Tang, 2015). González and Jackson (2013) found that is important for schools to be culturally responsive when deciding on the best ways to involve families in the school in order to be most effective.

Traditionally, African American and Latino families have been viewed as having lower rates of family involvement with their school aged children in comparison to other nationalities, and these families are often seen as uncaring (Simoni & Adelman, 1993). Studies have shown that some families may still believe the professionals at school provide academic education while families are responsible for moral education (Smrekar & Cohen-Vogel, 2001). Some cultures may consider it disrespectful to interfere with the school by attending a parent-teacher conference, even when given a direct invitation to do so (Mapp, 2003). On the other hand, numerous studies have found that these families are very involved in the education of their children, though their methods that may be deemed nontraditional (Fields-Smith, 2007; Freeman, 2010).

Many families that do not conform to the traditional views of education are assisting their children in ways that may go unrecognized by school staff members. Mapp's (2003) study showed that most parents engage in verbal support, constantly encourage their children to do well in school and succeed in life, or inquire about their school day. Making stakeholders aware of the various ways in which parental involvement can occur may help alleviate misunderstandings.

Research suggests that the amount of parental involvement is positively correlated to socioeconomic levels, meaning that students in lower income areas have less parental support overall (Hara & Burke, 1998; Lopez et al., 2001). A similar relationship has been found between parents who harbor negative feelings as a result their own experiences with rote memorization of facts when they attended school (Shymanksy et al., 2000; Solomon, 2003).

Some of the discrepancy involved in the responsibility of educating each child seems to be influenced by social class. According to Lareau (1996), middle-class parents tend to share with the school the task of educating the child, while lower class parents believe the responsibility of education lies mostly in the hands of the school. The differences seen here also affect the relationships that families have with the schools. Generally speaking, middle class parents believe it is their right to contact the school to inquire or question, whereas lower and working class families do not feel it is within their right to question the happenings at the school site.

Poverty and socioeconomic status. Socioeconomic factors are shown to be a strong predictor of cognitive skills for students entering kindergarten (Lee & Burkam, 2002). The lower the socioeconomic level, the lower the cognitive skills, with the opposite also being true. These trends continue throughout the academic career of students (Hart & Risley, 1995). Some parents may be unavailable to participate heavily in their child’s education due to job constraints (LaRocque et al., 2011). A parent who works during the day and early evening may find it difficult to lend a helping hand at the school site. Some parents may even sleep during the day and work at night and are unable to assist with assignments at home. Socioeconomic status plays a key role in the types of jobs that parents are able to obtain and the allowable amount of time off for child rearing purposes.

Semantics. Another part of the discrepancy surrounding parental involvement lies in the definition of the words "parental involvement." Traditionally speaking, parental involvement is seen as parents going to the school to meet with the teacher or assist in the classroom. While some parents may not be able to do these things, many parents believe telling their students to do their best, bringing their child to school, and ensuring their students do their homework is also parental involvement.

Content knowledge. In the area of science education, parents seem to think they do not know enough about the subject to assist their children. In a study where science experiments were taken home to complete with the parents, some parents expressed reservations about a child possibly asking a question the parent could not answer (Solomon, 2003). In general, parents typically do not use the skills taught in the classroom on a daily basis, so they may have forgotten (Mapp, 2003). The new shift to the Common Core state standards has transformed the way teaching and learning is taking place, and parents may be unaware of or might not understand these new expectations. There seems to be decreased parental involvement as children get older, and this could be due in part to the increased difficulty of assignments (Hoover-Dempsey & Sandler, 1995).

Language. Families with limited English proficiency may find it difficult to assist their children with schoolwork. Language can also play a factor in a family member's willingness to interact with the teacher or other members of the school site. Many parents find it hard to assist their children with work or participate in school meetings if their English is limited (Moles, 1993; Pena, 2000). Even when schools ensure the sending home of materials in various language, keeping the website updated, and posting signs outside of the school there is still a chance that some parents have limited language abilities and therefore are not privy to the information (Pena, 2000).

Social. Networking with other families is part of staying informed with what's going on in the community and at the school. Research suggests that lower and working class students spend the majority of time outside of school engaged in unorganized activities with their siblings and cousins of varying age ranges (Lareau & Benson, 1984). On the other hand, middle class students spend much of their time outside of the classroom engaged in structured sports activities based on age (Lareau, 1996).

Time. Many parents work more than one job to support their family, so making the time to assist their child can be difficult. There may be issues with child care for other siblings or transportation may not be readily available (Moles, 1993).

Options. Parents who may be unable to participate in the traditional forms need other options. Mapp (2003) found that many parents suffer from a lack of suitable options to participate.

Teachers. Some teachers may hold an assumption that parents are not interested in their child's education. This assumption can lead to teachers not making an honest effort when it comes to bridging home and school (Epstein & Hollifield, 1996). Some teachers may find the effort required to reach out to parents is too much or will not yield great results, so teachers may do nothing at all (Pena, 2000). Additionally, there is little energy put forth to assist teachers in learning more about effective ways to engage with parents (Epstein, 1995; Moles, 1993).

Perceived school climate. Studies have shown that, coupled with limited knowledge about education, parents from low socioeconomic backgrounds may feel intimidated by the power the teacher possesses, (Moles, 1993).

The Home-School Connection

Research has showed that families, regardless of socioeconomic status or ethnicity, want their children to do well in school (Mapp, 2003). Engaging families in the educational process of their child can be difficult if there are barriers preventing families from full involvement. It is imperative that trust be built between the school and families in order to begin the facilitation of parental involvement (LaRocque et al., 2011). Trust can be established by providing many opportunities for bidirectional communication between home and school.

Parents and caregivers want their children to achieve, but not all know the best way to accomplish this. One research-based way of improving parental involvement at home focuses on educating the teachers on ways to increase their interpersonal skills (Hara & Burke, 1998). A teacher who opens the doors of communication between home and school can open the doors to greater learning for both their students, parents and themselves. It appears that successful partnerships can be built with teachers taking the initiative with outreach programs to the families of students (Lareau & Benson, 1984).

Hoover-Dempsey and Sandler (1995) conducted extensive research on reasons why parents decided to become involved in their child's education. They found parents become involved because:

1. They develop a personal construction of the parental role that includes participation in their children's education.

2. They have developed a positive sense of efficacy for helping their children succeed in school.
3. They perceive opportunities or demands for involvement from children and the school (Hoover-Dempsey and Sandler, 1995, p. 310).

The research conducted by Hoover-Dempsey and Sandler (1995) suggests that merely sending home open invitations for parents to become involved at the school will yield little success. Parents are more likely to respond positively to very specific requests from the school or their child. Some parents simply believe that assisting their student is part of their job as a parent.

A model was created to show five levels to show the levels of parental involvement and the rationale for certain decisions (Hoover-Dempsey & Sandler, 1995). The bottom level, level one, discusses the reasons why parents get involved. The second level describes different forms of involvement by parents. The third level lists mechanisms by which the parents' involvement will influence student outcomes. The fourth level describes tempering and mediating variables, and the fifth level lists possible student achievement outcomes.

Hiatt-Michael (2008) described four forces that influence the different types of parental involvement: cultural beliefs, social structure, economic influences, and political pressures. Cultural beliefs can vary between parents and schools in regards to what is deemed appropriate parental involvement. Social structure may include changes in family structure. Economic influences could include employment options. Political forces could include power struggles in the government.

Traits of Successful Parental Involvement

Many staff members at schools understand the importance of parental involvement and have taken steps to increase the involvement at the school level. Most successful efforts include getting a team together that includes staff members and parents who accurately represent the diversity of the community (Epstein, 1995; Epstein & Hollifield, 1996). The major goal of this team is to design a plan for implementation that utilizes the various forms of involvement. Once the program is designed, team members implement and recruit other participants and revise the plan as necessary.

A family or parent center at the school site allows the parents to have a consistent place to meet. This venue can be used as a location for parenting events or classes. This center is also a location where parents can have informal discussions with other parents of students at the same school (Mapp, 2003). Many valuable pieces of information are disseminated by word of mouth.

One school in Massachusetts decided to implement a three-pronged approach to increase participation: welcome, honor, and connect, and this program successfully increased their parent participation to 90% (Mapp, 2003). The welcoming stage made parents feel a sense of belonging to school. The honoring stage recognized the strengths of the families and the knowledge they possess, while realizing that parents are partners. Finally, parents and teachers realized a connection in order to make the educational process better for all students.

The amount and degree of parental involvement is heavily dependent upon the culture of the school (Mapp, 2003). Schools with the greatest parental involvement place a high value on building strong relationships with all parents and this approach is one that is grounded in mutual trust. A key component in building this type of relationship with families is having a highly involved principal or other leader (Epstein, 1995; Mapp, 2003). The general school climate must support the cultures of the families and have a welcoming feel (Epstein, 1996; Pena, 2000). Staff members realize that many families are highly involved even though it may not be in the traditional fashion (Epstein, 1996). Getting students to become more involved in their child's learning before they enter school may help alleviate some of the achievement gaps found when students enter kindergarten.

Experiential Learning in OST programs

OST programs can serve as opportunities for students to extend their STEM learning. Participation in OST programs can also help students see what careers are available for them in the future. OST programs are most effective when they are learner-centered and focus on real world applications of knowledge (Worker & Smith, 2014). Many robotics programs for students are designed according the experiential learning theory (Kolb, 1984). The experiential learning theory is a cycle with five phases (Woffinden & Packham, 2001):

1. Experience: The process of engaging in the activity at hand.
2. Share: A social aspect where observations and reactions are shared with those in their environment.
3. Process: A reflection about what has happened.
4. Generalize: Discover ways to connect this experience to real-life.
5. Apply: Applications for similar and different learning experiences.

Experiential learning is based on the constructivist idea of learning, whereby students are active learners who combine what they already know with the new information they are learning (Barker & Ansorge, 2007).

OST programs can function in various ways. Papazian, Noam, Shah, & Rufo-McCormick (2013) have found that high quality OST experiences in STEM can get students interested and keep students interested in STEM subjects. OST programs are generally less formal than the traditional style of classroom and provide opportunities for students to interact on a more personal level with teachers and peers (Khisty & Wiley, 2013). OST programs serve as a tool to assist students in building their identity in STEM.

Using robots to teach skills to children has several educational implications. Working with robots not only teaches computer science skills, but it also teaches core values such as teamwork and collaboration (Bers et al., 2014). When attempting to have younger students gain interest in STEM subjects, robots serve as a fun and playful way to integrate academic content. Because robots are seen as toys to the students, students are more likely to remain engaged in the activity presented (Mauch, 2001). Fagin and Merkle (2003) asserted that robots can be instrumental in positively promoting learning and motivation.

Robotics programs allow students to engage in problem solving practices in real life and in their academic content areas. The use of robots allows for more creativity in learning when concocting solutions to problems (Beer, Chiel, & Drushel, 1999). Students can begin to realize that there are multiple valid ways to solving the same (Beer et al., 1999). Robots also allow students to access computer science, even at younger ages (Bers, 2008, 2010; Bers, Ponte, Juelich, Viera, & Schenker, 2002). Robotics programs assist with learning science and math by helping the students to understand scientific and mathematical principles (Rogers & Portsmore, 2004).

OST programs in science have also been shown to get students more interested in science careers (Bhattacharyya, Mead, & Nathaniel, 2011). Many students show increased interest and more positive attitudes in science careers after participating in robotics programs (Chen et al., 2014; Welch & Huffman, 2011). Many girls enjoy the collaborative and cooperative style of learning that experiential learning activities can provide as opposed to competitive activities (Cannon & Scharmann, 1996; Chang & Mao, 1999).

Self-Efficacy

Bandura (1986, 1997b) stated that self-efficacy describes people's beliefs of control over their lives and includes cognitive, motivational, and emotional responses. A student's self-efficacy can be determined by four sources: mastery experience, vicarious experience, social persuasion, and physiological states. The degree to which each of these sources matters depends on the task at hand. A person with high self-efficacy will set goals and work to achieve those goals and is considered to have a mastery goal orientation (Urdan, 1997). People with high self-efficacy would also find ways to stay motivated to achieve their goals. Stressors are well-managed by people with high self-efficacy (Bandura, 1997b). People with high self-efficacy entertain more career options than those with lower self-efficacy. Student self-efficacy is a strong predictor of success in college programs (Bandura, 1986; Schunk, 1984).

Self-efficacy can be encouraged by providing students with constructive feedback that focuses on an improvement in their achievement (Bandura, 1977, 1986; Britner & Pajares, 2006). The physiological state of a person can also affect their self-efficacy. For example, states that can be interpreted as negative (e.g., stress and anxiety) can cause a person to think negatively about their self-efficacy and in turn they may not perform well on any given task (Britner & Pajares, 2006). All of these items contribute to how students develop and view their self-efficacy (Lopez, Lent, Brown, & Gore, 1997).

The attitude a student has for science has been shown to be positively correlated to their achievement in science and increased engagement (Germann, 1988; Napier & Riley, 1985; Taylor & Brown, 1988). Furthermore, students' perception of their self-efficacy is a powerful factor in career choice and development (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Additionally. when teachers have low self-efficacy about science, they will not teach it (Koballa

& Crawley, 1985). The National Research Council suggests that personal interest and enthusiasm in science may be linked to career and educational choices (Schweingruber, Keller, & Quinn, 2012). Some research suggests that students can be taught to be more optimistic and have a more positive outlook on science tasks (Chen et al., 2014).

Growth Mindset

Having a growth mindset means that a person feels that intellectual abilities can be changed (Dweck, 2000). Students with a growth mindset attitude are concerned with learning and believe that effort is important (Dweck, 2000). A growth mindset is evidenced when students are faced with a challenging or difficult situation. The reactions determine whether the student has a fixed or malleable mindset. The role of mindset can be one of the issues challenging women in STEM areas.

Growth mindsets can be explicitly taught. Some studies have shown that when students are taught to think of the brain as a muscle that needs exercise by learning new things, this learning can carry over to academic content areas and life skills (Blackwell, Trzesniewski & Dweck, 2007; Good, Aronson & Inzlicht, 2003). Cimpian, Arce, Markman & Dweck, (2007) believe that praising students for their effort may give students better skills to preserve when faced with challenging situation. This method is the opposite of offering praise for their intelligence. When students learn about how the brain can be developed, they also learn that knowledge can be developed. Students become more open to the idea of being able to gain knowledge overtime.

Gender Gaps

While the STEM pipeline is leaky, women seem to exit the pipeline at a much faster pace than men (Clark Blickenstaff, 2005). There are gender differences of perceived confidence that begin in middle school (Pajares, 2005). Women comprise approximately half of the workforce, yet they comprise less than 25% of US STEM jobs (Beede et al., 2011). Men overwhelmingly dominate the field of engineering (Falkenheim & Burrelli, 2012). The participation of females in engineering and computer science courses and careers is much lower than that of their male counterparts (Beede et al., 2011; National Science Foundation, 2017).

Various reasons are cited as possible factors that discourage females from pursuing degrees and careers in STEM fields. Some factors that inhibit females from participating in these areas include (a) males outperforming females on spatial skills and the standardized tests that allow entry into the profession, and (b) females choosing careers based on gender-role biases (Ceci, Williams, & Barnett, 2009; Halpern et al., 2007; Hill et al., 2010). Academic sexism—such as sexist comments about academic competence—can also affect the attitudes of females in regards to STEM-related fields (Clark Blickenstaff, 2005; Campbell & Storo, 1996; Hill et al., 2010; Leaper & Brown, 2008). Not having a role model or a family friendly work environment can also contribute to the disproportionate lack of women in STEM fields (Beede et al., 2011; Clark Blickenstaff, 2005). Women can become intimidated in advanced science classes by the lack of other females in the class with them (Bailey & Campbell, 1999; Clark Blickenstaff, 2005; Campbell & Storo, 1996). A study conducted by Blake-Beard, Bayne, Crosby, and Muller (2011) found that students with a mentor achieve greater success. These are only some examples of what causes females to doubt their abilities in STEM-related subjects (Mosatche, Matloff-Nieves, Kekelis & Lawner, 2013).

Oftentimes, women view STEM subjects as not fitting with their gender identity (Bailey & Campbell, 1999; Casey, 2012). One study showed that these negative mindsets towards science have been developed during the student's school years (Cvencek, Meltzoff, &

Greenwald, 2011). Other research suggests that girls have a difficult time viewing themselves in a STEM career so more measures must be taken to shape the STEM identities of young girls (Riedinger & Taylor, 2016). Oftentimes young boys are given gifts that allow for manipulation or construction which allows boys to develop their identity as a scientist early on (Oakes, 1990).

Some research suggests that parenting may bring about the gender gap. Furthermore, research shows that parents feel their sons are more intelligent than their daughters (Furnham et al., 2002). It is believed that parents estimation of their child intelligence may be self-fulfilling meaning that sons are more intelligent because the parents think it to be true (Furnham, 2001). When asked to self-report IQ scores, men also gave themselves higher scores than women. In high school, girls receive a consistent message that science is not for them, based on the vast majority of scientists in their textbooks being male (Sadker & Sadker, 2010)

Stout, Dasgupta, Hunsinger & McManus, (2011) argued that perhaps deciding to enter a non-STEM field is not really a choice. Jones et al. (2000) found that girls have less access to science equipment than boys. In the classroom, boys are continuously encouraged to keep trying while girls may be allowed to give up (Oakes, 1990). Some would argue there is a lack of congruency between the lived experiences of students and the experiences students have at school (Costa, 1995; Phelan, Davidson & Cao, 1991). All of these factors have aided in creating limited desires for females to study and enter a STEM-related field.

Many of the gender gaps are evident in elementary school-aged students. Some studies have showed that when students are asked to draw a representation of a scientist, girls ask for permission to draw a woman (Losh, Wilke, & Pop, 2008; Manzoli, Castelfranchi, Gouthier, & Cannata, 2006). In that same study, boys had the tendency to include more technological aspects, while girls drew figures related to biological or medical sciences.

Research suggests there are some steps that can be taken to alleviate some of the deleterious effects that gender biases and stereotypes have on females. Simply learning and being made aware of the discrimination that occurs against females can serve as a way to prevent accepting these mistruths (Weisgram & Bigler, 2007). Being made aware of the valuable contributions of females in STEM fields and possibly having a female as a mentor has also been proven effective at increasing the self-concept of girls (Carlone & Johnson, 2007; Stout et al., 2011). Mentoring programs have shown positive effects on increasing enrollment in STEM fields (Payton, 2004).

Educators and policymakers across the US want to ensure that women are well represented in STEM fields to maximize the competitiveness, creativity, and innovation of the workforce (Hill et al., 2010). Women comprise slightly more than half of the adult population while their mean wage is less than that of males (Institute for Women's Policy Research, n.d.). The lack of women in these areas may contribute to this employment and salary gap between the sexes. The issue of confidence is critical to increase the prevalence of females in STEM fields. Increasing confidence in girls is highly correlated to perseverance in difficult tasks (Hill et al., 2010). Some believe that females are underrepresented in STEM subjects and careers due to a lack of mentoring for these women (Marlow & Marlow, 1996).

Mentoring Programs

The mentoring of individuals can be described in various ways. Swoboda and Millar (1986) described grooming mentoring and networking mentoring. The more traditional approach to mentoring is when a more experienced person takes on a novice in a particular field, also referred to as grooming mentoring. Oftentimes this novice, or mentee, is referred to as the protégé. Another method of mentoring places peers in a mentoring relationship where the role of mentee and mentor can alternate at various times, and this is referred to as networking mentoring.

Some studies assert that both the mentee and the mentor have a mutually beneficial relationship (Brewer & Carroll, 2010; Karcher, 2008). Good, Halpin & Halpin (2000) stated that mentoring programs can assist in retention of minority students in STEM classes. One study suggested there is an appeal for peer mentoring because the mentee knows that the mentor has had similar experiences (Brady, Dolan & Canavan, 2014). Mentors also have much to gain, particularly in the sense of learning how to explain concepts to teach to other students; they also gain in their leadership skills (Good, et al., 2000). Healy and Welchert (1990) also noted the mentors gain positive feelings of being able to assist other. Mentoring can also be a cost-saving way of assisting students in achieving their goals.

Description of the Program

The Einstein Science High School is in the CGI Unified School District are four independent charter schools in a small Unified School District. Each of these charter schools have a focus on either Science, Design, Innovation, or Communication. The Innovation school serves grades K–8 while the other three schools serve grades 9–12. Each school focuses on students engaging in a project-based learning approach.

Many colleges and universities look for ways to build their educational repertoire with schools and assist the students at these schools in becoming college- and career-ready. One charter school—Einstein Science High School—partnered with Cal Poly SLO and Northrop Grumman to design the SWE Program that targets girls in grades K–12. The aim of the program is to bring a highly qualified, diverse group of students to and through Cal Poly's engineering program and into STEM jobs at top-tier engineering companies, such as Northrop Grumman.

This team identified four "bottlenecks," or places where students tend to fall out of the STEM pipeline:

1. Many students in our community, particularly girls, are "turning off" to STEM, and engineering in particular, before they reach high school.
2. Many students enter their freshman year at Cal Poly San Luis Obispo (SLO) unprepared for the rigor and workload.
3. The majority of top graduating DVS students do not choose Cal Poly SLO over their other options.
4. Supporting the success of student at Cal Poly SLO.

Additionally, the faculty and staff at Einstein Science High School believe in the urgency of STEM education. One such program that addresses the need for more STEM learning is the FIRST Program. This OST STEM program focuses on collaborating, designing, building, testing a robot that is in a competition that tests the students' robot at a given challenge. Some female members of this program started the SWE Program.

To combat the first bottleneck, the girls' mentoring program, SWE, was created. This partnership has provided participating Einstein Science High School girls with access to engineering programs, engineering camps, and a junior robotics team. The Society of Women Engineers holds monthly "Femineers" events that bring girls in grades K–8 hear keynote speakers and they take part in engineering challenges all while interacting with students who attend the Einstein Science High School. The members of SWE design and implement these activities while at their monthly meetings.

Summary

This literature review examined the history of the educational system, legislation, and current issues pertaining to how schools are educating students in regards to science, technology, engineering, and math. The STEM pipeline was also discussed along with information detailing the leaky nature of this pipeline. It is important to include science education in our schools due to the increasingly technological world. This literature review also examined the importance of and barriers to parent involvement as a means of promoting greater student achievement through various policies and organizations aimed at parents. The description of the OST STEM programs was also discussed in this section. Improving student Self-Efficacy is viewed as a key way to improve the achievement of students in science and possibly keep students in the STEM pipeline.

Chapter 3: Methodology

Overview of Study Design

This chapter details the mixed methods case study that examined students' experiences in two OST STEM programs at Einstein Science High School in Southern California. An embedded mixed methods approach allows the researcher to obtain alternative forms of complementary data related to the topic (Creswell & Clark, 2007). In this study, a series of different data was collected with the aim of utilizing Bandura's theory of Reciprocal Determinism and suggests that high school GPA, attendance, parent support, teacher perception of teacher interests, participation in numerous instructional activities will affect a student's Science Self-Efficacy.

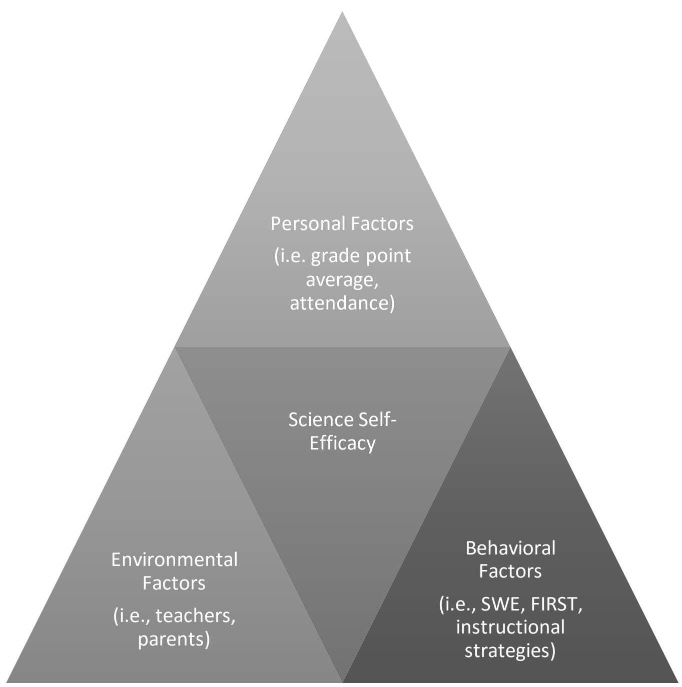

Figure 1. Study's factors placed within Bandura's reciprocal determinism model.

To secure that aim, the researcher participated in long, open-ended interviews with the two advisors who provided the background and information for this study. This background information is presented under the subheadings Sample Population and Research Design later in this chapter. The factors to be examined in this study were gathered in various ways. Student GPA and attendance in each of the OST STEM programs was collected from school records. Participating students participated in both a Science Self-Efficacy Survey (see Appendix A) and an instructional activities survey (see Appendix B). Parents participated in a short survey assessing their support of their child related to science (see Appendix C). Teachers (program advisors) also rated their perception of each student's Science Self-Efficacy in the form of a survey (see Appendix D). The analyses of this collected data provided a picture of the effects of OST STEM programs on the student's interest in science. The findings of this study can be used to assist in developing a better understanding of how a student's participation in an OST STEM program and related factors may affect their Science Self-Efficacy—an indicator toward selecting science as their career choices.

This study examined selected factors related to two OST STEM programs at the high school level and Science Self-Efficacy in high school students. The study asked the following research questions:

1. How does the degree of parent participation correlate to their student's Science Self-Efficacy?
2. How does the teacher rating of student interest correlate to student's Science Self-Efficacy?
3. How does overall GPA affect a student's Science Self-Efficacy?

4. How does student attendance in OST STEM programs affect a student's Science Self-Efficacy?

5. How does student participation in instructional activities in SWE affect a student's Science Self-Efficacy?

6. How does student participation in instructional activities in FIRST affect a student's Science Self-Efficacy?

More specifically, this study posed the following two null hypotheses:

1. There is no significant correlation between any of the following factors and a female student's score on the Science Self-Efficacy Survey: high school GPA, attendance at OST FIRST, attendance at OST SWE, teacher rating of student interest in science, parent level of support in OST science, or student score on Instructional Activities Survey.

2. There is no significant correlation between any of the following factors and a male student's score on the Science Self-Efficacy Survey, high school GPA, attendance at OST first, teacher rating of student interest in science, parent level of support in OST science, or student score on instructional activities survey.

First, the qualifications of the researcher are discussed, followed by the description of the population, research design, data collection, protection of human subjects and data analyses.

Qualifications

As a researcher and a credentialed teacher, I have an inherent interest in this program because of the impact it has on students and the possibilities it holds out for greater productivity for the US. I also have a strong interest in science education and serve as the science lead teacher at my school site. This is an important opportunity to learn from each other and it is a goal for me to discover ways of enhancing STEM education for all students.

Description of Population

The researcher has selected a case study and will focus in-depth on one high school site that has been highly interested in STEM for a number of years. The following information was obtained from the district superintendent, the site administrator, and the two OST program advisors. In addition, this material was further verified by them.

Einstein Schools opened as independent charter schools with three schools focused on "learning by doing." The Einstein Schools were authorized by the CGI School District. The authorization of the Einstein Schools into the CGI School District meant that both primary schools and high schools would be in operation. In 2014, the CGI School District became known as the CGI Unified School District and serves students from grades K–12 in four traditional district schools and four charter schools. Prior to the unification of the CGI School District and Einstein, CGI only consisted of three elementary schools and one middle school (Reference). This unique partnership allows for the sharing of resources like gym facilities.

For the Einstein Science High School, the physical location of the CGI Unified School District makes it ideal for partnership with many STEM-related companies like Northrop Grumman and SpaceX. The schools and these companies are within walking distance of each other and such close proximity can provide great inspiration for future STEM careers. Additionally, some employees from these establishments occasionally serve as mentors for the students in the OST STEM programs. A former aerospace headquarters has been designed to enfold the three schools into one building and will be opened to students in 2017.

The population comes from the students who are attending the Einstein Science High School. Approximately 135 students enter the Einstein Science High School as freshman each year. Students attend this school from the surrounding districts and this includes students from more than 80 zip codes. The Einstein Science High School was created to focus on promoting science careers and the population is 37% girls and 63% boys. Table 2 gives demographics for the Einstein Science High School.

Table 2

Einstein Science High School Standardized Tests Results

Percent of Students Scoring at Proficient or Advanced on standardized testing 2014-2015	English Language Arts (Grade 11)	Math (Grade 11)	Science (Grade 10)
All Students	80%	61%	30%
Female	73%	74%	30%
Male	83%	39%	32%
Black or African American	73%	72%	43%
Hispanic or Latino	73%	52%	18%
White	100%	75%	63%

The Einstein Science High School offers a curriculum based on project-based learning. Einstein offers various “career pathways,” or a set of courses that students can take that are related to a particular field. Regardless of selected pathway, each student takes the course Introduction to Engineering Design in 9th grade and Principles of Engineering in 10th grade. Students take classes related to their particular pathway beginning in the 11th grade. Einstein Science currently offers three pathways: STEAM (Science, Technology, Engineering, Art & Math), Biomedical, and Engineering. During the 2015–2016 school year, a new pathway called Medical started and was in high demand. Each pathway is designed to prepare the students for college courses and careers related to that field.

Research Design

The researcher selected an embedded mixed methods case study to allow for a close examination of the participants in the OST STEM programs. This is a case study because an in-depth look was provided on two of the many programs that Einstein Science High School has to offer. The researcher was interested in the delivery and outcomes of the program, a variety of data was collected in the form of surveys and interviews. Thus, this study is considered a mixed methods case study based on Creswell (2014). The data collected included the following:

1. Use of school records such as attendance and student GPA.
2. A student survey using a forced-choice scale that includes two open-ended survey questions, and a demographic survey.
3. A parent science involvement survey using check-off items indicating how parents support STEM at home.

Participants, namely students, parents and teachers, completed a survey (Appendices B, C, D, & E) sent to their email addresses. The survey was designed using Qualtrics and was taken at the recipient's convenience. Most survey questions used a 6-point forced-choice scale and others had option boxes that could be checked off. The survey consisted of 25 questions that required a rating on the 6-point forced-choice scale and there was an option for a short response for two questions. The survey questions used a forced-choice scale to allow the researcher to add the responses for each question to get a final score. It was assumed that this final score should reflect higher numbers for students with higher Science Self-Efficacy.

Sample population. The sample consisted of the students at Einstein Science who have chosen to participate in one or two OST STEM programs. The students in the STEM OST programs volunteered to participate. The researcher obtained a letter of support from the principal of Einstein Science High School to conduct this study (see Appendix E). There was a combined total of 111 students in grades 9–12 for the FIRST OST program and the SWE OST program. The FIRST teacher was an engineering teacher. The SWE Advisor was a 9th grade physics teacher.

Program design. The Einstein Science High School offers a "Program Fair" which is very similar to a job fair. Students had the opportunity to learn about the various programs being offered at the school and they decide which program(s) to enroll in. Some programs include the Garden Program, Feminist Program, Stay Woke-Social Justice Program, Debate Program, Glee Program, and the Prelude to Enlightenment Program. Participants chose to participate in OST STEM program(s) based on their interest in science education. Students were eligible to participate in more than one program if they desired.

After the inception of Einstein Science High School, teachers began noticing that girls were not choosing to attend the Science School, preferring rather to attend the other high schools that had non-STEM foci. Starting OST STEM programs was one way teachers thought they could build a community that embraced all students and encouraged more girl participation. One STEM OST program, The SWE, was started exclusively for girls by members of the FIRST Program. The STEM OST FIRST Program and SWE Program being offered at Einstein Science focus on:

1. Creation of a curriculum based on hands-on, interdisciplinary projects that address real-world problems.
2. Fun activities that boost not only math and science skills, but also motivation to aim for college.
3. Developing an integrated pathway for the development of future engineering leaders.

During FIRST sessions, students are challenged to work collaboratively to build a robot. Members of the FIRST Program are required to make each piece of the robot themselves. During competition season, students in FIRST meet daily and on Saturdays. Competition season usually lasts for 12 weeks during the Winter/Spring semester. During this time, only six weeks are allotted for the building and testing of the robot. For each meeting, a parent volunteer brings enough food to feed all of the students and teacher. Prior to competition season, participating students meet once a week for several hours after school. Parents also volunteer to feed the students and staff during these meetings as well.

Each member of the team specializes in a certain task, and the team compiles a final document that describes all of the learning that has taken place while being a part of the FIRST Program. Speaking, listening, and writing skills are also reinforced as students share their thinking and create their collaborative document using Google Documents. The motto for the FIRST Program is, “It’s More Than Robots!” This program also focuses on outreach to get more students involved in STEM. FIRST Program members constantly aim to attract new talent.

The FIRST Program has mentors from the industry that oversee the technical aspects of designing the robots. This relationship can best be described as a technical mentorship. Some of the mentoring is in the form of leadership, organizational skills, design, and control systems. The FIRST Program members get to learn from actual engineers, and there were 14 mentors who worked with FIRST during the 2015–2016 school year. A FIRST Program member founded SWE as a means of giving back to the high school.

The SWE Program meets weekly on Thursdays during the school’s 30-minute lunch to discuss and design activities suitable for girls in grades 2–8. On the second Saturday of each month, SWE holds a “Femineer’s” Day for the younger girls. The word “Femineer” comes from two words, female and engineer. An extra afterschool meeting is usually scheduled before a Femineer's event for any final preparations needed before an event. Each Femineer's Day has a particular theme or engineering focus which coincides with the expertise of the keynote speakers.

The first couple of Femineer's events were mostly planned by the advisor but over the course of the year, the girls took ownership of the program. The girls designed various challenges at different grade levels. This program is considered an investment because many of the girls in grades 2–8 may consider joining Einstein Science High School once they get to high school and possibly even joining the SWE Program. During the 2015–2016 school year, seven Femineer's Events were held and a minimum of 60 girls in grades 2–8 have attended each one.

A typical Femineer's event begins with introductions in which the students introduce themselves and provide an overview of the 2-hour time period. A guest speaker then talks to the girls about what it's like to be a female in engineering. After the speaker, the girls break out into similar-aged groups for a grade appropriate challenge. The girls then collaboratively design their prototype and take a break. After the break, the girls revise and test their projects using the engineering design process (see Appendix F). Everyone is gathered together for the last 15 minutes of the of the workshop to debrief. The participating girls are asked questions like, "What went well? What did you find challenging? How did you improve on your design?"

Each OST STEM program has a parent and family component that shows a strong understanding for the need for families to become involved. FIRST families are committed to bringing sustenance to the students as they work long hours. The FIRST Program also gets parents and friends involved in their "Booster Bots" program, while SWE parents are invited to remain with their students during the workshops.

Instrumentation. Participating students participated in a Science Self-Efficacy survey. The researcher selected this survey because of its validity and reliability to meet the purpose of this study. This Student Science Attitude Survey (see Appendix A) was created by members of Janet Dubinsky's grant writing staff to assess high school students whose teachers had attended a summer professional development workshop called BrainU. This survey was adapted from previous versions of student science surveys that allowed for free responses prior to 2010. The survey was adapted to include 18 forced-choice items that mirrored common responses from the previous surveys. After the initial utilization of the survey, more items were added. Permission to use the survey was granted by Janet Dubinsky (see Appendix G).

Janet Dubinsky and her colleagues used the Science Attitude Survey before and after brain awareness sessions. This survey has been used for high school audiences in both the BRAINS to High School grant and Changing Brains Through Inquiry, Not Drugs grant. Originally, the survey was created as a means to study the effects of two science programs in Minnesota. In just one session, there was change in the student's self-efficacy in science (Fitzakerley, Michlin, Paton, & Dubinsky, 2013). A factor analysis was performed on responses and showed shifts in students' opinions on 16 of the 18 survey items. Bartlett's test of sphericity got a chi^2 of 4907.07, *Df*=153, $p<0.001$ confirmed a relationship among the survey items and indicated that the data was not uncorrelated to science attitudes. There was an increase in agreement on the items, "science is fun" and "I can get smarter" between the pre- and post-tests. There was a decrease in item "I don't do well." Similar results were obtained across multiple administrations of this survey (Fitzakerley et al., 2013).

The Science Self-Efficacy Survey was piloted by sending it to 23 students at a high school in Torrance, California. The survey received 13 responses. The students averaged about six minutes to take the test with a range of 3–10 minutes. As a result of this administration, some test items were changed in an effort to better reflect Science Self-Efficacy. For example, one question was, “I don’t like doing science labs.” To make all the survey questions correlate to the forced-choice scale where a “strongly agree” rating was correlated to a higher Science Self-Efficacy score, this question was changed to “I like doing science labs.” An additional question of years in the OST program(s) was added to the teacher perception survey to obtain more information about the students in the OST program(s) for this study.

Data Collections and Research Questions

A survey was administered to participating students, teachers, and parents using school email addresses to measure student Science Self-Efficacy. There were a total of 111 possible student participants and their parents. Email was recommended for this study because email is the most frequent method to communicate with teachers and peers at Einstein. The emails originated from the SWE and FIRST teachers because this email was recognizable to the participants. The first email with a link to the survey and copies of the consent form was sent on September 15, 2016. A follow-up reminder was sent on November 16, 2016. Table 3 relates the data that was being collected to each of the research questions.

Table 3

Data Collection Connected to Research Questions

Data Source	RQ1	RQ2	RQ3	RQ4	RQ5	RQ6
Student surveys on science efficacy	X	X	X	X	X	X
Student surveys on instructional strategies					X	X
Student program attendance			X	X	X	X
Parent survey	X					
Teacher Student Rating		X				
Student GPA.			X	X	X	X

The first research question was answered by a parent survey sent to all parents of students participating in either the FIRST or SWE OST program. The parents were asked to complete the survey for each student in the program. The survey asked parents to gauge the level of enthusiasm their child had for the OST STEM program. The parents were also asked to check off items they may do with their child to promote science at home. There was an option “other” where the parents could add their own response. The researcher was unable to meet with the parents to discuss the study, and parent participation was lower than expected.

The teacher survey asked each OST program advisor to rate the level of interest they perceived each student to have. The OST program advisors listed participating students on the form provided (see Appendix D) using a 6-point scale ranging from “Not Interested” to “Eager to Attend.” This information was correlated to the scores students receive on their Science Self-Efficacy assessment. The OST program advisors also provided data for the number of years each student had participated in that OST program. This survey was given to the teachers on September 15, 2016.

To determine each student’s GPA, the researcher spoke with the principal of the school who obtained the grade information. This information was used to assess whether or not there is a correlation between Science Self-Efficacy and GPA. Grades were submitted to the researcher on January 23, 2017.

The teacher overseeing the FIRST Program provided the researcher with student attendance information for their sessions. The purpose of obtaining attendance information was to assess whether or not attendance was correlated with each student’s Science Self-Efficacy. The SWE teacher did not have accurate attendance records and no attendance information was used for the purpose of this study.

Each participating student was asked to take a second short survey (see Appendix B) in which they identified the frequency of certain instructional activities that occurred during their sessions. The frequency of instructional activities checked off indicated which practices were most meaningful to the students while in their OST STEM program. This second survey automatically began once the students completed the first Science Self-Efficacy Survey.

Protection of Human Subjects

Prior to the collection of data, permission to conduct the study was obtained from Pepperdine Institutional Research Board (Appendix H). At Einstein both STEM programs are completely voluntary, and students are able to withdraw at any time without penalty. Interested students were given an application for the program during the school's Program Fair. Extra applications were available for students who needed an additional copy or decided to apply after the initial recruitment presentation. Students were allowed to withdraw from the programs and/or any activities without penalties or repercussions at any time. Students who were accepted to the program were given release forms that explained enrollment as completely voluntary.

The data collected from these programs was used to assess the impact on Science Self-Efficacy being made with students who participate in OST STEM programs. The collection of this information is a normal part of such educational programs. Parent, student, and teacher information was collected and data was analyzed and correlated. To begin the data analysis, the school and district were assigned pseudonyms, Einstein Science High School and CGI Unified School District. Student names have been removed from all survey responses to protect their identities and a code was assigned to each student. Each student in the study was assigned a code number from 001–111. The code number was the identifying number used throughout the study. The key to this code identifying the code for each student was kept in a password protected, secure file on the researcher's computer. Only the researcher had the password to open the document. Teacher names and school locations were changed in this document to protect their identities. All student names and teacher names were kept confidential. All data will be deleted three years after the end of the study, on December 15, 2019.

Summary

This chapter detailed the history of the Einstein Schools and how students were selected to participate in this study. The design of the study was also discussed in detail.

Chapter 4: Analyses of Data and Findings

Overview

This study examined selected variables of two OST high school science programs on students' Science Self-Efficacy and other factors that may contribute to these 26 girls and 19 boys students' Science Self-Efficacy, i.e. an interest in science. These analyses of data included the student scores on, The Student Science Attitude Survey, a Science Self-Efficacy Survey. In addition, the student's score was related to their program attendance, parental involvement, GPA, and perceived interest as judged by their program teacher. This chapter presents the results of the data analyses for the six stated research questions and the two null hypotheses, presented in Chapter 3.

In this chapter, the steps for data analyses are discussed, researcher field notes are displayed, descriptive statistics are presented, and the findings for each of the research questions are given.

Data Analyses

The researcher used a three-phase data analysis: data preparation, descriptive statistics, and inferential statistics to prepare the data.

Response rates. At the time of the study, there were 111 student participants who received the student surveys. The researcher requested that one parent or guardian for each student complete the parent survey. The two participating teachers were asked to complete one form with student attendance and perceived student interest in the OST program. The response rates are listed in Table 4.

Table 4

Participant Response Rates

Participant Type	*N*	%
Student Surveys	52	47%
Parent Survey	35	32%
Teacher Survey	2	100%

Data preparation. Raw data collection was reviewed for potential errors and for consistency. To assure confidentiality, the school was assigned a pseudonym, Einstein Charter. Each student in the study was assigned an identifying code number from 001 to 111. The code number was the identifier used for each participant used throughout the study. The parent information correlated to the student identifier, a “P” notation was added to the data number, for example P001.

The researcher prepared a master list of student names and code numbers that was in a password-protected secured data file. This code number was used to connect the student name to each of the independent variables and the dependent variable. At the beginning of the data analysis, the code number was placed next to each student’s name on each piece of collected data, namely

- teacher’s Student Interest Rating Form;
- the list of student names with their GPAs;
- the list of student names with their attendance at FIRST;
- the list of student names with their attendance at SWE;
- the list of parents and their score on the Parent Science Involvement Survey;

- the list of their scores on Science Self-Efficacy Survey; and
- the list of their score on the Science Instructional Activities Survey.

In addition, each student was coded according to their gender, number of years in FIRST, and number of years in SWE. This information was collected as part of the Student Science Self-Efficacy Survey. All participant information was placed into an Excel spreadsheet by the researcher. The researcher sent the file to a trained statistician to compute the correlational analyses. The data was entered, student by student, in SPSS using only their assigned code numbers. The data collected was analyzed using the most current version of the Statistical Package in the Social Sciences (SPSS) by a trained statistician.

All surveys were provided to participants using the online Qualtrics platform. The Qualtrics platform is a website used for collecting survey data. This survey platform allows for the data collected to automatically populate into a spreadsheet. With this spreadsheet, a score was calculated for each student as well as the scores for each item on each of the survey items.

For each of the factors, descriptive statistics provided the frequency, percentage, measures of central tendency, mean, mode and median, and standard deviations. Descriptive statistics provided a numerical picture for each factor. This information was placed into tables depicting students' GPAs, attendance at FIRST and SWE, parent support, teacher ratings, scores on instructional activities, and Science Self-Efficacy score for males and females.

Descriptive statistics

Sample. As shown in Table 5, there were more females (57.8%) than males. Less than half of the student sample participated in FIRST (48.9%) and only a quarter participated in SWE (26.7%). About a quarter participated in both programs (24.4%).

Table 5

Student Demographic Information

Variables	*n*	%
Program attended		
SWE	12	26.7
FIRST	22	48.9
Both programs	11	24.4
Gender		
Male	19	42.2
Female	26	57.8

Student surveys on science self-efficacy. Each question on the Science Self-Efficacy Survey was assigned a numerical score. The scores for each item were added to determine a final score for each student. The total score for the Science Self-Efficacy Survey was 125. The higher the score, the greater the students' Science Self-Efficacy. One student associated with both OST programs wrote her name on the survey and completed no questions, this response was removed.

Table 6 displays the means, standard deviations, and independent t-test results for Science Self-Efficacy across girls and boys. Girls averaged a higher Mindset score than boys with an average of 3.97. The boys averaged a higher level of Enjoyment at 4.05.

Table 6

Means, Standard Deviations, and Independent t-test Results for Science Self-Efficacy Across Girls and Boys

	Boys (*n* = 19)		Girls (*n* = 26)			
Variable	*M*	*SD*	*M*	*SD*	*df*	*t*
Science Efficacy						
Mindset	3.76	.61	3.97	.78	43	-.97
Enjoyment	4.05	.75	3.95	.68	43	.47

Student surveys on instructional activities. On the Student Instructional Activity Survey each item was assigned a numerical score. The scores for each item were added to determine a final score for each student. The OST STEM teachers verified the instructional activities listed on the survey to ensure the activities listed on the survey matched activities completed in their OST STEM program. There were different Instructional Activities scores for SWE and FIRST. The possible range of scores for the FIRST Instructional Activities Survey was 0–100. The possible range of scores for the SWE Instructional Activities Survey was 0–125.

For SWE and FIRST, the students completed open-ended questions that were coded by a small group of trained doctoral students; the doctoral chairperson was present to participate in and guide the coding session. In preparation for the coding, the researched posted six large sheets of Post-It paper on the walls, one for each of the questions that was asked of the participating students. A line down the center of each Post-it paper divided the responses by gender. The following questions were taken directly from the survey and listed at the top of each page:

1. My teacher made learning easy/fun by....
2. My teacher made learning difficult by....
3. SWE- My favorite SWE activity, field, guest speaker, or event was....
4. SWE- The activity I disliked the most was...
5. FIRST- My favorite FIRST activity, field, guest speaker, or event was...
6. FIRST- The activity I disliked the most was...

The researcher used the mail merge feature of Microsoft Word in conjunction with the data in the Excel spreadsheet to create and print each student's short responses answers on individual sheets of paper labeled only with their identification code, OST program affiliation, and gender. These response sheets were divided amongst the coders. Coders first removed sheets that had no responses, or a coded response of "-99." The number of surveys that had no responses for any question was counted. Each coder divided their remaining surveys by gender.

The researcher served as a facilitator for this process, recording comments on the poster paper. The coders read across question one, and the researcher asked for the big ideas that emerged from the data and these ideas were noted on the Post-it paper. Each coder provided their thoughts on the big ideas. The big ideas were highlighted and the number of occurrences for each big idea were counted. The coders also gave a count for the number of participants that chose to not respond to the question. This process was repeated for questions two through six. The researcher shared the themes that emerged and the coders provided similar insights based on their analyses of the student short responses.

There were 68 total responses for the Instructional Activities survey for both SWE and FIRST. Of those 68, 15 participants designated themselves as members of both groups, 35 participants designated themselves as members of the FIRST OST program and 18 participants designated themselves as SWE OST program participants. The short answer section was left blank for nine participants, two of these participants identify themselves as members of both OST programs. Figure 2 displays a graphic representation of the student participants.

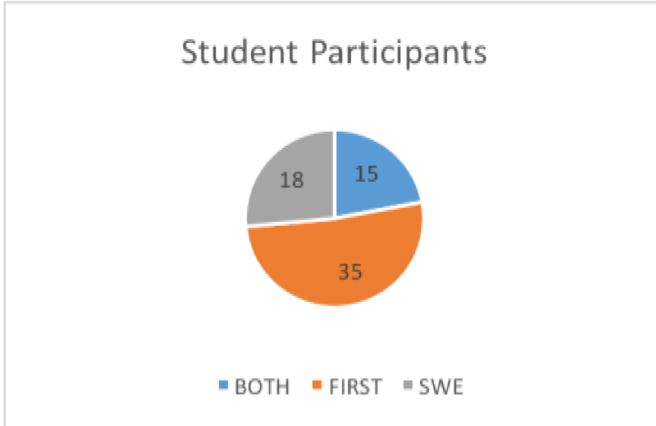

Figure 2. Student participants.

In response to the question, "My teacher made learning easy/fun by…" students had a variety of answers. There were 59 participants who responded to this question and nine participants left this question blank. In response to the question, "My teacher made learning difficult by…" 50 participants responded. Three participants wrote "nothing."

In response to the question, "My favorite SWE activity, guest speaker, or event was…" nine participants did not respond or responded "I don't know." For the question, "The activity I disliked the most was…" nine participants wrote nothing, not applicable or wrote how they enjoyed everything and nine participants left this question blank.

In response to the question, "My favorite FIRST activity, field, guest speaker, or event was…" eight participants left this question blank and eight wrote nothing. For the question, "The activity I disliked most was…" seven participants left this question blank and 26 participants wrote nothing.

Parent surveys. To determine parental support for each student, each item on the survey was assigned one point. One parent survey only has the parent name and the student's affiliation, the other questions were left blank. Parent surveys were scored and results had a range of 0–8. Attendance at parent orientation for question one was worth one point. Question two had a maximum score of seven points, and each item that marked earned one point.

Table 7 displays the number of activities that parents participated in on average as determined by the parent survey. Parents of girls average more activities than parents of boys. The parents of FIRST students participated in more activities than the parents of SWE students.

Table 7

Number of Activities Parents Participated In

	First		SWE		Both	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Parents of boys	3.08	1.78	--	--	--	--
Parents of girls	3.25	1.50	1.00	--	1.00	--

Teacher rating. Each OST program advisor was asked to rate the perceived level of interest in the OST program for each of the students in their program. The master participant list showed 13 students attending both OST programs. Of those 13, the FIRST OST program advisor did not provide a score for the perceived level of interest for two students. Both the SWE and FIRST OST program advisors rated seven students with a score of five for Highly Interested in each OST program. In three instances, the FIRST OST program advisor rated students with a score of five but the SWE OST program advisor rated those same students with a score of four. On the contrary, the FIRST Program advisor rated two different students with a score of three and five while the SWE OST program advisor rated those same students as a five.

Assessing normality. Univariate normality was assessed via the variable's skewness and kurtosis indices. The ratings assessed by the teachers did not have a normal distribution. When kurtosis was present, the data collected was not symmetrical. Per Kline (2011), a skewness index above an absolute value of three and a kurtosis index that falls between 10 and 20 indicate non-normality. The findings, notated in Appendix J, reveal that teacher's perceptions about FIRST student's interest in science was highly skewed, meaning that the majority of students were rated with a score of five (or Very Interested) and the data was skewed towards the rating of five. This variable was recoded into a binary variable; students who did not receive a five were categorized into one group and students who received a five were categorized into another group. This was also done for the teacher's perceptions about the SWE students' interest in science (just so the variable definitions would be similar across program type).

Student GPA. GPAs were collected for participating students. Table 8 displays the means, standard deviations, and independent t-test results for GPA across girls and boys. Girls averaged a higher GPA, 3.78, than boys, 2.86.

Table 8

Means, Standard Deviations, and Independent t-test Results GPA Across Girls and Boys

	Boys (n = 19)		Girls (n = 26)			
Variable	*M*	*SD*	*M*	*SD*	*df*	*t*
GPA	2.86	.53	3.78	.60	43	-5.33 ***

Note.* $p < .05$. ** $p < .01$. *** $p < .001$.

Field Notes

The researcher had an opportunity to visit both OST STEM programs to present to participating students the research that was to be conducted. The students were also afforded an opportunity to ask the researcher any questions. Field notes were recorded by taking handwritten notes on a legal pad.

The researcher visited the SWE club during its regularly scheduled lunch meeting on Tuesday, September 13, 2016. On this particular day, the students were giving short speeches for officer elections. After the speeches for each category were given, the candidates would go outside while a silent vote was conducted. In this particular case, a silent vote involved the students covering their eyes and raising their hand when they heard the name of the candidate for whom they wished to vote. Once the teacher counted all the votes, the candidates were invited back inside and the winner was announced. A couple minutes at the end of the meeting were allowed for the researcher to discuss the project and pass out parent permission slips.

Two days later, on Thursday, September 15, 2016, the researcher visited the FIRST OST program. This program was engaged in various breakout groups when the researcher arrived. A small group of six to eight students was seated outside on the benches. This group was working on a project but was also designated to help the researcher disseminate information to the other students. This group decided that the best way to disseminate the survey to the students was to post the link to the survey on the website for FIRST students. Representatives from this group escorted the researcher to a room where FIRST students were learning from an engineer. This engineer was asked to attend the meeting to help students with a part of their robot design. The researcher was given a few minutes and the students opted to take the survey right then and there. Next, the researcher was escorted to another room where the students were working under the supervision of the FIRST advisor. Students were asked to pause their work and listen as the researcher presented the details of the study. The FIRST advisor requested that the students take the survey after obtaining parental permission.

An interview with the SWE program advisor revealed that SWE events were very teacher-focused when she first became the advisor. The SWE program advisor would plan the events and tell the students what their role would be. In the last two years, the SWE students had taken over all aspects of leading the Femineer's Events. According to the SWE OST program advisor, the 30 minutes allotted for lunch time is usually not enough time to complete the planning of events and many SWE students must make arrangements for final preparations on their own time. The SWE program advisor said that it is difficult for all students to attend all events and meetings due to their busy schedules. The SWE program advisor did not keep track of attendance at meetings or events.

An interview with the FIRST program advisor revealed that his students were highly motivated to be in the FIRST OST program because attendance is monitored. The FIRST program advisor made it very clear to the participating students that each student is a vital part of the team and their presence is needed. Students who miss meetings are subject to removal from the OST program.

Null hypotheses. To test these hypotheses a forced entry regression procedure was conducted. The assumptions of multivariate normality, linearity, and homoscedasticity were checked prior to conducting the procedure. Per Norussis (1991), multivariate normality is fulfilled when the points are clustered towards the diagonal.

Findings

Inferential statistics. Research questions one through six were analyzed using a Pearson Product-Moment Correlation Coefficient. Each coefficient described the measure of strength between each factor and the score on the Science Self-Efficacy Survey. A Pearson's r is a measure of the linear correlation between the two variables in which 1 means a total positive correlation, 0 is no correlation, and -1 is a negative correlation. Each coefficient was compared to each factor and to the students' score on the Science Self-Efficacy Survey. Findings are presented in various tables.

Following the correlation analyses, the researcher conducted a stepwise regression analyses to answer the two hypotheses. In a stepwise regression, the factors or predictor variables, were entered into the regression equation using SPSS. The dependent variable is a score on the Science Self-Efficacy Survey and the other factors are the independent variables. Multiple regressions helped determine the variance each of the factors have on the Science Self-Efficacy score.

Science self-efficacy. The Science Self-Efficacy measure appeared to consist of three subscales: Mindset (fixed vs. malleable), Enjoyment, and general science knowledge. A mean composite was created for each subscale. A higher score indicated malleability, greater Enjoyment, and greater knowledge. Because the knowledge subscale had poor reliability (i.e., Cronbach's alpha was only .41), it was not included in subsequent procedures.

Research question #1. How does the degree of parent participation correlate to their student's Science Self-Efficacy? This research question sought to determine whether the degree of parent participation would be correlated to student's Science Self-Efficacy ratings. To answer this question, Pearson and Kendall Tau correlation procedures were conducted. Correlations were assessed using a two-tailed p-value of .05. The findings in Table 9 reveal that degree of parent participation was not significantly associated with Mindset.

Table 9

Pearson Correlations Between the Study Variables

Variables	*N*	1 Mindset	2 Enjoyment	3 Parent participation in SWE	4 Parent participation in FIRST	5 Teacher rating of SWE interest[a]	6 Teacher rating of FIRST interest[a]	7 GPA	8 Student participation in SWE
1 Mindset									
2 Enjoyment	45	.27							
3 Parent participation in SWE	8	.09	.05						
4 Parent participation in FIRST	22	-.10	-.05	.89 *					
5 Teacher rating of SWE interest[a]	22	.52 **	.28	.12	-.20				
6 Teacher rating of FIRST interest[a]	30	.10	.05	.60	-.02	-.05			
7 GPA	45	.30 *	.09	.31	.06	.51 **	-.08		
8 Student participation in SWE	20	.34	.39	.18	-.15	.46 *	.41	.31	
9 Student participation in FIRST	31	-.24	.26	-.48	.06	.18	-.11	.14	.62

Note. [a] Kendall tau correlations are reported because these variables were not distributed normally.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Research question #2. How does the teacher rating of student interest correlate to student's Science Self-Efficacy? This research question sought to determine whether the teacher's rating of students' interest in the OST program would be correlated to student's Science Self-Efficacy ratings. To answer this question, Pearson and Kendall Tau correlation procedures were conducted. Correlations were assessed using a two-tailed p-value of .05. The findings in Table 9 reveal that teacher's perceived interest in the OST program was positively correlated with Mindset, $\tau = .52$, $p < .01$.

As noted in Table 10, teachers indicated that more than half of the students who participated in the SWE program were not very interested in the program (57.1%). But teachers noted that majority of the students that participated in the FIRST program were very interested in the program (86.2%).

Table 10

Perception: Teacher of SWE Program and Teacher of FIRST Program

Variables	*n*	%
Teacher's SWE perception		
Not very interested	12	57.1
Very interested	9	42.9
Teacher's FIRST perception		
Not very interested	4	13.8
Very interested	25	86.2

Research question #3. How does overall GPA affect a student's Science Self-Efficacy? This research question sought to determine whether overall GPA would be correlated to student's Science Self-Efficacy ratings. To answer this question, Pearson and Kendall Tau correlation procedures were conducted. Correlations were assessed using a two-tailed p-value of

.05. The findings in Table 9 reveal that GPA were also positively associated with mindset, r = .30, p = .047

Research question #4. How does student attendance in OST STEM programs affect a student's Science Self-Efficacy? Accurate student attendance for SWE was not available. Table 11 shows the correlations between FIRST absences and Science Self-Efficacy. The raw data showed that most students had zero absences, two students had two absences and one student had one absence. Attendance information was not available for SWE participants. There was no significant correlation between attendance and Mindset. There was no significant correlation between attendance and Enjoyment

Table 11

Kendall Tau Correlations Between FIRST Absences and Science Self-Efficacy (N = 22)

Variables	1 Number of FIRST absences	2 Mindset
1 Number of FIRST absences		
2 Mindset	-.05	
3 Enjoyment	-.13	.25 *

* p < .05. ** p < .01. *** p < .001.

Research question #5. How does student participation in instructional activities in SWE affect a student's Science Self-Efficacy? This research question sought to determine whether student participation in instructional activities in SWE would be correlated to student's Science Self-Efficacy ratings. To answer this question, Pearson and Kendall Tau correlation procedures were conducted. Correlations were assessed using a two-tailed p-value of .05. The findings in Table 9 reveal that students' participation in SWE was not significantly correlated with Mindset nor Enjoyment. But there was a positive trend.

Research question #6. How does student participation in instructional activities in FIRST affect a student's Science Self-Efficacy? This research question sought to determine whether student participation in instructional activities in FIRST would be correlated to student's Science Self-Efficacy ratings. To answer this question, Pearson and Kendall Tau correlation procedures were conducted. Correlations were assessed using a two-tailed p-value of .05. The findings in Table 9 reveal that student participation in instructional activities in the FIRST OST program was not significantly associated with Mindset.

Hypothesis 1. There is no significant correlation between any of the following factors and a female student's score on the Science Self-Efficacy Survey:

- High school GPA.
- Attendance at OST FIRST.
- Attendance at OST SWE.
- Teacher rating of student interest in science.
- Parent level of support in OST science.
- Student score on Instructional Activities Survey.

It was hypothesized that high school GPA, teacher rating of student interest in science, and student participation in instructional activities in SWE and/or FIRST would positively correlate with Science Self-Efficacy in female students. As shown in Appendix I, this assumption was confirmed. The assumptions of linearity are met when the plot of the studentized deleted residuals by the standardized predicted values yields a random scatter (Norussis, 1991). As shown in Appendix J, this assumption was also confirmed.

The findings in Table 12 indicate that none of the variables significantly correlated to Mindset. However, student participation in instructional activities was positively correlated to Enjoyment, β = .55, p = .012. The greater the student participation, the greater was their Enjoyment of science.

Table 12

Regression Results for the Mindset and Enjoyment Female Models (N = 23)

	Mindset			Enjoyment		
Variables	*B*	*SE*	β	*B*	*SE*	β
GPA	.25	.37	.18	-.05	.28	-.04
Total number of activities	-.00	.00	-.05	.01	.00	.55 *
Teacher interest rating	.23	.22	.28	.10	.17	.15

Note. Teacher interest rating was coded 0 = not very interested and 1 = very interested. Overall model statistics for mindset, $F(3, 19) = 1.25$, $p = .319$, $R^2 = .165$. Overall model statistics for enjoyment, $F(3, 19) = 3.56$, $p = .033$, $R^2 = .361$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Hypothesis 2. There is no significant correlation between any of the following factors and a male student’s score on the Science Self-Efficacy Survey:

- High school GPA.
- Attendance at OST FIRST.
- Teacher rating of student interest in science.
- Parent level of support in OST science.
- Student score on Instructional Activities Survey.

As shown in Appendix K, this assumption was fulfilled.

The findings in Table 13 reveal that none of the variables significantly predicted Mindset and Enjoyment. But student participation in FIRST instructional activities marginally predicted Mindset, β = -.51, p = .07. The greater the student participation, the more fixed Mindset was.

Table 13

Regression Results for the Mindset and Enjoyment Male Models (N = 17)

	Mindset			Enjoyment		
Variables	*B*	*SE*	β	*B*	*SE*	β
GPA	.19	.31	.15	.04	.45	-.03
Total number of activities	-.14	.48	-.08	-.06	.69	-.03
Teacher interest rating	-.02	.01	-.51	-.00	.01	-.05

Note. Teacher interest rating was coded 0 = not very interested and 1 = very interested. Overall model statistics for mindset, $F(3, 13) = 1.34$, $p = .304$, $R^2 = .236$. Overall model statistics for enjoyment, $F(3, 12) = .01$, $p = .999$, $R^2 = .002$.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

The research questions sought to determine whether degree of parent participation (first research question), teacher rating of student interest (second research question), overall GPA (third research question), student attendance at OST programs (fourth question), student participation in instructional activities in SWE (fifth question), and student participation in instructional activities in FIRST (sixth research question) would be correlated with student's Science Self-Efficacy ratings.

Results of Coding

The trained group of doctoral coders determined some key insights after analyzing the student responses.

Question 1. The first question was "My teacher made learning easy/fun by." Three key themes emerged from this question, group work, hands-on activities/experiments/labs and a variety of activities. Twenty-two responses made a reference to group work activities. Twelve responses mentioned the words "hands-on." One student mentioned, "Activities, science shows, class games" as making learning fun/easy. Many students said, "making learning fun" but no specific examples were given. Another student described hands-on activities as, "Interactive lessons (performing experiments, labs, etc.)."

The idea of fun was also mentioned in terms of the teacher; one student member of both OST programs said, "Rating to us through humor, which made the class exciting and, therefore, memorable." A SWE student said their advisor, "made the class funny and had many labs that was pretty cool." The next most popular theme was mentioned twice, a variety of activities.

Question 2. The second question was "My teacher made learning difficult by." There were many items listed by students for making learning difficult. The major deterrent to learning listed was being vague. Other difficulties included challenging, lecturing, inflexible, memorization, and not hands-on. Ten responses felt that assignments and tasks were vague. One student acknowledged the vagueness and the fact that their learning was improved. This male FIRST student said, "Telling us to 'Figure it out' (In the end i[sic] fell this made is learn the most.)." Another student said the advisor "did not always going over everything." Other students mentioned too much information to cover in one unit and content not being explained clearly. Another three participants believed there was not enough question and answer time allotted. A FIRST student said it was problematic when the advisor was, "Trying to teach too much information at once while not making sure the past lessons have properly been taught." One SWE student and one FIRST student disliked worksheets.

Question 3. The third question was, “SWE: My favorite SWE activity, field, guest speaker, or event was.” Two major themes emerged from the data, field trips and Femineer events. Eight students mentioned their favorite activity being a field trip. Field trips mentioned include Johnathan Club for guest speaker and luncheon, a trip to the Long Beach convention center for a science meeting, and trips to UCLA. Six students mentioned their favorite activity occurring at one of the Femineer’s events. One female SWE student said, “volunteering to help out young girls to experience agricultural engineering by facilitating a project.” Another female SWE student also said this about the Femineer events, “My favorite activity was when SWE helped the girls go throught [sic] the design process of how to build the bridge. I loved seeing how the girls worked together and how they had developed many interesting ideas.” Two students mentioned having guest speakers come to their class as their favorite activity. One student said, “I really enjoyed having an Aerospace Major from Cal Poly Pomona come to talk to the class about Aerospace Engineering.” Another student enjoyed having UCLA students go to their class.

Question 4. The fourth question was “SWE: The activity I disliked the most was.” A strong theme did not emerge from the data here. Many students did not have things they did not like, one student wrote, “Nothing SWE IS MY LIFEEEEE”. Two students specifically mentioned the Cal Poly trip. Disliked activities that only appeared in a single response included long presentations, constant retelling of women becoming engineers and listening to podcasts. One student said, “we were constantly bringing up the topic of women being in engineering. At one point, it became a daily thing to discuss.”

Question 5. The fifth question was “FIRST: My favorite FIRST activity, field, guest speaker, or event was.” Three themes emerged here. The strongest was participation in competition. Responses mentioned FRC (FIRST Robotics Competition), LA regional event, Long Beach regional, FIRST LEGO competition, and the world championship in St. Louis. One student said this about competitions, “I love going to FRC competitions. There, there are a lot of great speakers and workshops to attend other than just competing with a robot.” Two student responses mentioned activities held at the orientation, specifically the icebreaker game. Another two responses mentioned manufacturing and design. Two students spoke about outreach programs offered by FIRST, they enjoyed “Being a camp counsalor[sic] at the robotics camp, which was correlated with FRC” and “Helping lead a children's summer camp.”

Question 6. The sixth question was, “FIRST: The activity I disliked the most was.” Just like the SWE OST program students, many students did not have an activity they disliked. Students responded with, “Nothing. It’s all been great!...N/A…everything is fun.” And “N/A everything is alright.” There were 11 isolated dislikes that only appeared once. Some of these dislikes included build season preview day, SLO field trip, learning about business, and lectures. One student disliked “that attendance has to be on time and try not to miss any day.” One response stuck out from the rest of them, this student disliked, “Actually running around and using my legs and energy.”

Summary of Findings

More girls (*n*=26) than boys (*n*=19) participated in this study. More members of the FIRST OST program (boys and girls) participated than members of the SWE OST (girls only) program. The scores of the boys and girls on the Science Self-Efficacy Survey were above average. The scores of boys and girls were not significantly different between genders with an average standard deviation of .75, indicating that all students scored above average to exceptionally high on Mindset and Enjoyment of science.

The parents of girls participated in more parental activities than did parents of boys as measured by the parent surveys. Of the 22 parents responding to a survey, parents of FIRST OST program students had higher parental involvement score that those parents of the SWE OST program. Findings revealed no significant difference between parents of boys and girls and their participation in number of OST SWE or FIRST activities.

The FIRST OST program teacher rated most of the students with a five (using a 0–5 scale) and only seven students received less than five, indicating the teacher felt that most of these students were highly interested. The teacher ratings of students' perceived interest in their science OST program was also positively correlated to Mindset and Enjoyment for boys and girls. Attendance data was only available for the FIRST OST program. Of the 31 students, 28 students reported no absences. One student was absent once and two others were absent twice.

A significant difference in overall GPA between boys and girls existed. Girls averaged a higher GPA than boys ($p<.001$). Girls' GPA was also positively associated with Mindset and Enjoyment on the Science Self-Efficacy Survey. No data was able to correlate with the Mindset or science self-efficacy for boys. Attendance information was only provided for the FIRST OST program. However, there was no relationship between student attendance in the FIRST OST program and students' science self-efficacy score.

Correlations among the study's data sets revealed that parent participation in FIRST correlated with parent participation in SWE. Teachers' rating of student interest in SWE correlated with a positive score on Mindset. Students' GPA correlated with their teacher's rating of their interest in SWE. Students' GPA correlated with Mindset. Student participation in SWE correlated with the Teacher's rating in SWE.

From the students' comments on the Science Self-Efficacy Survey, students primarily indicated positive comments regarding instructional activities in both OST programs. Primarily, students enjoyed hands-on activities, working with other students, and being challenged. Students preferred working in small groups and/or working as a mentor to assist their less experienced peers. Students disliked vague explanations and directions, lectures, and limited time for question-asking.

When visiting each OST program, the researcher noted differences in the style of the meetings. The OST program held meetings weekly during a short 30-minute lunch break, with the advisor and students attempting to eat and participate at the same time. The FIRST OST program was held afterschool and there was a designated dinner break for students. During this break one family provided dinner for all the students, the advisor, and any mentors present during the session. The SWE OST program appeared to have a whole group meeting format whereas the FIRST OST program had breakout sessions focusing on particular aspects of STEM.

Chapter 5: Summary, Conclusions, and Recommendations

Summary

Problem and purpose. A review of the literature in the area of STEM education suggested a need to examine how science education could be used to increase the motivation in high school students. The purpose of this study was to examine the Science Self-Efficacy of high school students who participated in two OST STEM programs. Limited research had been conducted on the effectiveness of OST programs on participating students and this study aimed to gather insights on possible effects, positive or negative. The two programs selected for this study were the SWE and the FIRST programs.

This study used the following research questions as a way of measuring the Science Self-Efficacy of students:

1. How does the degree of parent participation correlate to their student's Science Self-Efficacy?
2. How does the teacher rating of student interest correlate to a student's Science Self-Efficacy?
3. How does overall GPA affect a student's Science Self-Efficacy?
4. How does student attendance in OST STEM programs affect a student's Science Self-Efficacy?
5. How does student participation in instructional activities in SWE affect a student's Science Self-Efficacy?
6. How does student participation in instructional activities in FIRST affect a student's Science Self-Efficacy?

This study asked the following two null hypotheses:

1. There is no significant correlation between any of the following factors and a female student's score on the Science Self-Efficacy Survey:
    - High school GPA.
    - Attendance at OST FIRST.
    - Attendance at OST SWE.
    - Teacher rating of student interest in science.
    - Parent level of support in OST science.
    - Student score on Instructional Activities Survey.
2. There is no significant correlation between any of the following factors and a male student's score on the Science Self-Efficacy Survey:
    - High school GPA.
    - Attendance at OST FIRST.
    - Teacher rating of student interest in science.
    - Parent level of support in OST science.
    - Student score on Instructional Activities Survey.

Methodology

This study utilized an embedded mixed methods case study design. The Einstein Science High School is located within walking distance of large, well-known aerospace companies such as Northrop Grumman and SpaceX. The location of the high school provides for easy-access collaborations with STEM professionals. Annually, the school year begins with an average of 135 freshman students coming from more than 80 zip codes.

Einstein Science High School offers many different OST programs. At the beginning of each year, the school holds a Program Fair where each group promotes its respective OST program. Students have the opportunity sign up for multiple programs if they desire.

The Einstein Science High School prides itself on its approach to learning that utilizes project-based and hands-on learning techniques. The school focuses on preparing students for their future careers by allowing students to select one of four career pathways: STEAM, Biomedical, Engineering, and Medical.

The researcher employed four methods to answer the research questions. First, the researcher secured the participation of Einstein Science High School and the program advisors of two OST programs at said school. The principal of Einstein Science High School gave permission to use the school site and its students. The principal gave the option to work with various OST programs. The FIRST and SWE programs were selected for this study.

In the FIRST OST program, students are given the challenge of creating a robot that can solve a certain problem selected by the national FIRST office. Students must make all of their own materials from scratch. Students use a 3D printer to make many of the parts needed. In the SWE program, the students plan and implement Femineer's Days. A Femineer event is an event for young girls to learn more about women engineers and it usually lasts around two hours. Femineer events include a guest speaker and grade-appropriate engineering design challenges. Both OST programs offer options for parent involvement in their child's STEM education. FIRST parents are asked to help chaperone and transport students to competitions as well as bring dinner for the entire group during their meetings. SWE parents are asked to transport students to Femineer's events and the parents are invited to stay for the session.

Following the selection of the OST programs, the researcher approached the OST program advisors and asked for their permission to use the students in their respective OST program for the study. After obtaining approval from the OST program advisors, the researcher conducted interviews with both OST program advisors to learn more about their respective programs and to explain the scope and purpose of the study. The OST program advisors also provided guidance on the types of activities for the Instructional Activities Survey. Both OST program advisors gave the researcher approval to visit their respective OST programs during one of the regularly scheduled meetings. During these meetings, the researcher discussed the purpose of the study and what the participants were being asked to do. Students were asked to take a Science Self-Efficacy Survey and the Instructional Activities Survey. The Science Self-Efficacy Survey was used to assess the extent to which students believe that the ability to learn science is either fixed or malleable. The Instructional Activities Survey measured the frequency and types of activities that occurred in each OST program.

Students who participated in the FIRST OST program and SWE OST program were invited to take the Science Self-Efficacy Survey and the Instructional Activities Survey. The Science Self-Efficacy Survey and the Instructional Activities Survey instruments were designed by researcher Janet Dubinsky. Dubinsky uses these surveys to assess students' Science Self-Efficacy after the teacher of the students attend her workshop series. The Science Self-Efficacy Survey consisted of 25 questions with a 6-point forced choice scale ranging from 0 to 6 and two short response questions. The Instructional Activities Survey also consisted of 25 questions asking about the frequency of certain instructional activities and two short response questions. For the first 25 questions, there were five possible answer choices: never, one time, two times, monthly and weekly.

Student participants in this study ranged from grades 9–12. There was a combined total of 111 possible student participants. A total of 26 girls and 19 boys responded to the student surveys. A total of 34 parents participated in the parent survey. Two OST program advisors are also included in this study.

Parents were asked to complete a short survey about the different ways they are involved with their child's education. The parent survey consisted of three questions. The parent survey was developed by the researcher with assistance from the OST program advisors. The most common ways that the OST program advisors saw the parents involved with their child were listed. There was an option for parents to write in their own response in case their choice was not listed. Email reminders to take the surveys were sent to all participants on September 15 and November 16, 2016.

Finally, The OST program advisors were asked to provide meeting attendance for each student, to rate each student on how interested the student appeared to be in the program, and provide the number of years each student has been in the respective OST program. Information on GPAs for each student was obtained from the school.

The researcher utilized the Bandura model as the theoretical framework for this study. The Bandura model highlights three factors that influence Science Self-Efficacy: personal factors, behavioral factors and environmental factors. In this study, the personal factors consisted of the student's GPA and attendance in an OST program. The behavioral factors included the instructional activities that students were asked to perform while in the SWE and/or FIRST OST program. The environmental factors included the influences of teachers and parents. Each of the factors listed plays a role in shaping the Science Self-Efficacy of students.

Findings

More girls (*n*=26) than boys (*n*=19) participated in this study. More members of the FIRST OST program (boys and girls) participated than did members of the SWE OST (girls only) program. The scores of the boys and girls on the Science Self-Efficacy Survey were above average. With an average Standard Deviation of .75, the scores did not differ significantly between genders, indicating that all students scored above average to exceptionally high on Mindset and Enjoyment of Science.

According to the parent surveys, parents of girls participated in more parental activities than did those of boys. Of the 22 parents who responded to the survey, parents of FIRST OST program students had higher parental involvement scores that those parents with children in the SWE OST program. The findings reveal no significant difference between parents of boys and girls and their participation in the number of OST SWE or FIRST activities.

The FIRST OST program advisor rated most of the students' interest as a 5 (using a 0–5 scale) while seven students received less than five. The scores indicate that the advisor felt that the majority of students were highly interested. The advisor ratings of students' perceived interest in their science OST program was also positively correlated to Mindset and Enjoyment for boys and girls. Attendance data was only available for the FIRST OST program. Of the 31 students, 28 students reported no absences. One student was absent once and two others were absent twice.

A significant difference in overall GPA between boys and girls was found. Girls had a higher average GPA than boys ($p<.001$). Girls' GPA was also positively associated with Mindset and Enjoyment on the Science Self-Efficacy Survey. No data was able to correlate with the Mindset, or Science Self-Efficacy for boys. However, there was no relationship between student attendance in the FIRST OST program and participants' Science-Self-Efficacy scores.

Correlations among the study's data sets revealed that parent participation in FIRST correlated with parent participation in SWE. Advisors' rating of student interest in SWE was correlated with a positive score on Mindset. Students' GPAs correlated with their advisors' rating of their interest in SWE. Students' GPAs correlated with Mindset. Student participation in SWE correlated with the Advisor's rating in SWE.

From the comments on the Science Self-Efficacy Survey, students indicated primarily positive comments regarding instructional activities in both OST programs. Students enjoyed hands-on activities, working with other students, and being challenged. Students preferred working in small groups and/or working as a mentor to assist less experienced peers. Students disliked vague explanations and directions, as well as lectures, and the limited time for question-asking.

When visiting each OST program, the researcher noted differences in the styles of the meetings. The SWE OST program held its meetings weekly during a 30-minute lunch break, and the advisor and students attempted to eat and participate at the same time. The FIRST OST program was held afterschool with a designated dinner break for students. During this break, one family provides dinner for all students, the advisor, and any mentors present during the session. The SWE OST program is held as a meeting with the entire group whereas the FIRST OST program has smaller breakout sessions which focus on particular aspects of STEM.

Conclusions

Based upon the findings of this study, the following five conclusions were drawn.

Conclusion 1. The students who attend OST programs tend to have above average to exceptionally high Mindset towards science and Enjoyment of science. Mindset towards science was measured using the Science Self-Efficacy Survey. On the survey, both boys and girls scored above average to exceptionally high. This conclusion agrees with Germann (1988), Napier and Riley (1985), and Taylor and Brown (1988) who demonstrated that a positive attitude towards science correlates to increased achievement.

In contrast, Rice et al. (2013) found that students view science and math in a negative light. Some of this negativity can be associated with previous bad experiences in math and/or science. This study concluded the opposite; most students expressed very little, if any, negative views about their OST program. When students answered the question about what they disliked in their program, many said “NA” or “None.” The overwhelming majority of students in these two OST programs enjoyed participating. This is a science pathway high school that students specifically selected to be a part of so this view should be expected. The Einstein Science High School in CGI Unified School District began as a charter school. Students who live in the immediate area are given priority enrollment, students outside of the vicinity are placed in a pool and allowed entry and space permits.

Conclusion 2. Students who are interested in science tend to join science OST programs. Students at this high school had several other OST programs to choose from, but many chose this program. In fact, the majority of members were returning students for their second, third, or fourth year. Information gathered from the student surveys revealed that most students had little to no complaints about their OST program. One fourth-year student in the SWE OST program said, “SWE IS MY LIFEEEEE.” A fourth-year student in the FIRST OST program said, “I love going to FRC competitions. There, there are a lot of great speakers and workshops to attend other than just competing with a robot." The FIRST OST program is similar to an athletics program in terms of the amount of time and commitment students must contribute, especially during competition season. Students may be working on their robots well into the night on weeknights and on weekends. Competitions can vary in location so teams must occasionally travel out of the state to compete.

Ralston et al. (2012) are proponents of the STEM pipeline, and the students who join these OST programs are a vital part of the pipeline. It is likely that students in these OST programs were turned on to STEM prior to their high school careers. This conclusion agrees with the literature regarding Science Self-Efficacy being stronger for students who turn on to science earlier in their educational careers (Bers, 2008; Gelman & Brenneman, 2004); however, this study did not have a tool in place to measure when students became interested in science. Students accepted at Einstein Science High School come from more than 80 of the surrounding zip codes. These students have all had varied experiences in science leading up to their enrollment at this particular high school.

Conclusion 3. The teachers' enthusiasm, dedication, and instruction promoted Science Self-Efficacy. These two teachers possess a keen perception of students' interest in science and provide appropriate hands-on, student involved, and thought provoking activities for them. The students' comments support their qualities. One student noted the teacher's keen perception of students' interest by saying the teacher was "relating to the students by being fun and showing them things the students also see within their lives. The teacher is very laid back and is always open to questions, and they do lots of activities (labs and discussions) in class." Another student mentioned how their teacher was dedicated and was providing student involved activities by, "Creating activities for us to do that help us experience what she is teaching," Students appeared to enjoy the collaboration and hands-on nature of meetings while "doing projects with teams" and "Making our projects interactive." Students also appeared to enjoy the thought provoking nature of activities, one student said the teacher was "Always making sure that we are focused and on task and if we are ever confused, to ask questions."

Based upon the results from the teacher survey, teachers assessed that students' interest was high the OST program. All but three students were given a score of highly motivated. These two teachers, who served as OST program advisors also saw the importance of STEM programs and the value that STEM programs add to society. The work of Brown et al. (2011) notes the importance of the motivation and dedication of teachers to success of girls and boys in STEM. A dedication to STEM education may be one of the reasons why these teachers continue to be the advisors of these programs. Both the students and the teachers have a large time commitment, and many of their evenings and weekends are spent preparing for events.

Students can become very involved in their program while serving as mentors to one another. Students can act as grooming mentors were a more experienced student assists a novice or students can alternate the roles of mentor and mentee in network mentoring (Swoboda & Millar, 1986). Depending on the type of experiences students are engaged in, the mentoring requirement may be different. In either case, all participants are benefiting from the mentoring relationship. Mentees are gaining new learning while mentors are deepening their understandings and working on their leadership skills (Good et al., 2000).

This study showed some of the ways advisors kept the students encouraged. The program advisors found ways to connect learning to the individual lives of the students. One student in both OST programs remarked the science teacher was "Engaging us in labs that are relevant to our own lives." A FIRST student enjoyed when the advisor, "tells stories relevant to the topic we are learning." Another FIRST student said the advisors was, "Encouraging students and assisting them with anything they need with my[sic] providing an enjoying task in order to help." These student quotes show some of the important ways in which the advisors interact with the students.

This conclusion also coincides with Brown et al. (2011) who asserted that there needs to be more awareness of STEM subjects. These teachers may be critical for keeping students in the STEM pipeline by raising the awareness of STEM. This conclusion also agrees with the conclusions reached by Chen et al. (2014) that teachers play a vital role in keeping students motivated and encouraging students to work together to problem solve. The teachers work in close proximity with the students. The teachers have the ability to provide assistance and encouragement so students do not give up on challenging tasks.

Conclusion 4. Girls who are interested in OST science tend to possess high overall GPAs. GPA information collected from the school showed that girls possessed high GPAs and that the girls' GPAs were significantly higher than the boys' GPAs. This finding is consistent with research conducted by Voyer and Voyer (2014); girls generally outperform boys in all academic subjects, except in physics courses. Other studies tend to support the idea that girls tend to do better at school activities than boys because schools are tailored to language use and attributes related to females. Girls generally enjoy the collaborative nature of experiential learning and thus perform well (Cannon & Scharmann, 1996; Chang & Mao, 1999).

The data from the parents and teachers did not provide any support for one gender being more capable than the other in these OST programs. Ceci, Ginther, Kahn & Williams (2014) asserted that women should no longer be underrepresented in STEM field due to gender discrimination. Career choices made by women may be based on stereotypical gender roles and/or females may score lower on entry level spatial tests (Ceci et al., 2009; Halpern et al., 2007; Hill et al., 2010). Women might be discouraged from taking advanced science classes because of the lack of other women in those courses (Bailey & Campbell, 1999; Clark Blickenstaff, 2005; Campbell & Storo, 1996). Women may just doubt their abilities to perform well in STEM courses and careers (Mosatche et al., 2013).

Although girls tend to have higher GPAs, there are other factors contributing to women being represented at a much lower rate than men in STEM jobs. Some factors that contribute to women being underrepresented start before women ever reach the workplace. For example, Furnham et al. (2002) who found that parents may view their sons as more intelligent than their daughters. This study also revealed that teachers may subconsciously promote the idea that boys are better equipped for science and math. Peltz (1990) noticed that boys tend to utilize science lab equipment more than girls. Other research suggests that girls must find a way to build their science identity; for example, the use of mentors can help girls see themselves as a scientist (Riedinger & Taylor, 2016). Studies found that when girls were asked to draw a scientist, they were not sure if they would be allowed to draw a woman (Losh et al., 2008; Manzoli et al., 2006). Building the science identity of girls appears to be very important for these girls to later be turned on to advanced STEM courses and careers.

Conclusion 5. Parents support students who are in science OST programs. This study measured parent support by the responses received on the parent survey. The participation rate for parents was 32%. Low response rates may have been due to parents not being aware of the purpose of the survey. Parents learned about the survey through email only, some students may have mentioned the survey to their parents. Parents that responded to the survey averaged between 3.08 and 3.25 activities for FIRST OST parents and 1 activity for SWE OST parents.

The Einstein School has found different ways to get parents involved at school. Parents encouraged to help transport students to and from sponsored events as well as provide food for the OST group during meetings. These types of parental involvement are consistent with Epstein's (2001) volunteering type of involvement where parents volunteer their time to the assist as needed.

This finding is also consistent with the work done by Rice et al. (2013) who described how student's attitudes towards math and science were more favorable when students felt support from their parents. The work of Lopez et al. (2001) demonstrated the value in forging relationships with families by offering a varying number of ways to participate. According to information gathered during OST program advisor interviews, parental involvement is highly encouraged at Einstein Schools. For those who respond to the instructors' call, their children will receive the benefits.

Parents are able to assist the programs on the weekends by helping with the transportation of students to and from events. Parents can also serve as volunteers during events or serve as the cheering section during student competitions. Some parents might be experts in a field of need or have connections to experts that are willing to donate some of their time to the programs. Experts can teach necessary skills to the students or serve as a guest speaker for an event. Many parents also set aside time to take their children to STEM based events, museums, and assist with science projects.

Recommendations

Based upon the prior conclusions, the following recommendations are made.

Recommendation 1. All schools should provide one or more opportunities for students to participate in various OST programs. Having several opportunities for OST programs gives students the chance to choose which project will be best for them and programs that may assist them in their future careers. OST programs provide a great opportunity for cross-age peer groupings. Students who may not normally work together in a grade level course will be afforded an opportunity to work together in their OST program. The creation of multi-age OST STEM groups can prove effective ways of teaching additional content available to students in a hands-on way.

The creation of multi-age groups can also uphold the integrity of the OST program because not all members will be lost at the end of the year due to graduation, and many students return the following year. Students who have been in the program can serve as cross-age tutors for students entering the program. When encountering challenges, students who have previously been in the OST program can recall information about their previous experiences to shape their thought processes while new students can provide a fresh look at solving challenges. Students can help each other out with their varied knowledge when they encounter projects and challenges. Brady et al. (2014) mention how the mentors understanding of what the mentee is going through can be beneficial for the mentee. When mentees have a mentor in school, it is more likely that mentees will continue on with their STEM classes (Good et al., 2000).

Students should have choice in the type of program in which they can participate. Student choice gives the students ownership of their decisions and are more likely to be engaged in the activities. Again, this setup of the FIRST OST program is very similar to a high school sports team. Every year the freshman join the team and learn from the more experienced student participants. One of the benefits for the mentor is gaining valuable leadership skills and developing collaborative skills. These OST programs can provide vital extensions of learning that can help students get turned on and/or stay turned on to STEM.

OST programs provide an opportunity to extend the learning day because the traditional school day may not allot enough time for instruction of all content. OST programs can reinforce or teach new content to participating students. OST programs have the ability to function differently from the typical school day and provide more excitement for students by the less structured approach. OST programs have also been shown to enhance the personal and social skills of students (Durlak, Weissberg, & Pachan, 2010). Many students reported enjoying working in groups during their OST program. A student in both OST programs said that learning was made fun by “making us work in groups.” Group work is another way for students to engage in peer tutoring and increase the social skills of students.

OST programs, particularly STEM OST programs, allow a space for students to practice applied science. The typical school day usually teaches science from a theoretical point of view. Applied science allows students to create more practical applications using their knowledge which keeps the students more engaged (Worker & Smith, 2014). For example, the FIRST OST program is based in applied science because the students design and build a robot that can accomplish certain tasks. Having students engaged in more applied science activities can assist them in understanding how important science is to their everyday life.

Current and potential students can be made aware of particular OST programs by attending the “Program Fair.” Additionally, each program could have information posted on the website for the school. An outreach program can be formulated that visits potential feeder schools to promote the OST programs at Einstein Science High School. Current students can visit classrooms of potential students or speak to students at assemblies. Brochures and posters can be made and placed in key areas where potential students may see them. Some locations could include the main office of the school, hallways, restrooms, local eateries and local stores.

Parents can also be made more aware of the OST programs offered by the school through emails, brochures, and parent meetings.

Recommendation 2. OST program advisors should seek out students who show interest in science. Students who show an interest in science are more likely to stay committed to their OST programs so seeking out these types of students can provide consistency for the OST program. These interested students may even convince a peer to also join the OST program by sharing their experiences with other students. The program advisor may even allow students to bring a friend for one meeting to see if this OST program is a good fit.

Identifying the students with science interest can be done by giving student's the Science Self-Efficacy Survey. Students who score at the higher end of the scale are more likely to enjoy science related activities. This assessment could be offered at the beginning of the school year to help place students with OST programs that fit their needs. Promoting student interest in science by obtaining those with a preference for science could lead to more students entering and remaining in the STEM pipeline. This could in turn allow more qualified US citizens to obtain jobs in the growing STEM fields.

Research suggest that many students begin to lose interest in STEM subjects by the time they reach middle school (Archer et al., 2010; Bers, 2008; Gelman & Brenneman, 2004; Rice, et al., 2013). Some students start to believe that science, or other STEM subjects, are not interesting. One way of mediating some of the negative feelings that students harbor about STEM is to make the students feel supported. Feelings of support from peers, teachers, and parents can improve student achievement (Rice et al., 2013). OST science programs have been shown to increase student interest in science and in science careers (Bhattacharyya et al., 2011)

Recommendation 3. Teacher selection for OST programs should include teachers with a Mindset for authentic and hands-on activities. Learning activities should mimic the activities performed by people who work in that STEM field. Ekwueme et al. (2015) found that placing students in situations that mimic real world applications can improve student achievement. With this style of teaching, the students are at the center of the learning that is taking place. Providing authentic learning opportunities is especially important for girls because these opportunities help to build their identity as a person who can seem themselves in a STEM career (Riedinger & Taylor, 2016)

The students in this study overwhelmingly attributed the hands-on and collaborative nature of their STEM program to be beneficial to their learning. These students enjoyed getting away from the traditional lecture style of teaching. Students noted that the collaborative style of learning made learning more enjoyable. Teachers who are selected to instruct the OST programs should have the ability to provide hands-on and interactive type lessons. These teachers should provide ample time to teach concepts through exploratory measures and allow students to ask questions. The program advisors should guide the students in their learning by carefully responding to the students' questions without just giving direct answers. One FIRST student said that, "having a lot of experiments and labs to make the concept engaging" was what made the learning fun. Another student also mentioned the teacher was "allowing my class to have meaningful debates and discussions about science topics and setting up hands-on labs and activities."

The teacher does not have to be the sole provider of the knowledge in the group; the teacher should be given the resources to bring in mentors that support their program. For example, both OST programs brought in experts in the field of engineering. For the SWE OST program, the expert provided a keynote address at one of the Femineer's events. In the FIRST OST program, the expert provided direct instruction to assist the students with their design challenge. While the program advisor will need some knowledge of STEM, the connections with mentors can be more valuable. Students cited some of these learning experiences as their favorite part of the OST program. Many SWE students said the Femineer's events were their favorite part and certain field trips. FIRST students enjoyed the competitions and others liked team building activities like the icebreaker game.

Additionally, OST program advisors must hold high expectations for all participating students. According to Cooper (1983), interactions with students may differ based on whether the teacher perceives the student to be high performing or low performing.

Recommendation 4. OST programs should focus on girls as well as boys in science. Students at Einstein Science High School created SWE when several FIRST students realized the need for girls to have a unique OST program. Curran & Kellogg (2016) noted how there is a very small difference in science achievement between boys and girls while they are in kindergarten. Over the course of the schooling process, the gap between science achievement tends to widen. Girls slowly begin to fall behind the boys. Calabrese Barton et al. (2013) asserted that girls suffer from a gap in their science identity. Girls need to be continually supported and encouraged to remain in STEM fields. Mosatche et al. (2013) argued that girls must be explicitly taught that academic ability is malleable. OST programs like SWE and FIRST can help girls build a stronger science identity and allow them to view ability as an aspect that can be changed.

Girls only represent 25% of STEM jobs (Beede et al., 2011). OST programs that focus on girls allow girls to have more opportunities to take on leadership roles. Girls must still be provided with numerous opportunities to participate in STEM activities, and it is important for girls to recognize their abilities and realize that peers can serve as mentors while in high school. Participation in an OST program can help guide girls towards a STEM career (Bhattacharyya et al., 2011). Positive experiences in OST STEM programs can help to shape the science identity of participating girls, especially historically underserved populations of girls (Riedinger and Taylor, 2016). When girls can behave as scientists, there is a higher likelihood that girls can envision themselves as scientists. Femineer's events are designed to place young girls in the roles of engineers and these experiences may allow the young girls to envision a future career as an engineer. The development of an identity as a scientist appears to be very important for girls.

Recommendation 5. School administrators and advisors of OST programs should make sure every parent has multiple opportunities for involvement. Allowing parents to donate time, food, expertise, and/or supplies can be beneficial to the OST programs. Research has shown that parental involvement tends to decline as students enter high school (Simon, 2001). Giving parents multiple opportunities to be involved in their child's education may yield greater parental participation. Parents can serve as guest speakers for events, assists with the execution of events hosted by students, attend competitions, and assist on field trips. Parents play a vital role in the education of their students (Shonkoff & Phillips, 2000). Parent support has been known to increase the academic achievement of students in various content areas (Keith and Keith, 1993). Parents in this study assisted students with transportation to events and, also, provided assistance at home, such as help with projects or trips to science-related museums. One parent described homeschooling two children which included trips to science museums, watching science shows, and working on science projects together.

Recommendation 6. School sites must provide more rigorous opportunities for STEM teachers to engage in professional development around STEM subjects beginning at the elementary school level. The professional development should be ongoing so teachers are and advisors are made aware of the current trends in STEM. Many students in the study mentioned disliking when the teacher was "vague" or "not answering questions." Howitt (2007) and Westerback (1984) discovered that teachers feel uncomfortable teaching these subjects and perhaps teachers may avoid going into depth about subjects or allowing too many questions. That reluctance that some teachers feel about science may be why some students described their science lessons as being vague or lacking an opportunity to ask questions about the lesson.

Research suggests that the negative attitudes teachers may feel about science can be transferred over to the students (Baker et al., 1992; Krajcik et al., 2003; Ramsey & Howe, 1969). Providing more learning opportunities for teachers can increase their content knowledge, reduce negative feelings about science, and provide greater confidence in the subject area. In turn, teachers can provide more learning experiences for the students by simulating real world issues and allowing collaboration in small groups. Based on the student survey responses, students really enjoyed interactive labs, participating in hands-on activities, and working in groups. Students expressed interested in having fun and being engaged in their learning. One SWE student said wanted to be able to "formulate connections." Overall, students are not fans of the lecture style of teaching. Another SWE student said she enjoyed time for "allowing my class to have meaningful debates and discussions about science topics and setting up hands-on labs and activities." Some vital components of STEM education for teachers should include various ways to make learning interactive and social.

Recommendations for Future Research

Future research questions. Given what this study found and given what the literature says, this study supports the notion that participation in STEM activities leads to higher Science Self-Efficacy. People with higher Science Self-Efficacy tend to do well in STEM courses and jobs. However, there is a lack of knowledge in some areas such as the structure of OST Clubs. Therefore, future research should seek answers to the following questions:

- What structure of OST programs promotes the highest student Science Self-Efficacy? This study looked at two OST programs, one primarily met during lunch and the other primarily met after school hours. Further research should provide a more detailed look at what type of structure is more conducive to student learning and achievement.
- When did students first get “turned on” to STEM? Many of students in this study were very happy with their OST program. The question of when students actually became interested in science is not answered by this study. Further research should be conducted in order to interview students and learn more about their STEM journey as well as when each student decided they enjoyed STEM. Another study could also look at the few students who parents and teachers rated as being less than very interested in their OST program and seek to understand reasons why.
- How many students that participate in these OST programs go on to enter college in a STEM field? How many students go on to enter into a STEM job? A study could pick up where this study left off and track former students who participated in these two OST programs. A longitudinal approach could be employed to track student participants as they leave high school, go to college, and seek employment.

- Would the results be similar at a non-science-geared school? Information gathered for this study was gathered at a school geared towards science. Another study could look at a school that did not have a science focus to see if the results would be similar.
- Do the girls in both programs feel more empowered to take on leadership roles in other OST programs? Many of the students in this study are girls. There are leadership roles exclusively for girls in SWE. Perhaps the confidence gained in their OST program can transfer over to areas like the classroom or other OST programs.
- Do the girls who participate in SWE feel more confident to share their ideas and/or take on leadership roles as opposed to girls who do not participate in SWE? Many students from this study are in both the FIRST and SWE OST programs. SWE is a program designed by girls and for girls. A potential study could look more closely at the girls in SWE and see how they behave in other programs.

Methodological enhancements. This study was only a brief snapshot of students' Science Self-Efficacy. One possible methodological enhancement could be to request face-to-face interviews of the students and parents. Some responses on the surveys left many questions and allocating time to interview the students and parents may have provided an opportunity to ask more probing questions and gain greater insights into the responses.

The Science Self-Efficacy Survey short response question was not clear when asking about how the science teacher made learning easy and difficult. This question could have been more specific to either refer to their current science teacher, or their current OST program advisor. While useful data was collected, the particular science teacher who is being referenced is not clear. Many students interact with more than one science teacher a day. Some students may have answered this question with their most favorite or least favorite science teacher in mind. Other students may have answered each question with a different science teacher in mind. The question was meant to refer to the OST program advisor and not any science teacher the students currently had during their regular school day. The OST program advisors did have at least one period of regular science during the regular school day but not all OST students were enrolled in those classes.

Having the contact information and the ability to connect directly with the participants would have been more efficient. The purpose of communication chosen for this study was to ensure that parents and students would understand that the survey was coming from a trusted person. The downside to using the teacher as a go-between was that the researcher was not certain if the information was getting disseminated according to the prescribed plan. The researcher did not have a previous relationship with the two OST program advisors, so building a working relationship with the teachers could have created more buy-in for the teachers to assist the researcher.

With direct communication to the participants, the researcher would select the time of day and days that tend to promote higher response rates. Participants would also have the ability to quickly reply to the email message if there were any questions about the survey. The researcher was dependent upon the two OST program advisors to disseminate important information to all participating parties. An alternative to relying on the OST program advisors would be to use the online survey platform, Qualtrics. The Qualtrics system has a way to send the survey to participants and this particular system will automatically send out email reminders to participants who did not complete the survey. Using the Qualtrics systems would have made it easier to keep track of participants who completed the survey and those who still needed reminders sent. Direct communication with the parents could have improved the response rates for adults. The orientation for both OST programs would have been an ideal time to present the study to the parents and provide quick access to the survey's web address and orientation provides a platform for parents to raise questions about the research.

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APPENDIX A

Student Science Self-Efficacy Survey

Directions: The statements in this survey have to do with your opinions and beliefs about science instruction in school and the importance of science in your life. Please read each statement carefully, and select the answer that best expresses your own feelings. Remember that this is not a test, and there are no “right” or “wrong” answers. Please respond to every item by darkening one oval on each line.

To what extent do you agree or disagree with each of the following statements about science?

	Not at All 0	1	2	3	4	Strongly Agree 5
1. I enjoy science class.						
2. You either get science or you don't.						
3. Evidence is necessary to support conclusions in science.						
4. You can learn new things, but you cannot really change your basic intelligence.						
5. Many scientific conclusions are simply not true.						
6. I usually understand what we are doing in science class.						
7. You can develop your intelligence if you really try.						
8. I don't do very well in science because I’m not a smart person.						
9. I think I can get smarter.						
10. Accurate observations are not very important in most scientific investigations.						
11. The really smart kids are the ones who get good grades in science without even trying.						
12. I don’t like doing science labs.						
13. The effort you exert improves your intelligence.						

14. I am good at science.						
15. When you exert a lot of effort, you show that you are not intelligent.						
16. Sometimes people do experiments and only report findings that support their ideas.						
17. You are born with a fixed amount of intelligence.						
18. Even when scientific investigations are done correctly, the conclusions that scientists reach may change in the future.						
19. I will probably take more science courses available to me at this school.						
20. The subject of science has little relation to what I do outside of school.						
21. I am already as smart as I can get.						
22. Some of the ideas in science are just too hard for me to understand.						
23. I often feel bored in science class.						
24. You can always change how intelligent you are.						
25. The science instruction I have received will be helpful for me in the future.						

My teacher made learning easy/fun by____

My teacher made learning difficult by ____

I'm a member of FIRST SWE BOTH

Do you agree to having the researcher obtain your g.p.a? Yes No

What is your name?___________________________________

APPENDIX B

Instructional Activities Survey

SWE Instructional Activities Survey

Think about the activities during this science program. The first column in the table below describes different
science activities. The following columns indicate how often the activity occurred in your science class. Please
indicate how often each activity occurred by selecting the box that best describes the frequency of that activity.

	Never	1 time	2 times	Monthly	Weekly
Listened to guest speakers that were 15–20 minutes long or longer					
Had classroom discussions about engineering activities					
Did activities that help me see how the topic is connected to other areas of science, other subjects, and/or the real world					
Did lab investigations					
Did activities or labs where students developed their own questions for investigations					
Did activities where we constructed a hypothesis statement for lab investigation					
Did labs or activities where we already knew what would happen					
Designed procedures for lab investigations					
Collected lab data in a table designed by me or my group					
Did labs that were quantifiable/measurable					
Used mathematics in lab data analysis					
Analyzed and evaluated my own data					
Had discussions about interpretations of lab results					
Conducted labs that could have many results					
Used evidence to defend a conclusion					
Maintained a lab notebook					
Worked on activities in small groups					
Had discussions about ethical issues					
Watched videos of movies that were 30 minutes or longer					
Gave group presentations					
Networked with engineering professionals					
Had discussion about why we need more women in engineering					
Worked in groups to design and plan a science and engineering activity					
Taught girls about the engineering process					
Learned from a guest speaker/engineering expert					

My favorite SWE activity, field, guest speaker, or event was….
The activity I disliked the most was...______________________

FIRST Instructional Activities Survey

Think about the activities during this science program. The first column in the table below describes different
science activities. The following columns indicate how often the activity occurred in your science class. Please
indicate how often each activity occurred by selecting the box that best describes the frequency of that activity.

	Never	1 time	2 times	Monthly	Weekly	Daily
Listened to lectures that were 15–20 minutes long						
Did activities or labs where students developed their own questions for investigations						
Did labs were the students designed the experiment						
Did labs or activities where the students already knew what would happen						
Used mathematics in data analysis						
Analyzed and evaluated data on my own						
Had discussions about interpretations of lab results						
Conducted labs that could have many results						
Used evidence to defend a conclusion						
Wrote and submitted written lab reports						
Maintained a lab notebook						
Worked on activities in small groups						
Created design requirements						
Problem analysis						
Prototype solutions						
Test and evaluate prototype solutions						
Watched videos or movies that were 30 minutes or longer						
Evaluated other students' work						
Worked with a mentor						
Networked with professionals						

My favorite FIRST activity, field, guest speaker, or event was….

The activity I disliked the most was…_______________________

APPENDIX C

Parent Science Involvement Survey

This a five-minute survey that is part of a Pepperdine student's doctoral dissertation. The findings will be helpful to Einstein Science programs and your support will be greatly appreciated. Completed responses will be entered into a raffle for 1 of 2 $50 Target gift cards. After the raffle, your responses will be given a code number and your names will be kept confidential. Your participation is completely voluntary.

Please complete this survey for each student in FIRST and/or SWE.

Which Program did your student participate in? FIRST SWE BOTH

(Parents will be directed to the appropriate form on the Qualtrics platform)

Parent Science Involvement Survey FIRST

1. Did you attend parent orientation? Yes_____ or No_____

2. What activities, if any, have you done at home with your student related to STEM? (Please check off all that apply)

- Transported student to/from Program
- Brought food for students
- Taken student to a science museum
- Worked on a science project together
- Attended the competition
- Watched a science show on television or the internet
- Other (please explain)_____________________

3. How would you rate your student's interest in FIRST? (5 point forced-choice scale)

Not interested(0)-----Moderately interested-----Eager to attend(5)

0 1 2 3 4 5

Parent Science Involvement Survey SWE

1. Did you attend parent orientation? Yes____ or No____

2. What activities, if any, have you done at home with your student related to STEM?

- Transported student to/from Program
- Brought food for students
- Taken student to a science museum
- Worked on a science project together
- Attended a Femineer's Event
- Watched a science show on television or the internet
- Other (please explain)_____________________

3. How would you rate your student's interest in SWE?

Not interested(0)-----Moderately interested-----Eager to attend(5)

0 1 2 3 4 5

APPENDIX D

Teacher's Perception of Student's Self-Efficacy Survey

FIRST Program

How would you rate each student's interest in STEM? Please indicate attendance in the afterschool program for each semester. Add additional lines if necessary

Name	Not interested 0	1	2	3	4	Eager to Attend 5	1st Semester Absences	2nd Semester Absences	Years in FIRST

SWE Program

How would you rate each student's interest in STEM? Please indicate attendance in the afterschool program for each semester. Add additional lines if necessary

Name	Not interested 0	1	2	3	4	Eager to Attend 5	1st Semester Absences	2nd Semester Absences	Years in SWE

APPENDIX E

Letters of Support

SITE PERMISSION LETTER

DA VINCI
SCIENCE

July 21, 2016

Pepperdine University
Graduate and Professional Schools Institutional Review Board (GPS IRB)
6100 Center Drive – 5th Floor
Los Angeles, CA 90045

RE: Jakeisha Gibson
An Assessment of Factors Relating to High School Students' Science Self-Efficacy

To GPSIRB:

This letter is to convey that I/we have reviewed the proposed research study being conducted by Jakeisha Gibson intended to conduct research at Da Vinci Science School and find **An Assessment of Factors Relating to High School Students' Science Self-Efficacy** acceptable. I/we give permission for the above investigators to conduct research at this site. If you have any questions regarding site permission, please contact: [redacted] at [redacted] or [redacted].

Sincerely,

Steve Wallis
Principal, Da Vinci Science High School

Pepperdine University Graduate and Professional Schools (GPS IRB) Site Permission Letter

[redacted]

Name of School District/School: [redacted]
Title of Study: An Assessment of Factors Relating to High School Students' Science Self Efficacy
Principal Investigator: Jakeisha Gibson

To the Pepperdine University Graduate & Professional School (GPS) IRB,

As a representative of the Da Vinci Science School, I confirm that the school district grants permission for the proposed research to be conducted once IRB approval has been obtained. The research will take place in the Da Vinci Science School.

Family Educational Rights and Privacy Act (FERPA)[1]
This letter confirms that the school district/school has policies and procedures in place as required by the FERPA and the proposed study complies with these policies.

Check one or more of the following as applicable:

_______ Written consent to disclose student information is required.

_______ The research falls under FERPA regulations and Pepperdine University Graduate & Professional Schools Institutional Review Board (GPS IRB) cannot waive written student consent and the research proposal includes plans to adhere to FERPA regulations.

_______ Written consent from the students to obtain student information is not required. The school district has entered into use-restriction and data security agreement with the Investigator(s) in accordance with FERPA. The use-restriction and data security agreement must be signed by the Investigator(s) and provided to the Pepperdine University Graduate & Professional Schools Institutional Review Board (GPS IRB) as a condition of approval of the research study.

____x___ Written [Signed] Consent from students subjects consenting to participate in research can be waived by the Pepperdine University Graduate & Professional Schools Institutional Review Board (GPS IRB) as outlined in 45 CFR

[1] http://www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html

APPENDIX F

Engineering Design Process

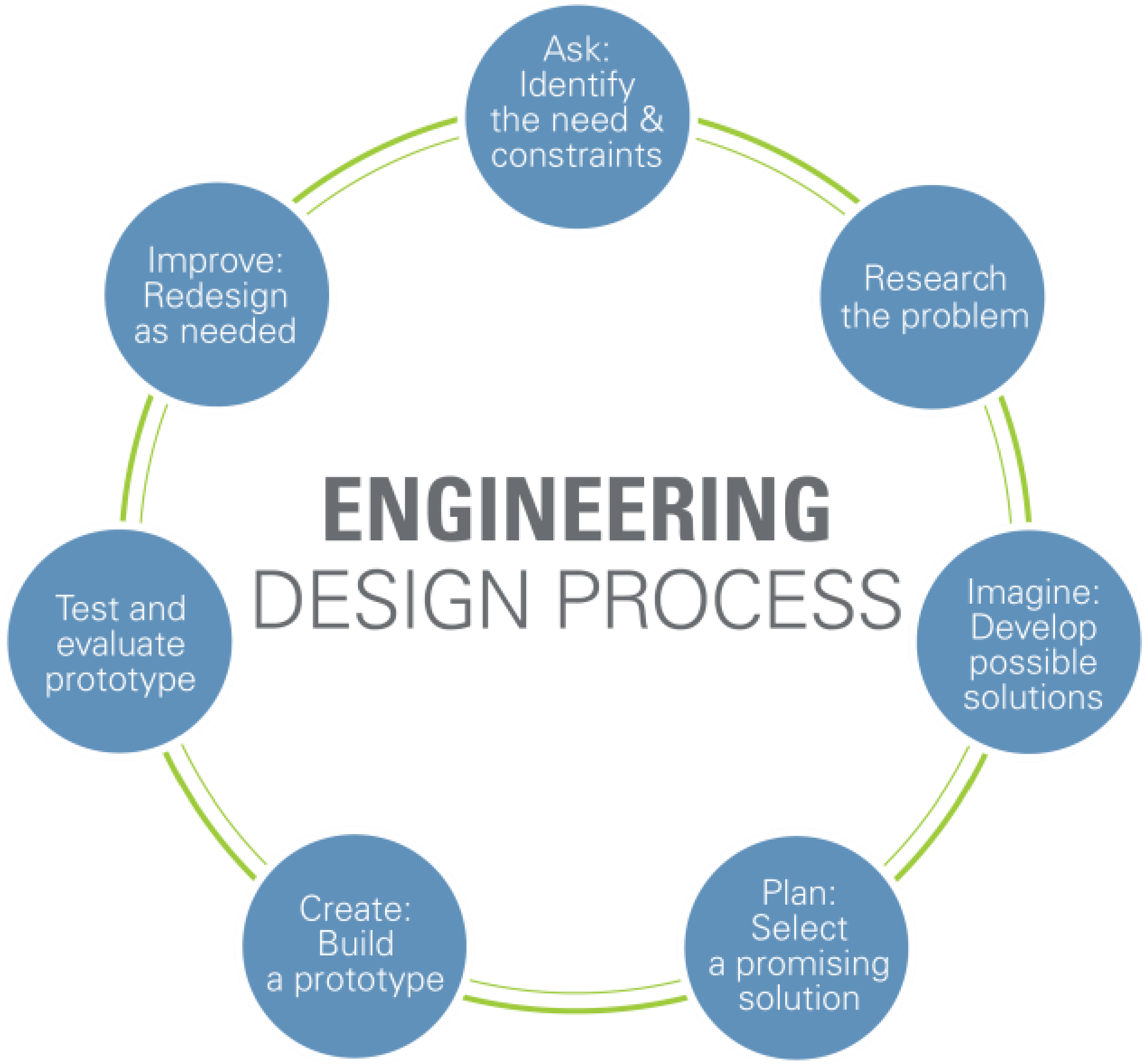

Figure F1. Engineering Design Process

Retrieved from https://www.teachengineering.org

APPENDIX G

Permission to Use Survey

Gmail **jakeisha Gibson <jakeisha.gibson@gmail.com>**

Survey permission
6 messages

jakeisha Gibson <jakeisha.gibson@gmail.com> Mon, May 2, 2016 at 7:35 AM
To: brainu@umn.edu

Hello,

I discovered a survey on your website that I would like to use for my dissertation. Is there any way I can be put in touch with the creator to ask for permission?

http://brainu.org/files/bu_docs/forms/science.pdf

Thank you,

Jakeisha Gibson

--
Check out projects to support my kiddos!
http://www.donorschoose.org/ms.gib

Janet Dubinsky <dubin001@umn.edu> Mon, May 2, 2016 at 11:09 AM
To: jakeisha Gibson <jakeisha.gibson@gmail.com>

Dear Jakeisha,
You have my permission to use it.
Jan

---------- Forwarded message ----------
From: **brainu Department of Neuroscience BrainU** <brainu@umn.edu>
Date: Mon, May 2, 2016 at 10:58 AM
Subject: Fwd: Survey permission
To: Janet Dubinsky <Dubin001@umn.edu>

Hi Jan - Another question for you. I don't remember what this survey was for off the top of my head but, if you'd like me to track down what it's connected to on the brainu.org site, let me know.

Thanks,
Sue
[Quoted text hidden]

--
Janet M Dubinsky, Ph.D.
Professor
6-145 Jackson Hall
321 Church St SE
Minneapolis, MN 55455
612-625-8447
dubin001@umn.edu
brainu.org

APPENDIX H

IRB Approval Letter

PEPPERDINE

Pepperdine University
24255 Pacific Coast Highway
Malibu, CA 90263
TEL: 310-506-4000

NOTICE OF APPROVAL FOR HUMAN RESEARCH

Date: September 06, 2016

Protocol Investigator Name: Jakeisha Gibson

Protocol #: 16-05-[illegible]

Project Title: An Assessment of Factors Relating to High School Students' Science Self-Efficacy

School: Graduate School of Education and Psychology

Dear Jakeisha Gibson:

Thank you for submitting your application for expedited review to Pepperdine University's Institutional Review Board (IRB). We appreciate the work you have done on your proposal. The IRB has reviewed your submitted IRB application and all ancillary materials. As the nature of the research met the requirements for expedited review under [illegible] Title 45 CFR 46.110 of the federal Protection of Human Subjects Act, the IRB conducted a formal, but expedited, review of your application materials.

Based upon review, your IRB application has been approved. The IRB approval begins today September 06, 2016, and expires on September 05, 2017.

Your final consent form has been stamped by the IRB to indicate the expiration date of study approval. You can only use copies of the consent that have been stamped with the IRB expiration date to obtain consent from your participants.

Your research must be conducted according to the proposal that was submitted to the IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit an amendment to the IRB. Please be aware that changes to your protocol may prevent the research from qualifying for expedited review and will require a submission of a new IRB application or other materials to the IRB. If contact with subjects will extend beyond September 05, 2017, a continuing review must be submitted at least one month prior to the expiration date of study approval to avoid a lapse in approval.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite the best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the IRB as soon as possible. We will ask for a complete written explanation of the event and your written response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the IRB and documenting the adverse event can be found in the *Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual* at community.pepperdine.edu/irb.

Please refer to the protocol number denoted above in all communication or correspondence related to your application and this approval. Should you have additional questions or require clarification of the contents of this letter, please contact the IRB Office. On behalf of the IRB, I wish you success in this scholarly pursuit.

Sincerely,

APPENDIX I

Normal Probability Plots for the Regression Models

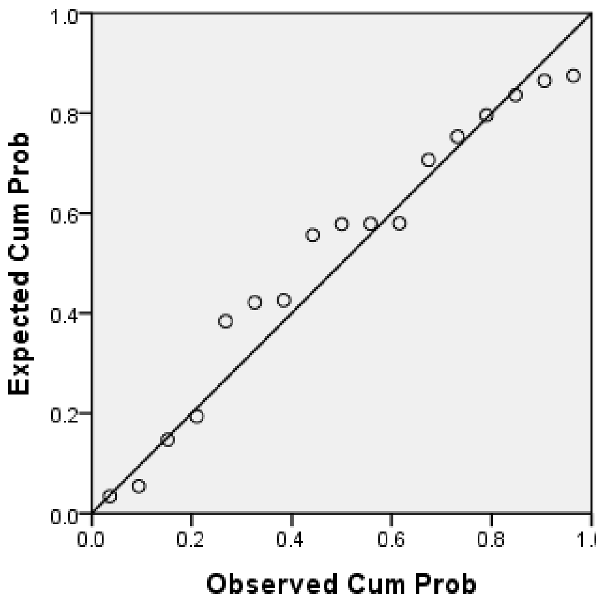

Figure I1. Normal probability plot for the female Mindset model.

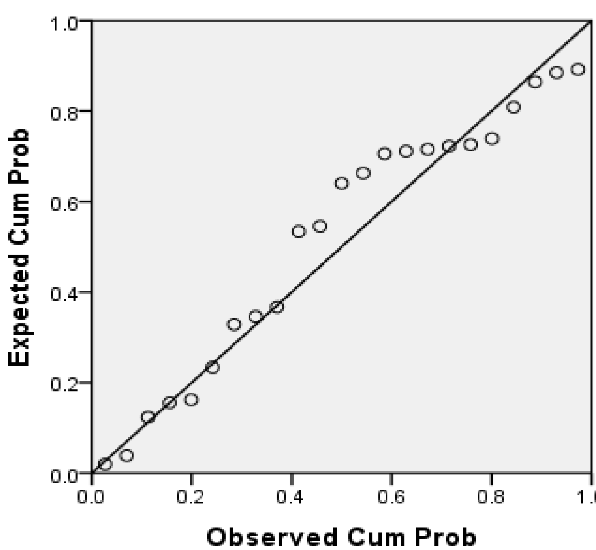

Figure I2. Normal probability plot for the female Enjoyment model.

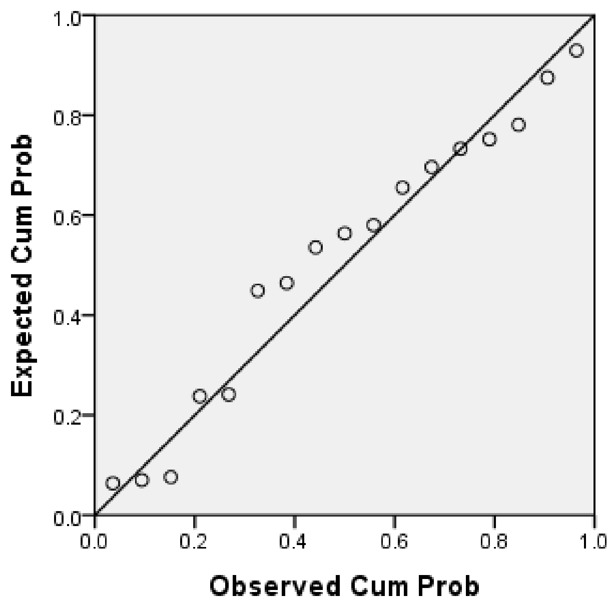

Figure I3. Normal probability plot for the male Mindset model.

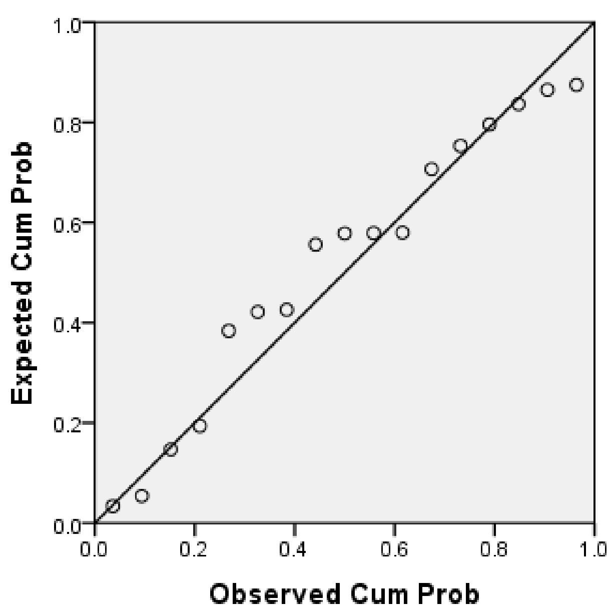

Figure I4. Normal probability plot for the male Enjoyment model.

APPENDIX J

Skewness and Kurtosis Statistics for the Variables

Variables	*N*	Skewness Statistic	Skewness *SE*	Kurtosis Statistic	Kurtosis *SE*
GPA	45	-.62	.35	.35	.70
Science Self-Efficacy					
Mindset	45	-.85	.35	.82	.70
Enjoyment	45	-.56	.35	-.02	.70
Number of SWE activities	20	-.47	.51	-1.27	.99
Number of FIRST activities	31	-1.04	.42	.15	.82
Parent SWE participation	8	.17	.75	-.91	1.48
Parent FIRST participation	22	.10	.49	-1.26	.95
Teacher SWE perception	21	-.72	.50	-.59	.85
Teacher FIRST perception	29	-2.87	.43	8.24	.85

Note. SE = standard error.

APPENDIX K

Scatterplots for the Mindset and Enjoyment Models

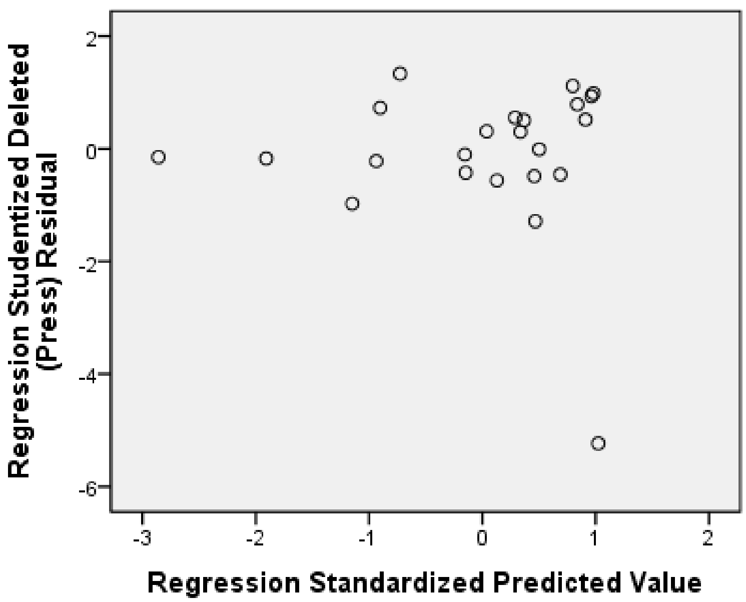

Figure K1. Scatterplot for the female Mindset model.

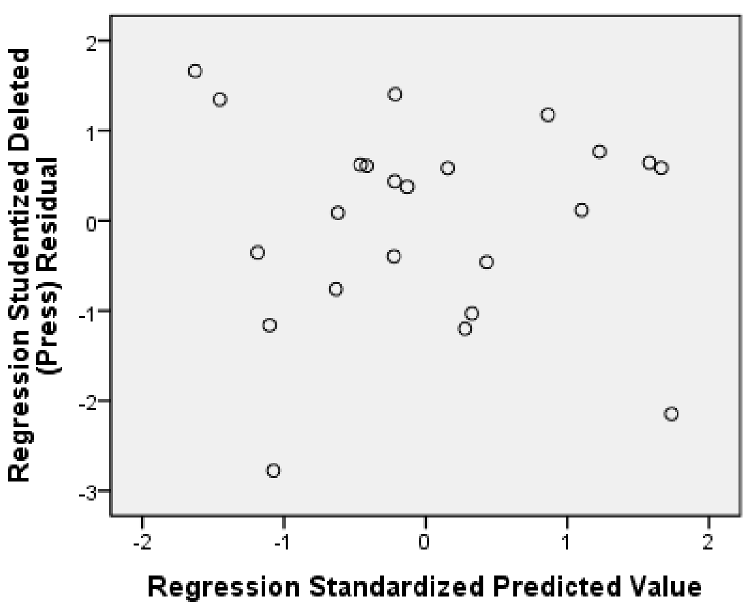

Figure K2. Scatterplot for the female Enjoyment model.

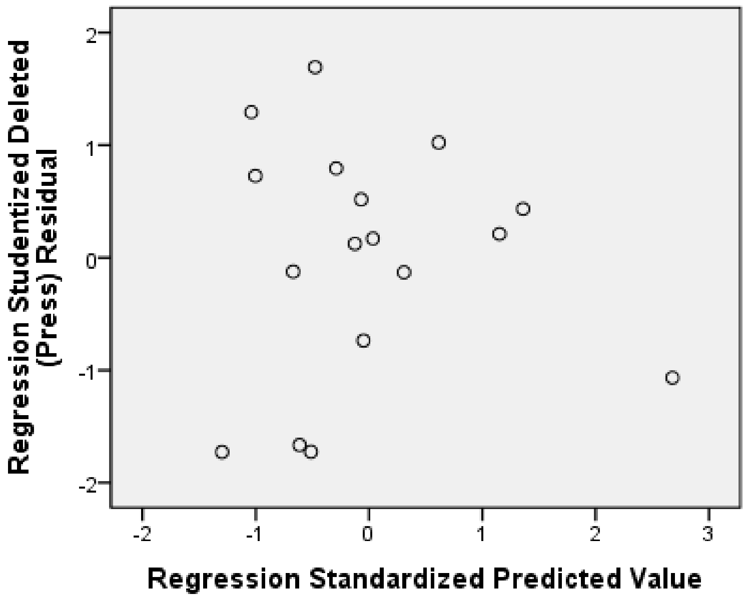

Figure K3. Scatterplot for the male Mindset model.

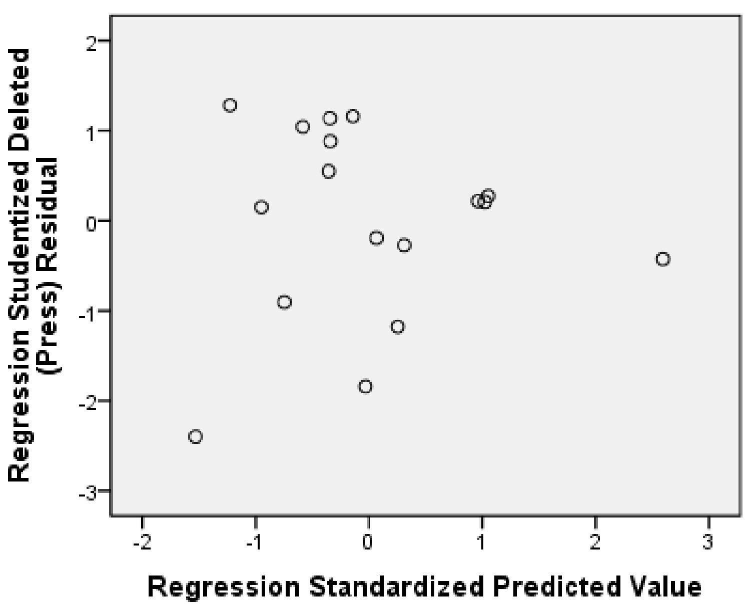

Figure K4. Scatterplot for the male Enjoyment model.