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Gender Effects of Robotics Programs on STEM-Related Self-Efficacy of High School Students

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Walden University

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Sandra Hall-Lay

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Walden University
2018

Abstract

Gender Effects of Robotics Programs on STEM-Related Self-Efficacy

of High School Students

by

Sandra Hall-Lay

MA, National Louis University, 1994

BA, National Louis University, 1993

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

General Psychology

Walden University

August 2018

Abstract

Lack of STEM-related self-efficacy has impeded the growth of women in STEM fields. Out of school (OST) robotics programs and other STEM-related OST programs provide secondary students with opportunities to work in groups, brainstorm, and formulate ideas that require communication and teamwork. The purpose of this quantitative, quasi-experimental study was to compare STEM-related self-efficacy scores among male and female students who participated in OST robotics programs or other OST STEM-related programming. Independent variables were type of OST STEM program and gender. The dependent variable was students' STEM-related self-efficacy as measured by the Coping Self-Efficacy Scale. Responses from 149 students in 4 southeastern U.S. metropolitan high schools were analyzed using a 2x2 factorial ANOVA. Findings indicated the relationship between STEM-related self-efficacy scores and type of OST programming was not moderated by gender. There was a significant main effect for program type. Students in the robotics OST programs demonstrated significantly higher STEM-related self-efficacy than did students in other STEM-related OST programs. Findings may be used to inform educators, community leaders, parents, and policymakers regarding the benefits of OST robotics programs, which may encourage women to obtain STEM-related degrees and pursue STEM careers.

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Chapter 1: Introduction to the Study

Only 16% of U.S. high school seniors are proficient in mathematics and are interested in science, technology, engineering, and math (STEM) careers (U.S. Department of Education, 2014). Interest in STEM subjects may lead to postsecondary education in these fields and to pursuing a STEM career. The United States is ranked 25th in mathematics and 17th in science among globally competitive nations (U.S. Department of Education, 2014). To maintain a top-tier position in technology and compete in the global economy, there must be an increase in participation by men and women in STEM-related postsecondary majors and careers (Munce & Fraser, 2012).

The study was designed to determine whether female high school students' participation in out of school (OST) robotics programming affects their STEM-related self-efficacy differently when compared to male students who participate in the same programs and when compared to male and female students who participate in other types of OST STEM-related programming. Findings from this study may serve as a catalyst for conversation among educators, community leaders, parents, and policymakers regarding the future of these voluntary programs. This chapter includes the background, problem statement, purpose statement, research question and hypotheses, theoretical framework, nature of the study, definitions, assumptions, scope and delimitations, limitations, and significance of the study.

Background

To ensure that the United States remains competitive in the world, student interest in STEM careers at the secondary and postsecondary education levels must be increased

(Cover, Jones, & Watson, 2011). Much concern surrounds the growth in STEM careers and the need for professionals in the industry (Atkinson & Mayo; 2010; Stout, Dasgupta, Hunsinger, & McManus, 2011; Tseng, Chang, Lou, & Wen-Ping Chen, 2013). By 2018, there will be a 100% increase in STEM jobs across the United States, and many of these positions will require at least some college education in a STEM field (Carnevale, Smith, & Melton, 2011).

The strongest influences in individuals' decisions to enter STEM-based professions occur before they enter college (DiLisi, McMillin, & Virostek, 2011). Byars-Winston, Estrada, Howard, Davis, and Zalapa (2010) found that high school students who had high self-efficacy in math and science expressed interests and aspirations to pursue a STEM degree in college. Researchers are studying STEM programs that have the greatest chance of developing and sustaining future STEM professionals (Robinson & Stewardson, 2012). Educators, technology professionals, and community organizers have created partnerships to address the need for increased interest by implementing OST STEM programs for high school students. Engaging students prior to college will provide more long-term, positive performance in the field (DiLisi et al., 2011; Tseng et al., 2013).

One method of attracting students to STEM careers is the use of OST programming. OST programs have been an option to schoolchildren and their parents since the early 1900s (Charmaraman & Hall, 2011). Research has indicated that these programs keep students engaged in positive social behavior that increases their likelihood of academic completion (Guèvremont, Findlay, & Kohen, 2014). OST programs provide a platform that is uniquely constructed to deepen learning by applying learning concepts through enrichment activities (Marten, Hill, & Lawrence, 2014).

Robinson and Stewardson (2012) found that mathematics and science concepts in a competitive robotics environment can create real-world applications for secondary students and may influence their postsecondary education and career choice. Participation in robotics programs has broadened the range of knowledge students have on STEM fields that exist in the current job market (Robinson & Stewardson, 2012). In a longitudinal study, Melchior, Burack, Hoover, and Marcus (2016) found that students involved in OST robotics programs showed more positive STEM-related interests and attitudes than students enrolled in science and mathematics classes in the same schools. Sahin (2013) found that STEM OST clubs and science fair competitions increased postsecondary students' matriculation in STEM majors.

Robotics programming has ushered in a new era for the way young people are affected by STEM by providing hands-on experiences that link academia with OST activities (Robinson & Stewardson, 2012). Many programs have helped participants interpret and connect abstract mathematics and science concepts, providing a more holistic development of participants (Robinson & Stewardson, 2012). The informal learning in OST robotics programs can be leveraged to promote STEM learning in support of technology skills relevant to the real world (Nugent, Barker, Grandgenett, & Adamchuk, 2010).

Graduation statistics show that only half of students who enroll in STEM majors complete a degree in a STEM field (Wilson et al., 2012). Students are not graduating with

STEM careers at a time when these professionals are in high demand. Students who enter postsecondary education to major in STEM fields are increasingly switching to majors in fields not related to STEM (Chen & Ho, 2012). Hardin and Longhurst (2015) found that undergraduate female students had less self-efficacy regarding their ability to succeed in STEM classes and lower interest in pursuing a STEM degree compared to their male classmates. Hardin and Longhurst suggested that female students are more likely to start postsecondary STEM classes with less self-efficacy than their male counterparts and that intervention is needed in high school or earlier to reduce the gender gap.

Problem Statement

STEM-related jobs are increasing significantly in every state (Carnevale et al., 2011). By 2018, there will be more than 8.6 million additional STEM jobs in the United States (Munce & Fraser, 2012). With the increase in STEM jobs, there will also be an increase in the need for STEM-educated personnel to fill the growing demand (Munce & Fraser, 2012). Policymakers and educators realize that filling this demand involves attracting more women to the STEM workforce (Ward, Miller, Sienkiewicz, & Antonucci, 2012). Many efforts have been made to include women, but the numbers of women who remain in STEM-related careers and education continues to be low compared to their male counterparts (Yoder, 2014).

Hardin and Longhurst (2015) acknowledged previous research that supports the notion that lower self-efficacy, or individuals' confidence in their ability to succeed in STEM majors, decreases interest in STEM majors and in pursing STEM careers. Hardin and Longhurst stated, "In understanding why women continue to leave STEM degree programs at higher rates than do men and thus to earn fewer STEM degrees than do men, researchers and educators must focus on what is happening…before these courses" (p. 6). The purpose of this quantitative, quasi-experimental study was to compare STEM-related self-efficacy scores among male and female students who participated in OST robotics programs or other OST STEM-related programming.

Purpose of the Study

Stakeholders are pushing to increase student interest in STEM at the secondary level (Tseng et al., 2013). Special attention must be given to gender issues, including differences in self-efficacy between male and female students in STEM courses (Harackiewicz et al., 2014; Hardin & Longhurst, 2015). The purpose of this quantitative, quasi-experimental study was to compare STEM-related self-efficacy scores among male and female students who participated in OST robotics programs or other OST STEM-related programming.

Research Question and Hypotheses

This study addressed gender differences in STEM-related self-efficacy between students enrolled in OST robotics programs and those enrolled in other STEM-related OST programs. The following research question (RQ) and hypotheses were used to guide the study:

RQ: Is there a significant difference in self-efficacy scores for boys and girls in Grades 9 through 12 who participate in OST robotics programs and those who participate in other STEM-related OST programming?

H_o1: There is no significant interaction between gender and type of OST programming of students' STEM-related self-efficacy.

H_a1: There is a significant interaction between gender and type of OST programming of students' STEM-related self-efficacy.

H_o2: There is no significant main effect of gender in students' STEM-related self-efficacy.

H_a2: There is a significant main effect of gender in students' STEM-related self-efficacy.

H_o3: There is no significant main effect of type of program in students' STEM-related self-efficacy.

H_a3: There is a significant main effect of type of program in students' STEM-related self-efficacy.

Theoretical Framework

Social cognitive theory (SCT) was developed on the premise that learning occurs in a social context based on specific individualized functions that include efficacy, environment, and the actual behavior that is taking place (Bandura, 1971). New patterns of behavior arise and take shape through direct experience or by observing others. The outcomes of social cognitive experiences allow individuals to process activities from an exploratory perspective to determine whether the affect is positive or negative (Bandura, 1971). Several humanistic processes affect social cognitive theory, including the cognitive process, the motivational process, the affective process, and the selection process.

The cognitive process involves self-efficacy beliefs that ultimately dictate whether thought patterns are self-aiding or self-hindering (Bandura, 1989). Human behavior involves constructing goals and personal goal setting based on self-appraisal and self-capabilities. The stronger the belief is in oneself, the higher the goals may be set with the commitment to achieving those goals. People's perceptions of their individual efficacy influence their ability to visualize success and allow for positive pathways of performance (Bandura, 1989).

The motivational processes hinge on individual beliefs that drive and determine how much effort will be put forth to champion obstacles (Bandura, 1989). The stronger the beliefs in personal capabilities, the greater the effort that will be exuded and challenges that will be mastered. Students who participate in structured programming are motivated by the challenge that robotics can bring.

The affective process involves how individuals react to threatening or taxing situations that can alter the course of thinking and coping capabilities based on aversive environments (Bandura, 1989). Those who find difficulty in challenging situations may find themselves in highly stressful situations that can impair their performance in robotics programs. Students who are able to handle such affective processes thrive in this type of problem-solving environment. During the selection process, individuals choose their environment by weighing the benefits of participation, personal development, and social influences that exist or that will evolve (Bandura, 1989). The section processes rely on efficacy beliefs that are products of self-persuasion.

With such diverse cognitive processes that directly affect the social learning theory, people do not live their lives in individual sovereignty (Bandura, 2000). The outcomes that are sought for achievement are captured based on interdependent efforts. People work together to achieve goals that they could not accomplish themselves (Bandura, 2000). This means that the core of the social cognitive learning theory involves the concept of individual agency turning into collective group agency. Group achievement is the key ingredient of the collective agency for efficacy (Bandura, 2000). The group environment allows each individual's cognitive processes to proceed in determining their level of motivation and dedication to the project.

The group establishment provides an environment that claims security through exercise of proxy agency (Bandura, 2000). This is where individuals bring different experiences, skills, and influences based on their experiences, beliefs, and efficacy. Not only do group members bring these important traits, but also by their association and formation as a group, shared knowledge and skills evolve (Bandura, 2000). The interactive, cooperative, and collaborative dynamics of the group create a collective efficacy. This is not just the sum of individual members' efficacy; rather it is an emergent of group-level property, which creates a group-owned efficacy where accomplishments, efforts, and failures are collaboratively shared (Bandura, 2000). In robotics programming, the group tasks are designed to create a group environment to foster focus on a robotics project that involves goal setting and designing and building robots that function to perform certain tasks.

Nature of the Study

The purpose of this quantitative, quasi-experimental study was to compare STEM-related self-efficacy scores among male and female students who participated in OST robotics programs or other OST STEM-related programming. The population from which the sample was drawn contained approximately 450 high school students (Grades 9 through 12) participating in OST robotics and other STEM-related OST programs in four high schools in a metropolitan area in the southeastern United States. These students were administered a questionnaire during their OST program to determine their STEM-related self-efficacy. The independent variables were type of OST STEM program (robotics or other STEM-related program) and gender. The dependent variable was STEM-related self-efficacy. The students' self-efficacy STEM courses were measured using the 18-item Coping Self-Efficacy Scale (CSES) developed by Lent et al. (2001) and used by Hardin and Longhurst (2015) as a measure of students' confidence in their ability to succeed in their STEM major. Additional demographic information (age, ethnicity, and grade in high school) was gathered to describe the sample.

Definitions

A number of terms and acronyms were important to this study:

Out of school time (OST) programs: These programs are offered outside of the traditional school day and usually occur before school, after school, and/or on weekends. Typically, these programs are student centered and provide cooperative learning strategies that foster learning through structured activities (Barker, Nugent, & Grandgenett, 2013).

Robotics programs: These programs are based on STEM concepts including electrical, mechanical, and computer science to build functional robots (Robinson & Stewardson, 2012).

STEM: The term refers to science technology, engineering, and mathematics fields of study that could represent either an academic setting or employment/career setting (Krishnamurthi, Ballard, & Noam, 2014; Munce & Fraser, 2012).

STEM-related OST programs: These programs are out of school activities that involve STEM subjects, including robotics teams, science clubs, engineering clubs, and earth/biology organizations (Yoder, 2014).

STEM-related self-efficacy: Self-efficacy is defined by Bandura (1971) as individuals' beliefs in their ability to accomplish specific tasks that involve individual determination to approach goals, tasks, and challenges. With respect to STEM fields in particular, Byars-Winston et al. (2010) found that high school students with a high sense of self-efficacy in math and science were interested in pursuing a STEM degree in college. The stronger a student's interest and self-efficacy beliefs are related to an occupational choice, the higher the certainty of that choice (Tracey, 2010) and the higher the persistence in that choice (Lent, Brown, & Hackett, 1994). STEM-related self-efficacy, for the purposes of this study, was defined as students' belief in their ability to accomplish specific tasks needed to feel confident in STEM courses.

Assumptions

Three assumptions were identified for this study. First, I assumed the students were honest in their responses when they completed the study's questionnaire. Second, I assumed the facilitators and mentors of the various OST robotics programs provided students with similar experiences. Finally, I assumed the facilitators and mentors of the various OST STEM programs provided students with similar experiences.

Scope and Delimitations

The respondents to the questionnaire were students attending high school. Students formally enrolled in a robotics class at their high school who took the class during regular school hours and received a grade for their participation were not included in the study. These students were members of a different population and were not the focus of the study. The study was delimited to students participating in OST robotics and other OST STEM-related programs in four high schools in a metropolitan area in the southeastern United States.

Information about the quality of OST programming provided to the students in the study was not collected. Information about the students' high school curriculum, their participation in that curriculum, and their grades received from participation in that curriculum was not gathered. This information could have provided additional data to suggest why the participants responded to the questionnaires in the way they did, but this information was not included in the study. The amount of involvement of the students' parents or guardians in their children's OST activities was not a consideration.

Limitations

This research was limited by using the posttest-only research design. The participants for the study were given a posttest assessment to record their STEM self-efficacy based on participation in STEM after-school programs. This posed some concern based on the historical time factors that were not captured in this study. Data collected from a pretest could have provided another level of data for analysis. The current study only included data from a posttest questionnaire.

The posttest-only design included all of the steps of the classic pretest/posttest design except that it omitted the pretest. A disadvantage of the posttest-only design is that pretreatment dependent variables are not controlled. The large sample from which the data were collected ensured two equivalent groups.

A further threat to validity was self-selection bias. The students who participated in STEM-related OST programs other than robotics may have had distinct personal or academic characteristics that were different from students who participated in the robotics OST programing. Determining why differences may have existed among the subsamples would have been difficult. Analysis of data from dissimilar groups may have provided results that were based not on true differences between the groups but on the confounding variables that were not controlled when the groups were formed (when the students chose to join the OST programs). Care was taken to avoid or eliminate demographic and programmatic differences in the students who formed the two groups. Some of the differences may have been controlled using a demographic questionnaire to determine differences in grade, gender, age, and ethnicity. Other confounding variables such as motivation and academic STEM record were not addressed in this study. Differences between the groups may not be explained completely by type of enrollment in OST programming.

Significance

Preparing students for careers in STEM is in the forefront of K–12 educational concerns in the United States (Sadler, Sonnert, Hazari, & Tai, 2012). Without this action, the United States may not be able to handle future technological change and advancement (White House, 2009). To champion such concerns, there must be an increase in participation by both men and women in STEM-related postsecondary majors and careers. Considering the tremendous increase in common use for technology, subject matter experts in technology are needed to combat the imbalance and decline of science and technology workforce professionals.

The study was designed to help understand how OST robotics and STEM programming affected female students' self-efficacy and may help educators understand how to increase the successful enrollment of women in college STEM majors (Hardin & Longhurst, 2015). Conclusions drawn from this study may provide useful information to educators, community leaders, parents, and policymakers and serve as a catalyst for conversations on OST youth STEM programs.

Summary

Much concern surrounds the growth in STEM careers and the need for an increase in the number of professionals in the industry. By 2018, there will be a 100% increase in STEM jobs across the country, and many of these opportunities will require at least some college education in a STEM field (Carnevale et al., 2011). To create interest in STEM careers, researchers are studying STEM programs that have the greatest chance of developing and sustaining future STEM professionals. Because the strongest influences in individuals' decisions to enter STEM-based professions occur before they enter college, educators, technology professionals, and community organizers have created partnerships to address the need for increased interest in STEM majors by implementing OST STEM programs for high school students. Students involved in high school OST robotics programs show more positive STEM-related interests and attitudes than other students enrolled in science and mathematics classes in the same schools. Mathematics and science concepts in a competitive robotics environment can create real-world applications for secondary students and may influence them during postsecondary education and careers.

Only half of students who enroll in postsecondary STEM majors complete a degree in a STEM field (Wilson et al., 2012). In many instances, undergraduate women, in comparison with their male classmates, have less self-efficacy in their ability to succeed in STEM classes and lower interest in pursuing a STEM degree (Hardin & Longhurst, 2015). Researchers have suggested that intervention is needed in secondary school or earlier to prevent these types of gender gaps. The purpose of this study was to determine whether differences in male and female STEM-related self-efficacy existed between students in Grades 9 through 12 who participated in OST robotics programs and other OST STEM-related programming. Chapter 2 contains a review of the literature relevant to social cognitive theory and social cognitive career theory. Chapter 2 also includes important aspects of OST learning and the gender perspectives from researchers on STEM fields of study and STEM careers.

Chapter 2: Literature Review

The purpose of this quantitative, quasi-experimental study was to compare STEM-related self-efficacy scores among male and female students who participated in OST robotics programs or other OST STEM-related programming. The first section of Chapter 2 contains an overview of the theoretical framework. The next section includes a synthesis of the related literature.

Literature Search Strategy

The literature search was conducted by using research from peer-reviewed journals, articles, program documents, and books. To provide the most valid information, I selected literature published within the last 5 to 7 years. This research was conducted using the Walden University library databases to discover relevant documents. The databases included PsycArticles, PsycKey, PsycInfo, and ERIC. Key words used included *self-efficacy*, *after-school programs*, *STEM*, *out of school time (OST)*, *minority representation in STEM*, *female STEM participants*, *robotics*, *effective after-school community youth programs*, *after school comparison*, *turnkey youth*, and *project-based learning*. Other identifiers included *high school*, *computer science*, and *minority*.

The literature review was conducted using studies from qualitative, quantitative, and mixed-methods research. The studies used to complete this review were selected and analyzed for relevance and timeliness. Although many researchers emphasized the importance of OST programs, the common factors that showed the most relevance included participant age, program objectives, days/times offered, and the focus on STEM programming. This chapter contains a comprehensive review of important factors regarding after-school programs and the evolution of STEM-focused programming in the 21st century. Several studies addressed in-school curriculum-based STEM programs; the focus of the current study was on out-of-school programming.

Recent White House (2013) leadership made stakeholders aware of the need to increase the number of skilled STEM professionals by providing access to successful STEM programs for all groups, including minorities and women. The strategy for the current study involved researching the advancement of STEM exposure programs to promote the U.S. initiative to innovate, educate, and build more effectively than the rest of the world (White House, 2013). Presidential interest created an effective situation for research on this subject, as many scholars have shown increased attention to STEM-related programming because of federal financial support (Cover et al., 2011).

This review includes an investigation of how participation in OST robotics programs affects participants' STEM-related self-efficacy. The reason for this focus was the need for increased interest in STEM from students at all academic levels, particularly female students (King, 2015). Recruiting women into the technology fields has been a challenge (Gorman, Durmowicz, Roskes, & Slattery, 2010). As of 2010, postsecondary enrollment in STEM-related majors has declined and many young girls have not shown interest in pursuing STEM majors. The current study addressed whether exposure to OST STEM programs affected students' self-efficacy regarding STEM-related subjects.

Theoretical Framework

OST robotics programs provide STEM activities that involve working in groups, brainstorming, and idea formation, as well as other social activities that require communication with fellow teammates to solve problems. Social cognitive theory (SCT) was used as the foundation of the current study. SCT is based on the idea that people learn by observing, which over time may directly influence their self-confidence and interest (Bandura, 1988). There is a lot of influence on social cognition directly related to the type of environment presented (Bandura, 1988). I sought to determine whether the OST environment is part of a reciprocal triadic relationship among students in the program. In a reciprocal triadic relationship, a person's behavior influences and is influenced by the social environment (Bandura, 1988). In the study, the social environment was OST STEM and robotics programs.

SCT involves self-generated motivations and phenomena that appear to affect proximal determinants of motivation and action (Bandura, 2000). These factors relate to humanistic patterns that control internal judgements to affect individual changes based on self-determined efforts (Bandura, 1989). In OST programming, such motivations and participation are produced voluntarily by students who wish to develop an interest or who already have an interest in STEM (Stout et al., 2011).

According to SCT, the mechanical agency concept provides an internal construct through which external influences affect simple everyday actions (Bandura, 1989). This means that there is no motivation, self-reflection, or creative influence because the agency resides in the environmental forces. This concept is mostly dependent on factors beyond self-control. In these situations, the humanistic patterns develop in childhood and persist throughout adulthood (Bandura, 1989). The self-concept is a warehouse for experiences that an individual observes and participates in (Bandura, 1989). In the current study, examining the influence of exposure to STEM programs provides some insight into the effect of humanistic mechanical agencies. Lyon (2010) revealed that exposure to OST STEM-related programs during postsecondary experiences tends to promote long-term interest in STEM careers.

Triadic reciprocal causation is associated with SCT. This concept involves behavior, individual cognition, and environmental influences that operate as determinants interacting in multiple directions (Bandura, 1989). These factors have different levels of impact; one may have more impact than others may, and time may affect the connection. The interaction of factors brings about responsive behavior patterns and actions (Bandura, 1988). Reciprocal determinism, as defined by Bandura (1986b) is a triangular interaction between behavioral, personal, and environmental factors that generate responses or actions. The interactions between the person, behavior, and environment emphasize the influence on social cognitive components (Harare, 2016). Triadic reciprocal causation highlights how an individual's physical surroundings (environmental) influences behavior, how the individual's behavior (behavioral) has an effect on the environment, and how the individual's characteristics (personal) have a role in how the individual behaves (Harare, 2016). These factors influence and are influenced by each other.

To use skills effectively under different circumstances requires strong belief in the ability to exercise control over achievement and goal attainment (Bandura, 1988). The level of success depends on whether the self-beliefs are in line with the motivation to accomplish goals within an individual environment (Bandura, 1988). Students with high levels of motivation to participate in STEM programs are more likely to continue participation. Those who do not show significant levels of motivations are less likely to continue (Lent et al., 2005). Lent et al. (2005) found that the significance of SCT included the overall effect of this theory on long-term academic and career choices in STEM. Lent et al. indicated that environment made a significant difference in the determination of interest in STEM programming.

The most prevalent mechanism in SCT is individuals' beliefs about their capabilities to exercise control over life (Bandura, 1989). However, individuals do not live their lives in autonomy (Bandura, 2000). Work and school outcomes are interdependent on group efforts. SCT extends through the collective agency where people's shared beliefs and collective power create a synergistic dynamic (Bandura, 2000). This is the proxy agency where people bring their unique experiences and backgrounds to a forum of learning and goal achievement (Bandura, 2000). OST programs create a learning environment that involves teamwork and goal accomplishment (Stout et al., 2011).

The cognitive process provides thought patterns for the regulation of personal goal setting and is influenced by self-appraisal experiences (Bandura 2000). The major function of thought is to enable people to foresee events and exercise control over their actions (Bandura, 2000). Rules and regulation of events trigger other cognitive issues such as uncertainties and ambiguities that affect individual desires (Bandura, 2000). In searching predictive rules, individuals generate hypotheses based on previous experiences that were successful and unsuccessful (Bandura, 1988). In STEM-related OST programming, students who adhere to protocols that govern robotics development and construction may become successful, which may cause continued participation. When protocols provide negative experiences that prove to be unsuccessful for robotics outcomes, there may be a decrease in participation.

Individual self-confidence determines how much effort is placed in an endeavor and how much endurance is displayed (Bandura, 1989). This motivational process defines the optimistic sense of personal efficacy. Human behavior is regulated by forethought that involves goals influenced by self-appraisal or self-efficacy (Bandura, 1993). These thoughts are framed based on belief in capabilities to perform. Those who have high self-efficacy visualize success that comes from positive guides and support for their performance (Bandura, 1993). Those who have low self-efficacy visualize failure in their performance and create scenarios of the many things that can go wrong (Bandura, 1993). In addition, their support and guidance may also weaken their vision.

There is a difference between individuals processing knowledge and the skills they possess to accomplish a task. Personal accomplishments not only require the skills but also the self-efficacy and perceived assurance to be successful (Bandura, 1993). Based on the level of self-efficacy, individuals with the same skills and abilities may perform differently (Bandura, 1993). Positive attitudes toward STEM subjects are better predicted by perceived targeted self-efficacy than by actual ability (Hardin & Longhurst, 2015). STEM self-efficacy provides a targeted approach to predicting both the confidence and motivation for specific task completion and task performance (Bandura & Locke, 2003). Researchers have found that high levels of STEM self-efficacy predict better performance and longevity in STEM disciplines compared to lower STEM self-efficacy (Rittmayer & Beier, 2008). Research on STEM self-efficacy has shown that success in STEM-related fields favors men.

Gender Difference in Social Cognitive Theory

Gender development is a natural part of human growth from birth through adulthood (Bandura, 1986a). Individuals are cultivated on the most common aspects of life based on what they see and hear around them on a daily basis (Bussey & Bandura, 1999). Bussey and Bandura (1999) posited that individuals' talents, perceptions of others, conceptions of themselves, social life, and occupational paths are largely developed by societal stereotyping. Basic male and female observations and societal depictions generally direct the individual pathways from culture than biological circumstances (Bandura, 1986a). Another aspect of gender development occurs within the familial transmission model, which indicates that gender behavior is modeled by what is seen within the family setting. SCT provides a multifaceted approach that both external and internal influences shape the individual gender design (Bussey & Bandura, 1999).

Theoretical aspects of SCT concerning the current study show a remarkable capability for symbolization that focuses on the environment for creating and regulating conditions that touch every aspect of life. These include education, religion, and relationships. For the current research, the environmental aspect is the most impactful throughout life. The environment provides a capability for observational learning that enables individuals to expand their knowledge and skills rapidly (Bussey & Bandura, 1999). This is completed by modeling behavior that is learned by seeing and repeating rather than going through the tedious process of learning in traditional ways. In after-school programs, participants are often exposed to problem-based programs that involve hands on interactions and learning from one student to another.

Environmental functions are key aspects of the theoretical framework for this research. Based on SCT, the essential gender components of the environment are already established to determine gender specific actions. Modeling becomes the most powerful means of transmitting values, attitudes, and patterns of thought and behavior (Bandura, 1986a). After observers extract the rules and structure of modeled activities and behaviors, they can generate new patterns of behavior that often will go beyond what was initially seen or heard (Bussey & Bandura, 1999). Children learn gender stereotypes using a similar concept, where they learn differential performances of male and female stereotypes from observational models (Bussey & Bandura, 1999). The extent to which they learn the details of the styles of behavior and become proficient at them depends on their perceived self-efficacy to model the activities, put them into practice, and interpret the social reactions that are received. Just as in STEM after-school programs, gender influences of stereotypical attributes may affect the overall performance and long-term interest. Specifically, women tend to be less confident in these programs based on the anxiety they feel when compared to their male counterparts (He & Freeman, 2010). SCT, compared to other theories, suggests that anxiety is less important when determining the level of efficacy in STEM programs (He & Freeman, 2010).

Smyth and Nosek (2015) conducted a study on gender-science stereotypes based on early childhood development that often provides inadequate information about the nature of opportunities in scientific domains available to both men and women. The perceptions, performances, and decisions about STEM pursuits are directly influenced by labels established many generation prior (Smyth & Nosek, 2015). This type of influence operates outside of consciousness and becomes the contextual background, which is individually specific. Smyth and Nosek studied over 150,000 participants to examine the stereotype mindsets of individual who were already in science professions or still attending higher education courses to pursue a degree. Through online assessment and random assignment, it was found that men still hold the higher male stereotypes. Men are perceived as ideal candidates and hold many of the STEM jobs (Smyth & Nosek, 2015). Smyth and Nosek also determined that once a scientific identity has been formed, the stereotype level for men remained high; for women, the level remained low. Smyth and Nosek emphasized that increased exposure to STEM concepts and same-sex peers could continually provide the positive influence necessary to affect the number of female representatives in the field. Smyth and Nosek's results also support the environmental, modeling, and exposure aspects of SCT that is fundamental in the current study.

From a young age, children prefer to attend to the more same-gender model than to other gender models, indicating that gender is personally relevant (Bussey & Bandura, 1999). Many daily activities are gender divided, which is a natural process. Because science, technology, engineering, and mathematics programs have historically taken on a masculine image, women feel less comfortable in these fields than do men (He & Freeman, 2010). General theoretical research suggest that there are gender differences that directly impact student educational interest, specifically in STEM fields of study

(Cover et al., 2011; DiLisi et al., 2011; Elster, 2014; He & Freeman, 2010). The basic thread of society breeds the difference and gender awareness is in the forefront of every aspect of life, including education, personal relationships, and employment.

Gender Differences and Self-Efficacy

Gender has a profound impact on research that involves reactions to technology (He & Freeman, 2010). The data show that female STEM anxiety is more probable than general attitudes toward STEM (He & Freeman, 2010). Litzler, Samuelson, and Lorah (2014) concluded that confidence has an impact on women who choose STEM fields. In male-dominated STEM professions, women are slow to develop the confidence needed to overcome biases that have existed for years. Women experience innate cultural biases and historical patterns that identify men as the best fit for STEM jobs and professions (Litzler et al., 2014). This is difficult to overcome, as women look different from the mold that portrays men as more fit for this field. Women role models in STEM fields have been found to play an important role in women choosing a STEM subjects and becoming successful in the field (Cech, Rubineau, Silbey, & Seron, 2011).

From a gender perspective, women are more likely to underestimate their abilities in science and mathematics when they compare themselves to their male counterparts (Litzler et al., 2014). That lack of self-efficacy likely contributes their failure to low skills and abilities, which leads to lower rates of persistence in the field (Litzler et al., 2014). Understanding the affect STEM-related self-efficacy has on women pursuing STEM fields can help educational stakeholders design retention strategies for girls and women.

SCT helps to understand how personal and contextual background characteristics assist in determining individuals' attainment aspirations and long-term career interests in STEM fields (Dika, Alvarez, Santos, & Suárez, 2016). These characteristics can include gender, ethnicity, race, socioeconomic background, and parental influence (Bandura, 1986a). Other characteristics include unconscious gender differences and biases that begin in childhood (Bussey & Bandura, 1999). Dika et al. (2016) found that high school interest directly affects STEM postsecondary degree completion. These contextual background factors posited in SCT provide a significant baseline for understanding the STEM interests and career goals that are set and achieved versus set and not achieved. High school students' exposure to STEM fields provides a worthy experience and appreciation for future pursuit, specifically for women (He & Freeman, 2010).

The lack of women role models in STEM fields is a result of repeated years of minimal representation in education and the workplace (Yi-hiu, Lou, & Shih, 2014). Yi-hiu et al. (2014) used the social cognitive learning theory to investigate STEM self-efficacy among high school girls and found that gender roles and STEM role models affect student self-efficacy. Yi-hiu et al. identified that STEM self-efficacy and women engineering role models directly affected participants' commitment to STEM fields. When female students are presented with an environment that includes successful women role models, their STEM-related self-efficacy is likely to be motivated and enhanced (Yi-hiu et al., 2014). The social cognition of the learning process showed that STEM self-assessments can be positively modified by exposure and modeling in the appropriate learning environment. Research has shown that gender has notable effects on STEM-related self-efficacy regarding education and employment. The current study provided evidence directly related to the gender aspects of this research.

Self-Efficacy in Education

Self-efficacy is an essential part of the theoretical framework of STEM research (Hardin & Longhurst, 2015; Lent et al., 2005; Raelin et al., 2011; Raelin et al., 2014). Providing such insight assists in understanding the self-regulatory and group environmental dimensions for STEM interest and participation. Self-efficacy plays a vital role in the academic achievement or lack of achievement of both male and female students (Raelin et al., 2011). Raelin et al. (2014) found that the presence of high levels of self-efficacy improved the capability to perform behaviors in a particular domain. In STEM education, self-efficacy posits encouragement for people to set goals and expectations that foster achievement in a particular field (Dahling, Melloy, & Thompson, 2013). Self-efficacy is individuals' perceptions regarding their own competence to engage in or complete tasks (Raelin et al., 2014). The dynamics of self-efficacy typically increase over time based on the experiences individuals encounter. This provides some insight into the correlation between the tract of students as they begin and continue through secondary and postsecondary education (Raelin et al., 2014).

Bruning, Dempsey, Kauffman, McKim, and Zumbrunn (2013) examined dimensions of self-efficacy in writing that involved writing ideation, writing conventions, and self-regulation. Writing requires skills to generate ideas and to manage anxieties and emotions that assist in overcoming situations that may cause writer's block and decrease interest in finalizing tasks and responsibilities. Bruning et al. tested 563 students in

Grades 11 and 12 using the Writing Habits and Beliefs Survey (WHBS). The WHBS is a 16-point assessment designed to extract data to identify participant ideation, conventions, and self-regulation (Bruning et al., 2013). The WHBS survey provided data relating to writing achievement. Participants were enrolled in different levels of writing/English courses (general English, composition, American literature and composition, and advanced placement language). The students reported their current academic performance in the class. Bruning et al. found that students enrolled at different levels of high school English/language arts classes displayed different levels of self-efficacy. Students in courses considered higher-level performance reported a higher self-efficacy measure for confidence in writing. The exposure in these courses provided a greater ability to generate ideas and formulate continuous writing. Mastery in any domain is the most reliable method for ensuring greater self-efficacy and success in task accomplishment (Bandura, 1986a). Regardless of the choice in subject matter, self-efficacy is a direct result of environment and exposure to certain domains.

Byars-Winston et al. (2010) investigated the interest and goals of students enrolled in STEM fields. Issues facing the workplace and the lack of qualified workers call for innovations that attract more interest in STEM and increase the availability of professionals (Byars et al., 2010). The need to increase interest in these fields may be impacted by the decrease in retention rates for African American, Latino/a, Southeast Asian, and Native American (ALANA) students. These American populations have experienced academic and social shortfalls that have directly affected their ability to pursue postsecondary opportunities, specifically in STEM fields (Byars-Winston et al., 2010). The overall purpose of the study was to show the effect of STEM interest, self-efficacy, and social climate on current college students enrolled in STEM courses.

Byars-Winston et al. (2010) used the social cognitive career theory (SCCT) to expose factors related to academic and career-related behavior through interactions between individuals and their environment. Self-efficacy is the underlying component that provides relevant beliefs in one's ability as it relates to a particular course of action. Byars-Winston et al. pointed out that individuals must overcome race and ethnicity issues to accomplish academic tasks. Lent et al. (2005) also underscored the necessity to deal with individual issues surrounding ALANA cultures. Abilities and capabilities are secondary to the need for self-efficacy when measuring success in STEM fields (Byars-Winston et al., 2010).

Byars-Winston et al. (2010) used the Self-Efficacy Academic Milestones Scale to measure participant confidence in their ability to accomplish tasks relevant to STEM majors. Byars-Winston et al. found direct relationships between self-efficacy and outcome expectations. There was little evidence to support the direct association between ethnicity and self-efficacy (Byars-Winston et al., 2010), indicating that as long as the members of the ALANA group felt comfortable interacting outside of their ethnic groups, they also felt confident about their STEM pursuits. The higher the efficacy level, the more secure the participants felt in STEM courses.

The current study was designed to complement the study by Byars-Winston et al. (2010). Findings from the current study may provide clues to determine whether self-efficacy in STEM courses is related to OST STEM and robotics programs. Belief in oneself provides personal agency that builds capacity for self-learning, motivation, and goal setting (Bandura, 1986a; Byars-Winston et al., 2010; Lent et al., 1994).

Social Cognitive Career Theory in STEM

STEM majors have been popular fields of study for incoming freshmen (Chen, 2013). However, more than 38% of enrollees do not complete STEM undergraduate degrees (Chen, 2013). According to Hardin and Longhurst (2015), lack of interest in STEM is indirectly associated with the learning environment. The SCCT explains contractual factors that affect students' ability to succeed in STEM subjects, which decreases interest in the subjects (Hardin & Longhurst, 2015). The SCCT model contains factors related to interest in these careers that are directly associated with individuals' self-efficacy or confidence in their ability to complete the relevant STEM tasks (Hardin & Longhurst, 2015). Lent et al. (2005) defined SCCT as the interplay between the person, environment, and behavioral variables that directly affect career interest, choices, and performance. This theoretical concept is interconnected with SCT, which contains factors of self-efficacy, outcome expectations, and interest.

Hardin and Longhurst (2015) examined students' interest and persistence in scientific degree programs. Their research highlighted the importance of the self-efficacy model. Self-efficacy is an important factor that keeps students pursuing STEM tracks of education (Hardin & Longhurst, 2015). As posited by Bandura, lower self-efficacy was directly correlated to the lower interest and persistence in STEM as well as a decline in overall interest in this field (Hardin & Longhurst, 2015). Conducting the current study using high school students allowed stakeholders to understand the trajectories and to pinpoint critical periods for STEM exposure in an effort to increase interest.

Hardin and Longhurst (2015) examined 184 students using a longitudinal study that assessed academic efficacy at the beginning and end of the semester. In using the CSES, participants provided feedback on their confidence to cope with and solve problems experienced at the university. The level of self-efficacy also had a direct effect on interactions with the university staff and fellow students. Results showed that women seemed to be at a disadvantage, reporting less self-efficacy to succeed in future courses.

SCCT theory has been used frequently to describe the reasons for interest and choices in certain educational fields of study (Hardin & Longhurst, 2015). According to this model, individuals' interest, particularly in STEM, is directly influenced by their confidence in their ability to succeed in accomplishing tasks (Hardin & Longhurst, 2015). In contrast, Lent et al. (2005) examined the characteristics of the SCCT theory to determine the STEM interest in male and female students enrolled at two historically Black colleges and universities and one predominantly White university. These included self-efficacy, outcome expectations, social supports and barriers, interest, and choice goals. Almost all of the 450 first-year students who participated in the study were enrolled in engineering majors. Eighty-seven percent of the participants were Black or African American. Thirty-three percent of the participants were women and 66% were men. Students who attended the historically Black institutions had significantly higher academic self-efficacy, outcome expectations, technical interest, and social support than students attending the predominately White institution. There were no significant differences to report in social barriers between men and women. Both types of universities provided a support structure for women in STEM (Lent et al., 2005). Lent et al. found that the environment in both institutions was the key identifier to affect the overall level of self-efficacy. Students were able to relate to a support system that included individuals with commonality based on gender or race (Hardin & Longhurst, 2015; Lent et al., 2005).

Gender Differences in STEM Participation

Obstacles have been faced by those who have strived to make the workforce equal for both men and women. These obstacles have been developed over many decades of humanistic evolvement. Many traits and stereotypes that define certain jobs and careers have been deterrents for men to consider becoming a nurse or for women to become computer programmers. Biological theories indicate that the natural physical differences and the roles played by the genders directly affect the development of STEM professionals (Bussey & Bandura, 1999). SCT is promoted by modeling, which stipulates that information be exemplified by models in one’s immediate environment, such as parents and peers and significant persons in social, educational, and occupational contexts. Because fewer women are in STEM fields, the collective power to create a synergistic dynamic for women creates fewer opportunities for young women to benefit from the social, educational, and occupational influences that help men enter STEM fields. Women and men have reached across the lines of professionalism to provide equality between the genders and positively influence STEM participation. The important factor, as it relates to this study, is a need for an increase in both male and female STEM professionals working to meet the challenges of technology growth.

Sadler et al. (2012) studied the gender differences of STEM interest. Sadler et al. focused on the volatility and stability of STEM interest in high school students. Both male and female interest in STEM appeared higher in those students who had above average performance in high school. The most interesting factor was that male students felt more comfortable expressing STEM interest both in high school and in their future college experiences. Research has shown that more boys than girls are interested in the field and would more likely to choose STEM as a postsecondary educational tract (Munce & Fraser, 2012; Sadler et al., 2012).

Sadler et al. (2012) named organizations such as the Boy Scouts and Girl Scouts that perpetuate the gender gap. Their badge processes pose a difference in gender that tends to continue such stereotypes. Boy Scouts offer boys more career-oriented language such as *mechanic* for boys versus *care* for girls or *astronomer* for boys and *sky search* for girls. These labels provide an example of how this can turn stereotypical and have lasting impressions for both genders.

Munce and Fraser (2012) found that single sex organizations feed into the stereotypic gendering of subjects by providing some activities to girls rather than to boys and vice versa. Munce and Fraser used a stratified national random sample of college students from over 4,000 institutions where more than 6,000 students were polled using surveys and grades gathered during their college experiences (Munce & Fraser, 2012). The study showed a higher retention rate (over 39%) for men in STEM-related educational programs during postsecondary education. Munce and Fraser found that growth in after-school programs appear to be on target to increase the interest in STEM-related careers for both boys and girls. Perhaps, gender comparisons are important to teach program providers the need for exposure for both boys and girls as well as clarify how subtle gender differences may affect future choices in education and careers.

Women in STEM Undergraduate Programs and Professions

Only 30% of STEM degrees are earned by women and only 31% of women in academia work in STEM areas, where the preponderance of these professionals are teachers of life science courses (Gorman et al., 2010). In a time when women make up more than 40% of the entire U.S. workforce, only 24% of traditional STEM jobs are held by women (Gorman et al., 2010). According to the U.S. Bureau of Labor Statistics (2013), 12% of engineers and technology professionals were women, which showed a decline from 2012 to 2013. Thirteen percent of women were employed in these fields in 2012. To sustain the current numbers of employed professionals in STEM fields, specific educational attainment is necessary to receive financial benefits of employment. According to the Higher Education Research Institute, only 19% of women were actually enrolled in college STEM majors (Hurtado & Figueroa, 2013). This means that 81% of enrolled students in undergraduate STEM programs are men. This is a large disproportion of women in STEM fields of study.

There are disparities in employment of women in STEM fields. Organizations provide different approaches to the workplace to present a more appealing picture of the STEM careers for women (Bilimoria, Joy, & Xiangfen, 2008). Some of these methods included major accomplishments over the years using affirmative action programs and antidiscrimination policies that focus on female representation at entry level and in ranked positions (Liang & Bilimoria, 2007). This presents an imminent need for creative methods of exposure that affect the interest or appreciation for these fields. Organizations such as Women in Technology have created gateways to careers in STEM fields (National Center for Women & Information, 2012). These support groups, comprised of prominent women in STEM fields, take extraordinary measures to increase the number of women in STEM careers.

The absence of women in STEM professions represents missed opportunities for important aspects of innovation and creativity (Milgram, 2011). O'Brien, Adams, Blodorn, Garcia, and Hammer (2014) provided important perspectives on the stereotypes present in the higher educational system. O'Brien et al. recruited African American and European American women to take the Implicit Association Test, which assesses general tendencies to associate STEM with gender. Perhaps this research provided a clearer picture of how society views STEM professionals, which is handed down to all generations and causes stereotypical associations as early as elementary school. The study involved 153 women at a college in the U.S. South. The results showed that the participants perceived STEM as a masculine field of study. From an ethnicity standpoint, African American women were more likely than were European American women to indicate that they were majoring in STEM field currently or in the future.

Covert sexism and discrimination may be major factors preventing women from participating in science and technology fields (Gorman et al., 2010). Women experience discrimination in STEM fields for many different reasons (Wolfinger, Mason, Goulden, & Frasch, 2009). The reason for such inappropriate sanctions may be due to the obsolete working model that forces women to choose between a stable career and family. Women who choose to enter the workforce while maintaining their role in the home as wife and mother report disparate treatment by their male peers (Smithers & Robinson, 2006). Women in STEM fields reported that they felt isolated and intimidated and received hostile treatment from their male colleagues (Rosenthal, London, Lobel, & Levy, 2011). These negative associations did not begin at the workplace, as researchers uncovered that the uncomfortable environments often begin during formal undergraduate degree training (Settles, 2006). Women reported that during the undergraduate experience, faculty did not provide favorable support to them when they were studying in STEM programs.

Rosenthal et al. (2011) conducted a longitudinal study to identify the components surrounding perceived compatibility and support of freshman students entering college for the first time with majors in STEM-related fields. Participants were recruited by email. The all-female cohort was provided with a survey that specifically sought to determine whether they felt compatible with their major. The questions were directed at their perceptions of feeling oneness with the major of choice (Rosenthal et al., 2011). This directly addressed the level of support provided by the STEM instructors and advisors that would specifically affect their perceived compatibility with their chosen major. A second survey, which addressed the same questions, was provided to the student at the beginning of the second semester. Rosenthal et al. found that perceived support and compatibility to STEM majors severely declined. Students entered into college with an open mindset of the possibilities of a successful STEM career; however, participants who felt no compatibility and insufficient support from the academic departments did not embrace the STEM major. The correlation of the perceived support and compatibility were direct indicators that there is a need for connection of female participants to other representatives in the field. Disparities in the number of women in STEM fields is, in part, due to the marginalization, bias, and stereotypes women face both in the academic setting as well as in the workplace (Rosenthal et al., 2011).

Women have reported that they experience a lack of security in STEM-related majors and jobs because of a lack of role models and mentors, which ultimately causes a long-term domino effect of underrepresentation among minority groups (Milgram, 2011). Female students who have exposure to female STEM experts show more positive attitudes and connection with the discipline necessary to pursue STEM careers (Stout et al., 2011). When same-sex experts were used as mentors to new college students, those students chose STEM careers (Stout et al., 2011). The exposure to women who held successful careers in the field provided a boost in female implicit attitudes toward STEM.

There are many opportunities for success in STEM fields in today's marketplace. STEM organizations are constantly searching for professionals to fill vacancies in the industry (Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013). Education professionals have noted a decrease in the proportion of students graduating with non-biological science and technological degrees, resulting in a lack of qualified personnel to fill positions (Bieber, Marchese, & Engleberg, 2005). Engagement for female and minority students is an even bigger challenge to steer them in the direction of STEM, where these students continue to be less motivated to participate in these activities (Charmaraman & Hall, 2011). Unfortunately, these groups have minimal opportunities to get involved and stay engaged based on a number of barriers such as lack of prerequisite knowledge, lack of STEM exposure, competitive application processes, inability to demonstrate pre-existing knowledge in science, and poor literacy skills (Lyon, 2010). A program called Project Exploration has expanded opportunities for minority groups to have access to STEM exposure in unlikely neighborhoods. It takes a unique set of strategies to ensure that underserved communities such as women get involved and stay connected with STEM fields (Lyon, 2010).

Women continue to be underrepresented in STEM-related majors and careers that specifically affect STEM leadership positions (Gorman et al., 2010). Only 26% of graduate students in the field of science and in STEM departments in research universities are women (National Science Foundation, 2011). Stout et al. (2011) indicated that the gender skew of representation will directly affect the number of future experts in these fields based on positive environments that properly expose students to STEM. There is a severe imbalance in the number of women in fields such as physics, engineering, and computer sciences (e.g., Mack, Rankins, & Woodson, 2013; Szelényi, Denson, & Inkelas, 2013). As a result, there is a tremendous need for growth in this field to address female underrepresentation.

Job Growth in STEM Industries

In 2010, 7.6 million people or 1 in 18 workers held STEM-related jobs. During the first decade of the 21st century, STEM employment grew at a rate of 7.9%, while non-STEM jobs grew 2.6% (U.S. Department of Commerce, 2012). The urgent call for STEM professionals in the United States has sparked conversations to determine the actual effect of the decline in students who pursue degrees in the field (U.S. Department of Commerce, 2012). In 2012, President Obama set an ambitious goal to train 2 million workers with the necessary STEM-related skills (U.S. Department of Commerce, 2012). Higher education institutions are receiving more than $1.5 billion for expansion of STEM-related degree programs (Anfit, 2013). Funds are made available for qualified students to receive support by choosing a STEM major. As a result, researchers are becoming more interested in the effect of gender to take advantage of such college funds.

Rozek, Hyde, Svoboda, Hulleman, and Harackiewicz (2015) outlined the tendencies of boys to be more likely to take high school classes related to science and engineering, rather than girls. Interventions are more likely to assist in closing the gender gaps where girls are more comfortable in these courses (Rozek et al., 2015). The study provided parents with a utility value (UV) intervention where the goal was to increase adolescent STEM UV. For this research, the UV was defined as the overall perceived importance placed on STEM subjects. The intervention provided parents with best practice techniques that assisted them in expressing the usefulness and relevance of mathematics and science. One of the two goals of this research was to identify if the intervention affected female students' interest in taking STEM courses. This study provided a distinctive parallel to the current study that uses STEM interventions to determine effect in STEM interest and performance. More than 100 students and their families participated in the study. Rozek et al. found that mother's education was an important aspect of the study and that the intervention provided a significant increase in STEM performance and interest, specifically for girls. It appears that parental-based intervention increased the UV, which was directly related to STEM subjects and increased achievement behavior in girls.

Postsecondary STEM education is the typical pathway to STEM professions. In 2011, more than 68% of the 4.7 million STEM workers had a college degree in a STEM subject, but they may not have been employed in the STEM industry (Missouri Economic Research and Information Center, 2014). However, experts acknowledge that STEM education provides the best opportunity for employment in the current workforce (U.S. Bureau of Labor Statistics, 2007). Many researchers indicate that even at the highest point in unemployment, STEM professionals experienced the lowest unemployment compared with those who held non-STEM jobs (Cover et al., 2011).

Across the country, STEM employment is on a steady rise (Langdon, McKittrick, Beede, Khan, & Doms, 2011). For instance, STEM-related industries in Missouri have some of the highest paying jobs in the state (Missouri Economic Research and Information Center, 2014). Individuals with the STEM-related skills and qualifications have a higher earning potential than those who are not educated for STEM professions.

President Obama made STEM education a high priority (Langdon et al., 2011). High tech innovation has become a vital part of the U.S. economy, as global competiveness continues to grow (Langdon et al., 2011). Developing STEM-related programming at the primary and secondary levels provides a unique opportunity for the United States to create high quality jobs, decrease the gender wage gap, and retain global economic leadership (U.S. Department of Commerce, 2012). Retooling the U.S. education system by increasing STEM-related resources and raising expectations of school administrators, teachers, parents, and students will successfully meet the needs of STEM-related industries.

STEM Secondary Education to Undergraduate Education

STEM professionals use skills learned in secondary school, beginning with the basic ability to solve problems. A strong background in science and mathematics is attainable through the traditional K–12 experience (Langdon et al., 2011). Most high schools offer advanced placement math and science classes that improve academic transcripts and allow students to adjust to the demands of STEM work (Vilorio, 2014). Other measures to increase the interest and performance of secondary school students include an overhaul of the mathematics and science curriculum (Liu, 2010). These measures include challenging, project-based, hands-on experiences (MERIC, 2014).

To increase the number of STEM professionals, many scholars and stakeholders believe more skilled teachers are needed to lead the effort (White House, 2013). It is through education that there is a positive effect on instructional strategies and student attitudes toward STEM majors (Capraro & Han, 2014). High schools are increasing the number of mathematics courses in both middle and high school curriculums (Markham, 2011). In Cleveland, Ohio, a special school was created to provide an array of STEM skills necessary to succeed in college (Vaga, 2012). The school primarily serves economically disadvantaged districts, where the free or reduced lunch population is 100% (Vaga, 2012). Empirical studies show that course acceleration is not the only factor that increases performance in STEM subjects (Meyrick, 2011). It is also the teachers' ability to transform learning patterns into meaningful student experiences (Meyrick, 2011).

At the highest point in unemployment, STEM professionals experienced the lowest unemployment compared with those who held non-STEM jobs (Cover et al., 2011). However, a degree is not the only criterion for being successful in STEM. Workers in this field must have the ability to think logically and problem solve using mathematics and science as the basic components (U.S. Bureau of Labor Statistics, 2010). Students who have a genuine interest, along with a successful education in STEM, are more likely to have a solid career in the field (Vilorio, 2014).

After-School Environment

An achievement gap differentiates low-income student households from high-income student households (Rennie Center for Education Research, 2010). This factor expands to all aspects of student achievement including their decision to pursue postsecondary education (Wang et al., 2014). After-school programs are positioning themselves to help close the academic performance gap, specifically in STEM subjects, for many students, especially from underserved communities. The three highest ethnic groups of students in after-school programs are Asian (25%), African American (24%), and Hispanic (21%), according to Gorman et al. (2010). Boys and girls are equally represented in OST programs (Stout et al., 2011). Those who are fortunate to participate in these programs receive support in both academic and behavioral development. Students who attend after-school programming have a higher success rate for completing high school and they are more likely to attend a postsecondary college, university, community college, or trade school (Vaga, 2012).

OST programs have been especially important in neighborhoods where there is a greater risk for truancy, drug use, dropping out, and teen pregnancy. Participation in OST programming has proven to be an important resource to keep students on the right path to finish secondary education and continue on to self-sufficiency. Fredricks, Hackett, and Bregman (2010) interviewed 54 elementary and middle school students to determine (a) motivation for attending after-school programs; (b) their perceptions of the programs, staff, and peers; and (c) school support with the necessary competence and autonomy. Among the highest motivations for attending included fun activities, friends, and safe environments. The altruistic benefits of students attending was academic achievement because students were provided tutoring and academic assistance (Fredricks et al., 2010).

OST programs provide structured programming that keeps students engaged in wholesome activities after the traditional school day is complete (Shernoff, 2012). Over time, many organizations have become major stakeholders in communities across the country. These organizations plan and implement unique programming that keeps young people on the road to becoming successful independent adults (O'Donnell & Kirkner, 2014). Some of these national organizations have made their mark in local communities across the country, such as the Boys and Girls Clubs of America, the Young Men's Christian Association, and the Young Women's Christian Association (Hirsch, 2011).

Communities, parents, and school systems are embracing these OST programs as their educational opportunity to provide the highest level of support to individual students and to increase students' chances of educational success (Hirsch, 2011). Many distractions may derail students (i.e., premature sex, teen pregnancy, crime, and drug use), especially during the formative high school years (Charmaraman & Hall, 2011). OST programs often provide safe environments and teach skills that give students a better chance at adult independence and self-sustainability (Wimer et al., 2008).

After-school programs are a forum to influence students of all ages, both socially and academically. OST programs have become popular to policymakers, practitioners, and researchers to increase extracurricular participation of students (Wimer et al., 2008). The objectives of these programs are to provide structure, workshops, and training for students (Wimer et al., 2008). Students in elementary or secondary schools who participate in the programs benefit from increased test scores and academic performance and decreased dropout rates, crime, teen pregnancy, and absenteeism (Shernoff, 2012).

OST programming provides structured activities that offer academic and social skills building, positive verbal and nonverbal communication, and friendship building (DiLisi et al., 2011). These activities often assist students in making decisions that directly affect their choices in postsecondary educational pursuits and career decisions. Current research supports the notion that the strongest effects on future career choices involve self-efficacy (DiLisi et al., 2011). Students involved in after-school programs have also shown improved performance and psychosocial development. The after-school programming that seeks to challenge students and piques their interest may spark a clearer, more defined confidence (DiLisi et al., 2011).

STEM in OST Programs

Although STEM programs are becoming an important resource to capture and keep the interest of high school students from all socioeconomic levels, low-income individuals and minorities often have limited access to high tech equipment and fewer opportunities for exposure to technology programs (DeCastro-Ambrosetti & Cho, 2002). Many OST organizations focus on programs to increase the number of students interested in pursuing technological careers. Based on participation statistics, the After-school Alliance (2011) found that the after-school structure brings adequate STEM exposure to participants and provides opportunities that bring these subjects alive for them. The positive exposure and supportive academic enhancement are the elements of after-school programming that provides a more comprehensive benefit for participants.

Project Wise provides STEM-related programming to girls. The program focuses on serving female high school students in an after-school capacity to establish student appreciation of STEM (DiLisi et al., 2011). The program collaborates with many undergraduate students in the community who are currently majoring in STEM fields. These students, from local colleges and universities, volunteer their time to affect the next generation of postsecondary STEM students. The goal is to give participants the opportunity to make real-life autonomous decisions with the guidance of near peers (DiLisi et al., 2011). The exposure to STEM careers through mentorship from individuals who are the same gender appears to have a positive effect on participants (DiLisi et al., 2011). Such effects may include a greater interest in STEM careers or simply an increased appreciation for the field.

Another gender-specific STEM program is operated by Techbridge in the California Bay Area. The program has served over 600 secondary and postsecondary girls (Fleming, 2012). The student's choice to pursue STEM careers is not the determinate of a successful OST program. The goal is to condition the students to STEM subjects that ultimately may affect future career decisions about STEM careers (Fleming, 2012). As a gender-specific program, Techbridge provides programming in this environment by fulfilling a need for increasing representation from minorities, specifically those students who are from underprivileged backgrounds (Fleming, 2012).

STEM and Robotics

Research shows an increasingly popular method of STEM exposure used in after-school programs for children and adolescents of all ages (Miller, Ward, Sienkiewicz, & Antonucci, 2011). This method is educational robotics, which involves building, designing, constructing, and some computer programming. Robotics programming gives students the opportunity to design and create new models of functioning robots. The students' perceptions of robotics shape their confidence in the use of robotic concepts and robotic design/prototype within the program (Liu, 2010).

Robotics after-school programming has specific objectives in offering services to participants including increased academic performance, and improved social and communication skills. These objectives provide students with individual accountability for their participation in the programs. Some of the diverse program activities include robotics, science fairs, field trips, software projects, website design, and other activities that involve dozens of career tracts available for study in higher education settings.

The innovative technology-enabled astronomy for middle school students (ITEAMS) program is an after-school STEM program that provides website development, internet searches, and various fundamental technological terms to affect STEM interest positively (Miller et al., 2011). Early results of this program suggest that the ITEAMS project has produced significant STEM interest among students by making the concepts fun and simple. Students tend to provide a higher level of participation in such programs when motivational factors are considered.

Barker and Ansorge (2007) reported that programs that provide hands-on experimentation with robots help students transform abstract science, engineering, and technology concepts into concrete real-world understanding of STEM subjects. This project-based model provides some clues as to the high level of interest that comes from the lowest to the highest levels of academic achievers (Elster, 2014). All achievement levels have shown success in robotics programs. Research on many robotics programs, whether during school or after school, has suggested that the variety of disciplines in robotics increases student options for careers after their secondary experience is complete (Barker & Ansorge, 2007). These disciplines may include marketing, computer programming, and website design, all representing some form of STEM. The programs are interdisciplinary and students learn to engineer robots from conception to creation (Barker & Ansorge, 2007). The interdisciplinary aspect of the robotics programs gives students a comprehensive experience in learning how things work together to create a product. It also gives students an opportunity to visualize themselves in future careers in STEM-related industries. Building robots from start to finish teaches students how all the parts of a complex system interact and depend on each other (Barker & Ansorge 2007). Providing such exposure to students in an OST program may positively affect student career choices and bring about a newly found appreciation for technology and science.

Robotics in Competition

Many competitive robotics programs around the country have goals aligned to increase STEM exposure and interest. Several of the competitions are nationwide and provide thousands of students the opportunity to participate. The newness of STEM programs that include robotic competitions provides an opportunity to explore the possibilities of increasing the interest and demand for such programs that assist in the overall need to supply professionals in this industry. The FIRST Robotics Competition was designed to increase high school students' interest in STEM subjects and related postsecondary fields of study (Welch, 2007). Theoretically, this competition seeks to inspire participating students through hands-on experience using concepts such as mechanical engineering, electrical engineering, computer programming, and business development skills (FIRST, 2010). Although all of these skills are important to students looking to achieve success in promising careers in their futures as adults, the core objective is to establish a cohesive team environment that allows students to use their problem-solving and technology skills. A group of peers uses problem solving and technology skills based on their individual skill sets and interests (FIRST, 2010).

The FIRST Robotics competition challenges hundreds of adolescents around the United States to join a team, either in a school or after-school setting, to build a robot in 6-weeks (FIRST, 2010). Each team, comprised of 12–20 students, is provided a kit of parts with a common set of rules. This kit is provided to all teams, specific to team status (i.e., rookie teams or veteran teams). The robots are designed to play a specific game designed by a STEM committee of technology professionals. Teams usually have a group of mentors, volunteers, and teachers to assist with the challenge. One of the unique factors about the FIRST Robotics Competition program is the competitive nature of the sport and the adrenaline rush that comes during exhibition tournaments, thus providing a deeper motivation to persevere in STEM-related programming (FIRST, 2010).

Project-based robotic programs challenge, capture, and keep the attention of the participants. Empirical studies with similar methods have shown to be effective on student performance in mathematics (Welch, 2007). In a 3-year study conducted in British secondary schools, the use of project-based learning afforded students a more controlled outlook on problem solving and the practical application of mathematic equations (McCright, 2012). The retention of these students was a higher rate than those programs that taught students using only textbook methods. Project-based programming that uses hands-on approaches to learning tends to equip students better with the capability to transcend the boundaries of the classroom (Boaler, 2006).

Motivation is an important element in determining the lasting influence of programs such as robotics (Hidi & Harackiewicz, 2000). This element becomes more important based on where students' academic performance lies. Two explanations for unsatisfactory academic performance include lack of ability and lack of effort, which directly affects motivation to participate (Hidi & Harackiewicz, 2000). Students who put little effort into achieving high academic levels often experience lack of interest and motivation. Researchers indicate that instructional style and hands-on tactics may provide an increase in motivation and interest (Welch, 2007).

These robotics competitions seek to increase interest and obtain continued participation from students by making them an intricate part of the process (FIRST, 2010). The hands-on nature of the process allows students to take ownership and establish a higher level of interest in the game, robotics, and STEM concepts. Other competitions that provide similar programs include VEX Robotics and BEST Robotics. These competitions, held throughout the United States, expose tens of thousands of school-aged children to technology programs.

When analyzing STEM participation and interest, some researchers connect spatial abilities as a necessity for those who excel in these fields. Spatial abilities allow individuals to generate, retain, retrieve, and transform well-structured images (Coxon, 2012). A small number of students have a high-level talent for spatial abilities (National Science Board, 2010). Robotics has been identified as an effective source for spatial talent development in K–12 students (Coxon, 2012). As a result, researchers have found that using robotics competition programs provides exceptional benefits in spatial development, student social engagement, academic challenges, and an overall understanding of engineering concepts (Coxon, 2012).

Summary

Underrepresentation of women and minorities in the STEM industry continues to be a challenge. The literature review contains an assessment of the need to provide young people more exposure to STEM programming before their high school experience is complete. The OST environment is one vehicle to provide STEM-related programming and the academic support and social skills students need to excel in STEM subjects. The current study was created to determine whether the after-school robotics environment is conducive to increasing STEM-related self-efficacy. The need for this study is proven by the amount of interest in the last 5 years. In a world that has constant technological change from education to job choices to military intelligence to individual entertainment, STEM professionals will undoubtedly affect almost every aspect of everyday life.

Chapter 3 contains a description of the research design, methodology, and sample used in this study. The next chapter also contains a description of the data collection procedure and data analysis plan. This information was the guide to the actual study.

Chapter 3: Research Method

There is a need for STEM-educated personnel to fill the growing demand in STEM industries (Munce & Fraser, 2012). Policymakers and educators realize that filling this demand involves attracting more women to the STEM workforce (Ward et al., 2012). Many efforts have been made to include women, but the number of women who remain in STEM-related careers and education continues to be low compared to their male counterparts (Yoder, 2014). Hardin and Longhurst (2015) acknowledged previous research that supports the notion that lower self-efficacy decreases interest in STEM and in pursing STEM majors in college.

The purpose of this quantitative, quasi-experimental study was to compare STEM-related self-efficacy scores among male and female students who participated in OST robotics programs or other OST STEM-related programming. Results may indicate whether OST robotics programs are viable means of increasing female students' STEM-related self-efficacy. The independent variables were type of OST STEM-related program and gender. The dependent variable was STEM-related self-efficacy as measured by the STEM Coping Self-Efficacy Scale (CSES).

Research Design and Rationale

A quantitative, quasi-experimental design was used in this study. Quantitative research addresses questions about the relationships between measured variables to explain, predict, and control events (Leedy & Ormrod, 2010). Employing a quantitative research design reduces potential bias through analysis of the participants' responses without the need for interpretation. Specific questions are used to target the relationships between the variables of interest (Cooper & Schindler, 2008). In this study, students' STEM-related self-efficacy was quantified to examine the potential difference between male and female students enrolled in two types of OST programming.

The quasi-experimental research design is used extensively in the social sciences and is a useful method to measure social variables (Shuttleworth, 2008). A true experimental design randomly assigns participants to control and treatment groups. In most educational situations, randomization of groups is often inconvenient, difficult, or illegal (Brewer & Kuhn, 2010). The disadvantage to a quasi-experimental design is that many factors cannot be controlled; however, as long as the limitations to a quasi-experimental design are noted, these studies can be powerful tools when true experiments are not possible. The results found using quasi-experimental research could be used to support testable hypotheses (Gay & Airasian, 2000). Although not as powerful as experimental designs, the comparative design is common in educational research.

A posttest-only design was used to collect the data. Steinke et al. (2010) used the posttest-only design to assess media influences on middle school children and to examine potential gender differences relative to the traditional views of women in science, engineering, and technology fields. Lee (2010) used the posttest-only design to study the effect of self-efficacy statements provided to rebellious adolescents. Atasoy, Guyer, and Atasoy (2008) used the posttest-only design to determine how individual differences, cognitive styles, and gender influence the use of courseware technology. Kistler and Lee (2010) investigated the influence of sexual imagery of hip-hop videos on the attitudes of college students. The posttest-only design provided an efficient way of providing intervention (showing the videos) and collecting data (Kistler & Lee, 2010). Kistler and Lee suggested that further research should include the study's posttest-only design.

The variables in the current study (gender and type of STEM OST program) were not manipulated. Participation in the robotics program or other types of STEM-related OST program was voluntary. The students were not randomly assigned to the different types of programming. The purpose of the study was not to infer that differences in STEM-related self-efficacy scores were caused by the type of programming, but to report group differences (main effects of gender and type of programming) and the interaction between gender and type of programming.

Population and Sample

The population for this study was students enrolled in OST robotics and other STEM-related OST programming including the Science Bowl Team, Mathematics Team, Earth Club, and the Mathematics Honor Society located in a metropolitan city in a southeastern area of the United States. This population of high school students voluntarily registered for OST programs through a process orchestrated by school-appointed program administrators who organize daily activities and facilitate the STEM-based OST programming. All students in the four high schools were invited to participate in the study. OST STEM-related programs at these four high schools enroll approximately 300 students. Approximately 155 students participated in the robotics OST programs at these four high schools (see Table 1).

Table 1

Demographics of Schools in the Sample

	High school			
Characteristic	1	2	3	4
Enrollment	2,636	1,413	1,405	1,568
# teachers	137	84	92	92
Pupil/teacher ratio	19.2:1	16.8:1	15.4:1	17:1
Percent boys	51	51	47	52
Percent girls	49	49	53	48
Percent White	71	27	29	62
Percent Asian	16	2	2	3
Percent Black	7	48	62	21
Percent Hispanic	4	20	5	10
Percent other	2	2	3	4
Percent eligible for free/reduced lunch program	7	52	47	33
Number of participants in OST STEM-related programs	85	70	55	90
Number of robotics participants	50	40	30	35

The participants were recruited based on their participation in OST robotics and other OST STEM-related programs in four high schools. There were no other inclusion criteria. This process provides a cost-effective approach to research (Doherty, 1994). I conducted a power analysis using G*Power 3.1.9.2 for the fixed effects, main effects, and interactions of ANOVA, assuming four equal group sizes. An effect size of .25, $\alpha = .05$, and power of .80 called for a sample of at least 128 students, or at least 32 male students and 32 female students in each of the OST programs.

Procedures

After approval was provided by the institutional review board (IRB) at Walden University, permission was sought from two southeastern metropolitan school districts in which the four high schools were located (see Appendix A). After permission was received from all parties, recruitment of study participants was conducted during regular after school meetings of the OST robotics and other STEM programs. Because the OST programs occurred after school hours, data collection did not interfere with class time.

Letters of cooperation (see Appendix B) were obtained from the OST program leadership prior to recruiting from these after-school groups. I obtained permission from the advisors of each OST program to speak with the students involved in the activities. I visited each program at each high school, introduced myself, described the purpose of the study, and invited the students to participate (see Appendix C). Letters of consent and assent (see Appendix D) were sent home with students seeking their parents'/guardians' permission and the students' assent to participate in the study. I visited four times within 2 weeks of the first visit to collect the consent and assent forms and to encourage the students to bring the consent forms from home. The consent/assent forms were not collected individually. Rather, I used a secure collection box to gather the forms.

Data were obtained from students who agreed to participate in the study. The students were registered and attending high school in Grades 9–12. The participants participated in either an OST robotics program or OST STEM-related program. I allowed 4 weeks after the recruitment visit to collect the consent/assent forms. Then, I returned to administer the CSES and demographic questions to the students who provided their parents'/guardians' consent forms and who signed an assent form to participate in the study. Responding to the survey took between 10 and 15 minutes. The survey was administered in the classroom where the OST activities occurred.

Instrumentation

The dependent variable in the study was assessed using the 18-item CSES designed by Lent et al. (2001) and used by Hardin and Longhurst (2015) to measure STEM-related self-efficacy. For each CSES item (e.g., "Persist with these courses even if you did not see many other people of your culture or racial/ethnic group in them"), students were asked to indicate "confidence in your ability to cope with, or solve, each of the problem situations" using an 10-point Likert-type scale that ranges from 0 (*no confidence at all*) to 9 (*complete confidence*). Scores were calculated by dividing the summed item responses by 18, yielding a possible score range of 0 to 9, with higher scores indicating greater self-efficacy for coping with barriers to graduating from a STEM degree program. In addition to the self-efficacy survey, I used demographic questions (grade, gender, age, ethnicity, and type of program) to describe the sample and determine whether the two groups were similar.

Reliability

Lent et al. (2001) obtained a Cronbach's reliability of $\alpha = .95$ in a sample of 111 college students. Hardin and Longhurst (2015) calculated reliability for the CSES using responses from 184 students and obtained Cronbach's alpha reliability at the beginning of the semester ($\alpha = .92$) and the end of the semester ($\alpha = .95$).

Validity

Lent et al. (2001) based the development of the CSES on the key cognitive-person variables of self-efficacy, outcome expectations, and goals of SCCT. Proponents of the theory are interested in the interrelation of those cognitive-person variables with other aspects of individuals (e.g., gender, culture, support systems, and barriers) as they shape their careers. The items in the CSES were created after analysis of interview responses Lent et al. (2002) collected in an earlier qualitative study of students' math-related situational barriers and coping strategies. Lent et al. (2001) expected coping efficacy to yield medium-size correlations with barriers and supports identified in another section of their instrument. Those barriers and supports were defined by Lent et al. as environmental factors that persons perceive as having the potential to aid or hinder their efforts to obtain a STEM degree. As expected, stronger coping efficacy was associated with the perception of lesser barriers (r = -.42) and greater supports (r = .63). The large correlation with supports exceeded Lent et al.'s expectations.

Data Analysis Plan

A power analysis called for a total sample of 128 students, or 32 boys and 32 girls in each of the OST robotics and other OST STEM-related programs. The researcher was at each high school as many times as necessary to assure an adequate response rate to have at least 32 boys and 32 girls in the OST robotics program and at least 32 boys and 32 girls in other OST STEM-related programs. The students' responses were entered into a database and uploaded to SPSS for analysis. The dependent variable was calculated for all student participants based on their responses to the CSES instrument. Next, the data were screened for missing responses and outliers, and the assumptions of normality were tested, using SPSS procedures. The collected data were analyzed to answer the following research question and associated hypotheses:

RQ: Is there a significant difference in self-efficacy scores for boys and girls in Grades 9 through 12 who participate in OST robotics programs and those who participate in other STEM OST programming?

H_o1: There is no significant interaction between gender and type of OST programming of students' STEM-related self-efficacy.

H_a1: There is a significant interaction between gender and type of OST programming of students' STEM-related self-efficacy.

H_o2: There is no significant main effect of gender in students' STEM-related self-efficacy.

H_a2: There is a significant main effect of gender in students' STEM-related self-efficacy.

H_o3: There is no significant main effect of type of program in students' STEM-related self-efficacy.

H_a3: There is a significant main effect of type of program in students' STEM-related self-efficacy.

A 2x2 factorial analysis of variance (ANOVA) was used to examine the main effects of (A) program type and (B) gender. First, this researcher determined if there was a significant interaction (A x B) between program type and gender on self-efficacy scores among the students who participated in the study. Second, main effects for type of program and gender were examined. All associated significance tests were evaluated using $\alpha = .05$. In addition to reporting the multiple *F*-test results, appropriate effect-size coefficients were reported.

Threats to Validity

Internal validity is concerned with the factors that may make a difference in the study and affect the overall results (Yu, 2015). A historical threat to the internal validity of the study could be the differences in the OST programs at the four high schools, including type of instructional design, quality of program mentors/instructors, and the curriculum or programming that occurred before data collection began. No modifications or requests for modification of these programs were made by the researcher. The researcher provided a description of these programming elements, which may help the researcher and reader draw conclusions about the programs in which the students were enrolled and how the results may have been affected.

Another internal validity threat that can jeopardize the study was selection bias. All the participants in the OST programs in the four high schools voluntarily registered to participate in the robotics or other STEM-related programming at their school. The subsamples were pre-existing groups and it was impossible to separate the participants into randomized groups. The researcher collected grade level and age of the students to describe the sample and provide information that could determine whether the samples included a representative variety of students.

A specific threat to external validity is time, a traditional concern for educational research (Yu, 2015). In the current study, this may involve the specific phase of OST programming each participant was involved. In the robotics OST programs, participants may be in the planning stage, build stage, or competition stage. This issue was addressed by collecting data at the same time during the academic year rather than at specific programmatic periods. By following this data collection procedure, a threat to external validity may have been reduced, if not eliminated.

Ethical Procedures

After approval was obtained from the Walden Institutional Review Board (IRB) and the two school districts, letters of consent were sent home with students seeking their parent/guardian permission to participate in the study. The CSES and the demographic questionnaire were administered to students who provided a signed consent form from their parent/guardian and who signed an assent form to participate in the study.

Confidentiality of the participants is a necessary consideration (Drew, Hardman, & Hosp, 2007). Demographics were collected to describe the sample and answer the research question. Anonymity was preserved by asking for no names, student identification numbers, or other information that could identify single individuals. The schools and OST programs were not identified. After the questionnaires were completed, they were collected and stored in a locked, secured area in the researcher's home office. The data will be retained for 5 years and then destroyed in accordance with guidelines developed by the American Psychological Association (2009). Teachers, sponsors, parents, or students may request the results of the study. Email addresses of those interested in the results of the study were collected in a separate file and used to send a summary of the results after the dissertation was completed.

Summary

A quantitative, quasi-experimental study was conducted to determine whether there were significant self-efficacy differences between male and female students who participated in OST robotics programs and other STEM OST programming. The population was approximately 450 students in Grades 9–12 enrolled in OST robotics programs and other STEM OST programming in a metropolitan city in the southeastern United States. The STEM self-efficacy of the students was measured using the CSES. Chapter 4 contains a description of the results from the analysis of the data for one research question.

Chapter 4: Results

High school students who have a high sense of self-efficacy in math and science express interests and aspirations to pursue a STEM degree in college. One method of attracting students to STEM is the use of OST robotics programs. Mathematics and science concepts in a competitive robotics environment create real-world applications for students and may influence them during postsecondary education and careers.

Efforts have been made to include women, but the number of women who remain in STEM-related careers and education continues to be low compared to their male counterparts. Previous research supported the notion that individuals' confidence in their ability to succeed in their STEM major decreases interest in STEM and in pursing STEM majors in college (Hardin & Longhurst, 2015). The purpose of this quantitative, quasi-experimental study was to compare STEM-related self-efficacy scores among male and female students who participated in OST robotics programs or other OST STEM-related programming.

Three hypotheses were created to answer the research question: Is there a significant difference in self-efficacy scores for boys and girls in Grades 9 through 12 between those who participate in OST robotics programs and those who participate in other STEM OST programming? This chapter contains a description of the sample, reliability of the scale used to the measure the student participants' STEM-related self-efficacy, and the results of the analysis to answer the research question.

Data Collection and Description of the Sample

Students from Grades 9 through 12 who participated in OST robotics and other STEM-related programs in four high schools in a metropolitan area in the southeastern United States were invited to respond to a survey between August 2017 and January 2018. Data collection began after Walden University IRB approval (05-24-17-0102388) was received and authorization was granted from the director of research and evaluation at the local school system. Visits were scheduled throughout the week, and responses were received from 149 student participants. A power analysis called for a sample of at least 128 students, or at least 32 male and 32 female students in each of the OST robotics and other OST STEM-related programs. Table 2 contains an analysis of how the actual sample used to answer the research question compared to the projected minimum sample.

Table 2

Comparison of Actual Sample of Student Participants to Projected Minimum Sample

Group	Projected	Actual
Male students in OST robotics programs	32	32
Female students in OST robotics programs	32	49
Male students in other OST STEM programs	32	32
Female students in other OST STEM programs	32	32

Eighty-five of the students were enrolled in an OST robotics program, and 64 were enrolled in other STEM-related OST programs (see Table 3). More than half of the participants were female (57%) and African American (59%). More than one third (37%) were sophomores, while another 25% were seniors. Fewer freshmen (18%) were enrolled in robotics than were students in the other programs. The robotics participants were almost evenly split between African Americans (44%) and European Americans (49%), while more African Americans (79%) were enrolled in the other STEM-related OST programs than were European Americans (16%). Approximately the same percentage of students enrolled in the robotics program were sophomores (29%), juniors (26%), and seniors (27%), while the STEM-related programs contained more sophomores (48%). As illustrated in Table 3, the demographics of the sample were not representative of enrollment patterns in the school district.

Table 3

Description of the Sample

	Enrolled in robotics *n* = 85		Enrolled in other after-school programs *n* = 64		All students in sample *n* = 149		HS students in district
Characteristic*	*n*	%	*n*	%	*n*	%	%
Classification							
Freshman	15	17.6	17	27.0	32	21.6	32.2
Sophomore	25	29.4	30	47.6	55	37.2	25.4
Junior	22	25.9	2	3.2	24	16.2	22.3
Senior	23	27.1	14	22.2	37	25.0	20.1
Gender							
Female	53	62.4	32	50.0	85	57.0	51.2
Male	32	37.6	32	50.0	64	43.0	48.8
Ethnicity							
African American	37	44.0	50	79.4	87	59.2	79.8
Hispanic	3	3.6	1	1.6	4	2.7	6.8
European American	41	48.8	10	15.9	51	34.7	11.3
Asian	1	1.3	0	0.0	1	0.7	0.7
Multiracial	2	2.4	2	3.2	4	2.7	1.5

*Some categories have missing data. Percentages were calculated based on number of student participants who responded.

To preserve the number of student participants in each group, mean substitution (the mean of the items completed by the student) was used to create a STEM-related self-efficacy score for each student who responded to at least 14 of the 18 items in the scale. Nineteen of the 149 students (seven female students in the robotics group, four female students in the OST group, and four male students in each of the robotics and OST groups) did not respond to all 18 items in the scale. On average, the 19 students did not respond to 1.59 items in the scale. Thirteen (43%) students did not respond to one item, three (10%) did not respond to two items, one (3%) did not respond to three items, and two (7%) did not respond to four items. Dodeen (2010) reported that the mean substitution procedure was valid for 10%, 30%, and 50% of missing items in scales. An overall self-efficacy score was computed based on the mean of at least 14 of the 18 items. For example, for student participants who responded to all 18 items, the overall self-efficacy score was based on the mean of all 18 items. If student participants responded to only 16 items, their self-efficacy score was the average of those 16 items.

The reliability of the STEM-related self-efficacy scale was calculated using Cronbach's alpha coefficient. Alpha coefficient was calculated using data that included responses to all items. Data from a student who responded to fewer than 18 items was not included in this analysis. Alpha coefficients were obtained for the total group, gender, and program type (see Table 4). In each case, the value was near or above .80. Although the Cronbach's coefficients obtained using this sample of high school students were lower than those found in 2015 by Hardin and Longhurst ($\alpha = .92$), the values obtained were above .70 and indicated an acceptable reliability (see Nunnally, 1978).

Data from students who did not respond to all items in the scale were used in an additional reliability analysis to determine whether the overall alpha was affected in any way by the exclusion of their data from the original reliability analysis. This additional analysis was also conducted to determine whether using mean substitution to preserve sample size affected the reliability of the data. The imputed mean of each student participant's self-efficacy scale was substituted in each missing item in that student participant's scale, thereby creating responses to all 18 items. These new data were used to obtain Cronbach alpha coefficients that are reported in Table 4. In each instance, the alpha coefficient was not affected by the mean substitution process.

Table 4

Reliability of STEM-Related Self-Efficacy Scale by Program Type and Gender

		Original analysis		Additional analysis
Group	*n*	Cronbach's α	*n*	Cronbach's α
Robotics	74	.86	85	.86
Other STEM-related OST programs	56	.79	64	.79
Female students	74	.85	85	.84
Male students	56	.84	64	.84
All students	130	.84	149	.84

Results

The STEM-related self-efficacy scores were screened for outliers and normality. Four cases were identified as outliers. The four cases were responses by two African American and two European American female students in the robotics OST program. The data from these four individuals were examined for systematic errors and for missing data. None were found. In addition, the outliers were not cases far removed from the rest of the sample (see Figure 1). The four cases were determined to be representative of the population from which they were being sampled and were retained. All 149 cases were used in the analysis.

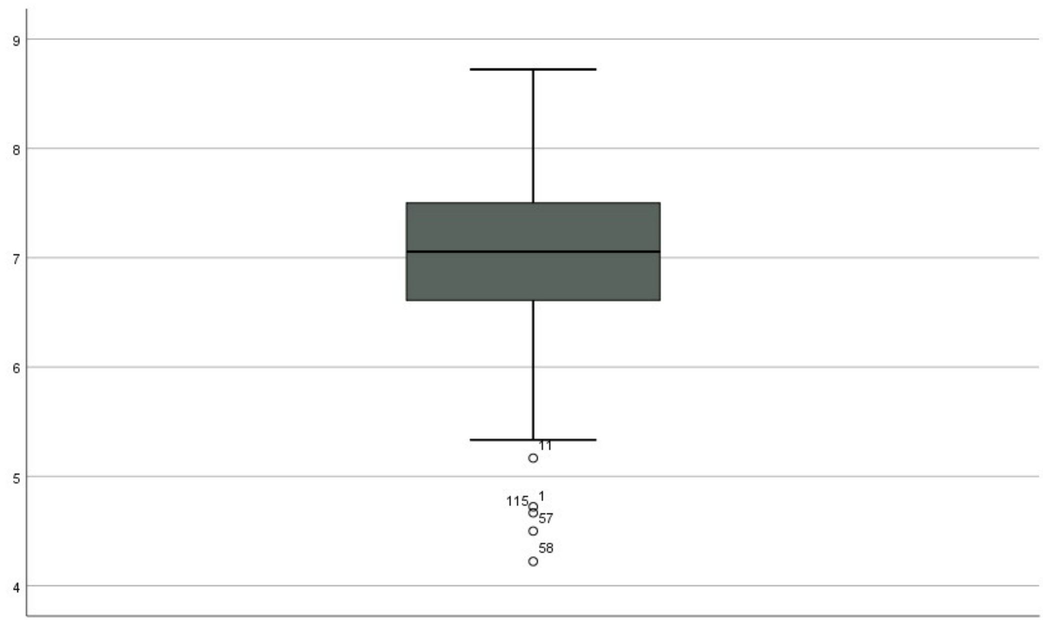

Figure 1. STEM-related self-efficacy scores in the sample of 149 high school students.

Assumptions of ANOVA include independence of cases, normality, and homogeneity of variances. Each case represented a unique student participant. The Levene's test of equality of error variances was not significant, $F(149) = 2.11$, $p = .10$, indicating variances between the two groups were equal. The distribution of the STEM-related self-efficacy score was near normal (skewness = -.91; kurtosis = 1.14; see Figure 2). Blanca, Alarcón, Amau, Bono, and Bendayan (2017) reported that ANOVA is robust regardless of type of nonnormality. The data met the assumptions of ANOVA.

The STEM-related self-efficacy scores of the 149 students were analyzed to answer the following research question and associated hypotheses:

RQ: Is there a significant difference in self-efficacy scores for boys and girls in Grades 9 through 12 who participate in OST robotics programs and those who participate in other STEM OST programming?

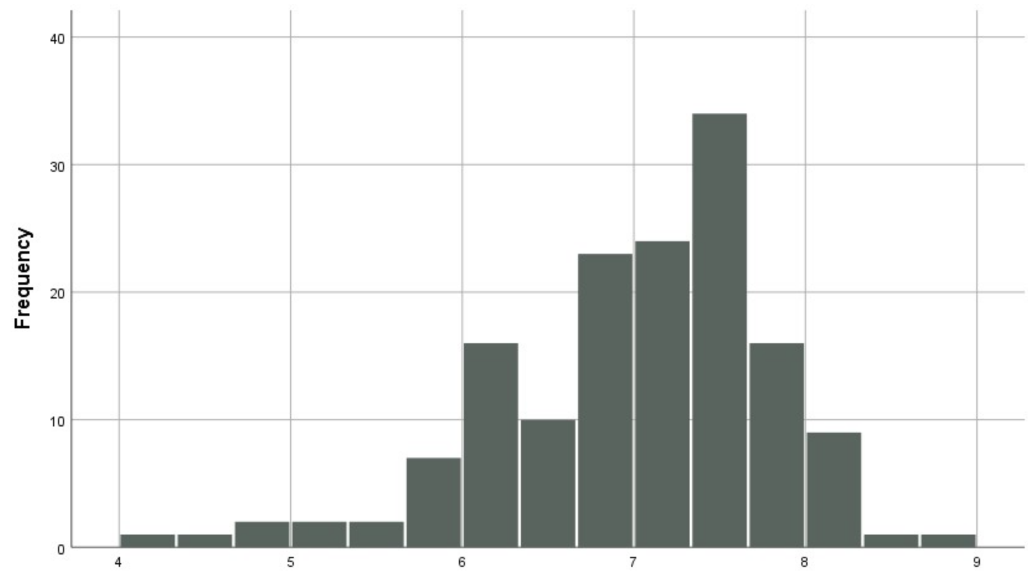

Figure 2. Distribution of STEM-related self-efficacy scores in the sample of 149 high school students.

H_o1: There is no significant interaction between gender and type of OST programming of students' STEM-related self-efficacy.

H_a1: There is a significant interaction between gender and type of OST programming of students' STEM-related self-efficacy.

H_o2: There is no significant main effect of gender in students' STEM-related self-efficacy.

*H*a2: There is a significant main effect of gender in students' STEM-related self-efficacy.

*H*o3: There is no significant main effect of type of program in students' STEM-related self-efficacy.

*H*a3: There is a significant main effect of type of program in students' STEM-related self-efficacy.

The means and standard deviations of the STEM-related self-efficacy scores by program type and gender are presented in Table 5. Females and males in the robotics programs had higher means than the females and males in the other STEM-related OST programs.

Table 5

Means and Standard Deviations of STEM-Related Self-Efficacy by Gender and Program Type

	Female $n = 85$			Male $n = 64$			Total $n = 149$		
Program	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Robotics	53	6.97	.93	32	7.29	.79	85	7.09	.89
Other STEM-related OST programs	32	6.78	.70	32	6.90	.53	64	6.84	.62
Total	85	6.90	.85	64	7.09	.70	149	6.98	.79

A 2x2 factorial analysis of variance (ANOVA) was used to examine the main effects of (A) program type and (B) gender. First, I determined if there was a significant interaction (A x B) between program type and gender on STEM-related self-efficacy scores among the students who participated in the study. Second, main effects for program type and gender were examined. The results of the ANOVA are presented in

Table 6. There was no significant interaction between program type and gender, $F(1, 145) = 0.63$, $p = .43$, indicating that the STEM-related self-efficacy scores of males or females were not dependent on the type of OST programming in which they were enrolled. Null Hypothesis 1 was not rejected.

Table 6

Differences in STEM-Related Self-Efficacy by Program Type and Gender

Source	*SS*	*df*	*MS*	*F*	*p*	η^2
Gender	1.68	1	1.68	2.77	.10	.019
Program type	2.95	1	2.65	4.86	.03	.032
Gender x program type	.38	1	0.38	0.63	.43	.004
Error	88.01	145	0.31			
Total	7351.76	149				
Corrected total	92.53	148				

There was not a statistically significant main effect of gender, $F(1, 145) = 2.77$, $p = .10$. Null Hypothesis 2 was not rejected. However, there was a statistically significant main effect of program type, $F(1, 145) = 4.86$, $p = .03$. Students in the robotics OST programs scored significantly higher on self-efficacy ($M = 7.09$, $SD = 0.89$) than did the students in other STEM-related OST programs ($M = 6.84$, $SD= 0.62$). Null Hypothesis 3 was rejected and Alternative Hypothesis 3 was accepted. The magnitude of the difference between the two program types is reported in Table 6 as $\eta^2 = .032$. Cohen's *d* was calculated as .33, indicating a small to medium effect size (Cohen, 1988).

Summary

One hundred and forty-nine students from Grades 9 through 12 who participated in OST robotics and other STEM-related programs in four high schools in a metropolitan area in the southeastern United States were surveyed. STEM-related self-efficacy was measured using the 18-item CSES. A 2x2 analysis of variance was used to answer one research question and three associated hypotheses. There was no significant interaction between program type and gender. The STEM-related self-efficacy scores of males or females were not dependent on the type of OST programming in which they were enrolled. No statistically significant main effect of gender was found, but there was a statistically significant main effect of program type, indicating that students in the robotics OST programs scored significantly higher than did the students in other STEM-related OST programs. The results of the analysis are discussed in Chapter 5.

Chapter 5: Discussion, Conclusions, and Recommendations

Based on the continued increase in technological advancements and resources, preparing students for STEM careers is of upmost importance (White House, 2013). To continue the level of high performance and to keep up with technological growth, educators and stakeholders in the United States have continued interest in the development of programs that capture and keep the interest of students in secondary education and beyond (U.S. Department of Education, 2014). However, studies indicated that many students who initially choose STEM careers in postsecondary education often do not complete higher educational credentials in these fields (Chen, 2013).

Researchers have found that self-efficacy assists with determining individual ability to foster academic success in both male and female students (Hardin & Longhurst, 2015; Lent et al., 2005; Raelin et al., 2011). Women have historically been underrepresented in STEM fields (King, 2015). As a result, there is a growing concern for policymakers to attract more female students to STEM fields (Ward et al., 2012). This study addressed the self-efficacy levels of high school students who participate in OST programs that attempt to solidify interest and establish long-term fascination with STEM. The key component of OST STEM-related programs is the exposure to environments that provide self-efficacy for future STEM career decisions.

Study Findings

The purpose of this quantitative, quasi-experimental study was to compare STEM-related self-efficacy scores among male and female students who participated in OST robotics programs or other OST STEM-related programming. Responses from 145 students were used in the analysis of the research questions. A two-way factorial ANOVA indicated a statistically significant difference in the STEM-related self-efficacy among students who participate in OST robotics programs compared to other STEM-related programs. The STEM-related self-efficacy scores of male or female students were not dependent on type of OST programming. Although no main effect of gender was found, students in the robotics OST programs demonstrated significantly higher levels of STEM-related self-efficacy than did students in other STEM-related OST programs.

Interpretation of the Findings

Both robotics and other STEM-related OST programs create extracurricular environments that allow students to work in groups, brainstorm, and formulate ideas that require communication and teamwork skills. Bandura (1988) posited that people learn by observing each other, which over time may affect their self-confidence and interest. In the OST environment, students are exposed to experiences and exercises that are linked to how their self-efficacy skills are formulated and/or successfully developed. STEM participation in OST programs has become a positive method for introducing students to mathematical projects and solidifying long-term interest (Miller et al., 2011). The current study supported findings that students participating in robotics OST programs have higher levels of self-efficacy compared to students participating in other STEM-related OST programs. Although students benefit from both types of OST STEM programs, exposure to robotics and technological concepts positively affect students' perceptions and confidence. OST robotics programming involves implementation of program activities and learning concepts that directly influence self-efficacy. Barker and Ansorge

(2007) reported that robotic hands-on experiments could transform traditional conceptions of STEM subjects into real-world understanding of unlimited possibilities for future careers. Other key components that illuminate the benefits of participation in OST robotics programs include the use of project-based learning, innovation, creativity, and hands-on technology (Liu, 2010; McCright, 2012; Milgram, 2011). The creativity aspect of OST robotics programming offers numerous benefits to female participants who have high levels of interest in using innovation and creativity (Liu, 2010).

Researchers have reported that participation in robotics OST programs help adolescents transform abstract science, engineering, and technology concepts into real-world understanding of STEM subjects (Charmaraman & Hall, 2011; Marten et al., 2014; Sahin, 2013). The self-efficacy that is achieved may have a long-term impact on students' ability to excel with confidence in STEM fields during their postsecondary educational experience and/or subsequent STEM credentials pursued.

Bandura (1989) indicated that self-concept is a warehouse for experiences that an individual observes and participates in, which assists in visualizing concepts for future educational and career decisions. Lyon (2010) found that exposure to OST programs in secondary school tends to promote long-term interest in STEM including postsecondary education. Findings from the current study provided insight into how humanistic mechanical agencies directly affect interest in STEM beyond high school. These agencies are generated by the participants based on enrollment, participation, and modeling (Lyon, 2010). An essential part of the theoretical framework of STEM research is self-efficacy (Hardin & Longhurst, 2015; Lent et al., 2005; Raelin et al., 2014). Research has shown that high levels of self-efficacy in students are associated with an improved capability to perform in STEM environments and foster high achievements (Dahling et al., 2013).

The triadic reciprocal causation associated with SCT involves behavior, individual cognition, and environmental factors that translate into actions and decisions based on what is seen and what is heard (Bandura, 1989). Participation in OST robotics provides STEM exposure that may have long-term effects. Bryars-Winston et al. (2010) found that high school students with a high sense of self-efficacy were more interested in pursuing STEM degrees in postsecondary education. The results of the current study showed that students who participated in OST robotics programs had higher levels of STEM-related self-efficacy, which may affect educational and career decisions.

Researchers have found that gender has an influence on choices for long-term STEM participation (Cech et al., 2011; He & Freeman, 2010; Litzler et al., 2014). Once scientific identify is formed, increased exposure to STEM concepts and same-sex peers could provide the influence necessary to affect the number of female representatives in the field (Smyth & Nosek, 2015). In the current study, both male and female OST robotics participants showed significantly higher STEM-related self-efficacy scores than students in other STEM-related OST programming. These findings suggest that both female and male students benefitted from OST robotics programs that increased STEM self-efficacy and the likelihood of long-term association in STEM fields.

Limitations of the Study

A notable limitation of this study was the posttest-only research design. The data collection process included the use of data collected based on posttest assessments to capture self-efficacy levels in OST robotics and other STEM-related OST programs. The study did not include data collected from participants at the beginning of the school year prior to participation in OST robotics programs and STEM-related OST programs. A threat to validity was the fact that students self-selected to participate in the study. Participants in STEM robotics programs may have distinct personal or academic differences from students who participate in other STEM-related OST programs, which may have affected the results. Additionally, the sample demographics were not representative of the school district. A larger percentage of female students and European Americans participated in the study than did male and African American students. Other variables that may have affected the study findings, such as motivation and participants' academic STEM record, were not examined.

Implications

This study was designed to address how OST robotics and STEM programming affected female participants' STEM-related self-efficacy. Results of this study aligned with prior research and underscored the need for preparing students during high school for careers in STEM fields. OST robotics programs promote high school students' self-efficacy and support pathways to STEM pursuits in higher education and careers (Robinson & Stewardson, 2012). Stakeholders must become aware of the need to increase the number of skilled STEM professionals by providing access to successful STEM programs, specifically during secondary school. Without this action, the United States may not be able to maintain a global lead in science and technology.

The objective of many STEM OST programs is to capture and keep the interest of high school students (DiLisi et al., 2011). Through OST robotics programs, students are exposed to hands-on, project-based designs that translate technological concepts into a real-world understanding of STEM subjects (Barker & Ansorge, 2007). Creating models of functioning robots promotes student interest and confidence in STEM subjects (Liu, 2010). Robotics programming has ushered in a new era for how students are affected by STEM by providing hands-on opportunities that link academia with OST activities (Robinson & Stewardson, 2012). Findings of this study indicated the unique ability of OST robotics programs to provide positive influences that can transform students' interest in and future decision-making about STEM. The results may foster more conversation and action to broaden the impact of OST robotics programs.

Exposure to STEM programming provides appreciation and experiences that develop future research interests, especially for women (He & Freeman, 2010). Yi-hiu et al. (2014) indicated that the lack of women role models in STEM fields is due to a lack of women representatives in the educational setting and the workplace. An environment that includes successful women may yield more female participation in the field. STEM industries need to increase female representation to counter the traditional gender biases that impede the recruitment and retention of qualified professionals. Female representation would make an immediate difference in the number of successful workers who can make invaluable contributions to the STEM fields.

The need for an increase in students' immediate and future interest in STEM subjects is an international concern. More education on the impact of OST robotics programs is needed to benefit countries outside the United States. Educators and stakeholders are communicating the need for more STEM robotics programs for underserved, disadvantaged students, specifically in countries where resources are minimal (Ashesi University College, 2012). The goal is to formulate a scientific worldview in the minds of young people.

The results of the current study indicated that OST robotics programs provide female and male students with a higher level of STEM-related self-efficacy than other STEM-related OST programs. OST robotics program participation during secondary school is a useful means of obtaining and maintaining the attributes necessary to be successful in STEM higher education and STEM careers. Findings from this study may inspire stakeholders, including educators, community leaders, parents, and policymakers, to begin or continue conversations about the benefits of OST robotics programs.

Recommendations for Action

This research determined that students in the robotics OST programs scored significantly higher STEM self-efficacy scores than did students in other STEM-related OST programs. High levels of self-efficacy increase the interest in STEM in secondary and postsecondary education. Both girls and boys who participate in these programs benefit from favorable learning environments and STEM concepts in a voluntary setting with a group of peers. Preparing children and adolescents for STEM fields in the United States is important. To increase the number of students interested in this field, more women and minorities must be afforded more opportunities to participate in OST STEM programs. The government has an obligation to increase the number of programs that directly affect the number of women in STEM careers (Byars-Winston, 2014). It is through the expansion of these programs that will make the United States more competitive in STEM innovations and development. It is time for stakeholders to begin conversations to increase STEM programs in the country. Many secondary educational institutions do not have access to these programs. Providing access to OST programs is a step forward to prepare more students in STEM fields. The earlier the exposure, the more successful students will be in STEM-related courses (DiLisi et al., 2011).

Recommendations for Further Study

Recommendations for further research include a comparison of STEM-related self-efficacy scores among high school male and female students in OST programs using a pretest/posttest research design. A comparative study would deepen the understanding of the relationship between OST robotics programs and other STEM-related OST programs. This study may be more productive using a longitudinal design, as collecting data may require an extended period.

Perhaps future research could be expanded to college students and to areas around the world. This expansion should focus on including diversified populations from different academic levels, various socioeconomic backgrounds, and diversified cultures. The current research used data collected from high school students in the United States. Expanding the research to students in other parts of the world would help to determine whether robotics programming in countries other than the United States would provide the same type of results as the current study. In addition, collecting data from college students who participated in OST robotics or other STEM-related OST programs during high school would present new factors in the analysis. Following students during the transition from high school to postsecondary education would be useful in understanding pathways actually pursued (Hardin & Longhurst, 2016). Concentrating on college freshman using experimental and longitudinal designs would be warranted to assess the long-term impact of participation in high school OST programs.

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Appendix A: Request to Use High School as a Data Collection Site

Dear Sir/Madam:

I am interested in how after-school robotics programs can help our female students feel more comfortable enrolling in STEM courses. The demand for STEM-educated personnel is increasing each year. Fulfilling this level of demand involves attracting more females. However, females are more likely to start STEM classes with less self-efficacy than their male counterparts and many do not continue in STEM majors. Intervention is needed in secondary school or earlier to prevent these types of gender gaps.

As a doctoral candidate at Walden University, I am conducting a study to determine how participation in after-school robotics programs affects both female and male students' STEM-related self-efficacy. I am seeking your permission to ask students in your high school who are enrolled in ***after-school robotics*** and ***other STEM-related programs*** to participate in a 15-minute survey.

I would like permission to contact the sponsors/advisors of the after-school programs and gain their approval to attend the classes and recruit their students to participate in the study. The consent and assent forms required for the students to participate in the study are attached. A copy of the questionnaire is also attached.

If you have questions, please contact me at [redacted] or [redacted]

I look forward to hearing from you soon.

Sincerely,

Sandra Hall

Appendix B: After-school Program Letter of Cooperation

Dear Sir/Madam:

I am interested in how after-school robotics programs can help our female students feel more comfortable enrolling in STEM courses. The demand for STEM-educated personnel is increasing each year. Fulfilling this level of demand involves attracting more females. Girls are more likely to start STEM classes with less self-efficacy than their male counterparts and many do not continue in STEM majors. Intervention is needed in secondary school or earlier to prevent these types of gender gaps.

As a doctoral candidate at Walden University, I am conducting a study to determine how participation in after-school robotics programs affects both female and male students' STEM-related self-efficacy. I am seeking your permission to ask students who are enrolled in ***after-school robotics*** and ***other STEM-related programs*** to participate in a 15-minute survey.

I would like to request your corporation in conducting this research with the students that participate in your program. The consent and assent forms required for the students to participate in the study are attached. A copy of the questionnaire is also attached.

If you have questions, please contact me at [redacted] or [redacted]

I look forward to hearing from you soon.

Sincerely,

Sandra Hall

Appendix C: Recruitment Flyer

WOULD YOU LIKE TO PARTICIPATE IN A RESEARCH STUDY?

- Do you participate in **STEM** after-school programs such as Robotics, Science Club, Earth Club, Computer Clubs, or Math Club?

- Are you interested in participating in a research study that will ask you questions about how you feel about STEM courses?*

**Self-efficacy to enroll in STEM courses* is defined as the belief of students in their ability to accomplish specific tasks needed to feel confident to enroll in STEM courses.

TO PARENTS

- Student participating in this study will be asked to complete a short 15-minute questionnaire how you feel about STEM courses. This research will be conducted at the school, during the time they are in the after-school STEM program.
- Parents/guardians who agree to allow their child to participate will be asked to sign an informed consent form.
- Students who wish to participate will be asked to sign an assent form.
- There is no payment associated with participation in this study.

For more information, or to volunteer, please contact Sandra Hall at [redacted] or at [redacted]

Appendix D: Assent Form for Research

Hello, my name is Sandra Hall and I am conducting research to learn about the effect STEM after-school programs have on students' feelings about STEM courses. I am inviting you to join my research. I am inviting all who are enrolled in STEM after-school programs including science clubs, robotics, math clubs, and other STEM after-school programs to be in the study. I am going to read this form with you. I want you to learn about the project before you decide if you want to be in it.

WHO I AM: I am Sandra Hall, a student at Walden University. I am working on my doctoral degree.

ABOUT THE PROJECT: This study will be to determine how participation in OST robotics programs affects female and male students' feeling about STEM courses.
If you agree to be in this project, you will be asked to:

- Complete the 15-minute survey on your feelings about STEM courses
- Be honest in your answers

Here are some sample questions:

I am confident that…

- I can complete the math requirements for most STEM majors
- Doing well at math will enhance my career/job opportunities
- A STEM degree will allow me to obtain a well-paying job

IT'S YOUR CHOICE: You do not have to participate in this research if you do not want to. If you decide now that you want to participate, you can still change your mind later. If you want to stop, you can.

Participating in the research study might make you tired or stressed, just like a final exam or assessment that you take at school. There are no right or wrong answers. We are hoping this project might help others by understand some key information regarding your confidence in taking STEM classes in high school.

PAYMENT: There is no financial payment for participating.

PRIVACY: Everything you tell me during this project will be kept private. That means that no one else will know your name or what answers you gave. The only time I have to tell someone is if I learn about something that could hurt you or someone else.

ASKING QUESTIONS: You can ask me any questions you want now. If you think of a question later, you or your parents can reach me at [redacted]. If you or your parents would like to ask my university a question, you can call [redacted].

The researcher will give you a copy of this form to keep for your personal records.

____
Printed name of student

____ ________________
Signature of student Date

Parental Consent Form

Your child is invited to take part in a research study to determine the impact of after-school programs on students' feelings about STEM courses. The researcher is inviting high school students who participate in STEM after-school programs to be in the study. This form is part of a process called "informed consent" to allow you to understand this study before deciding whether to allow your child to take part.

This study is being conducted by Sandra Hall, who is a doctoral student at Walden University

Background Information: The purpose of this study is to determine the impact STEM after-school programs have on students' feelings about STEM courses. If you agree to allow your child to be in this study, your child will be asked to:

- Complete the 15-minute survey
- Be honest in their answers

Here are some sample questions:

I am confident that…

- I can complete the math requirements for most STEM majors
- Doing well at math will enhance my career/job opportunities
- A STEM degree will allow me to obtain a well-paying job

Voluntary Nature of the Study: This study is voluntary. You are free to accept or turn down the invitation and, of course, your child's decision is an important factor. After obtaining parent consent, the researcher will explain the study and let each child decide if they wish to volunteer. No one at the high school will treat you or your child differently if you or your child decides to not be in the study. If you decide to consent now, you or your child can still change your minds later. Your child can stop at any time.

Risks and Benefits of Being in the Study: Being in this type of study involves the same risk or minor discomforts your child might encounter in daily life, such as fatigue or boredom with the process. Being in this study would not pose risk to your child's safety or wellbeing.

The benefits of this study will provide the community with information regarding students' self-efficacy to enroll in STEM courses. It will provide information that may help understand how educators can encourage more adolescents to enroll in STEM courses in high school and college.

Payment: There is no financial payment for participating.

Privacy: Reports coming out of this study will not share the identities of individual participants or their families. Details that might identify participants, such as the location of the study, also will not be shared. The researcher will not use your child's personal information for any purpose outside of this research project. Data will be kept secure by keeping all records locked in a designated area. Data will be kept for a period of at least 5 years, as required by the university.

The only time the researcher would need to share your child's name or information would be if the researcher learns about possible harm to your child or someone else.

Contacts and Questions: You may ask any questions you have now. If you have questions later, you may contact the researcher via email at [redacted]. If you want to talk privately about your child's rights as a participant, you can call the Research Participant Advocate at my university at [redacted]. The researcher will give you a copy of this form to keep for your personal records.

Obtaining Your Consent: If you feel you understand the study well enough to make a decision about it, please indicate your consent by signing below.

Printed Name of Parent	____________________
Printed Name of Child	____________________
Date of consent	____________________
Parent’s Signature	____________________
Researcher’s Signature	____________________