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Effects of Extra-Curricular Project-Based Learning Experiences on Self-Efficacy and Interest in STEM Fields in High School

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EFFECTS OF EXTRA-CURRICULAR PROJECT-BASED LEARNING EXPERIENCES
ON SELF-EFFICACY AND INTEREST IN STEM FIELDS IN HIGH SCHOOL

A Dissertation

Presented to

The Faculty of the Educational Doctoral Program in Educational Leadership

San José State University

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

by

Taihao Kevin Wan

December 2021

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EFFECTS OF EXTRA-CURRICULAR PROJECT-BASED LEARNING EXPERIENCES
ON SELF-EFFICACY AND INTEREST IN STEM FIELDS IN HIGH SCHOOL

by

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ABSTRACT

EFFECTS OF EXTRA-CURRICULAR PROJECT-BASED LEARNING EXPERIENCES ON SELF-EFFICACY AND INTEREST IN STEM FIELDS IN HIGH SCHOOL

by Taihao Kevin Wan

As our society and systems become more technologically advanced, increasing opportunities exist for students interested to pursue careers in Science, Technology, Engineering, and Mathematics (STEM) fields. However, pervasive inequities have led to differences in the extent to which women and underrepresented racial/ethnic groups choose to pursue study and career pathways in STEM. Project-Based Learning (PBL) is among the most widely researched strategies suggested to support student learning and motivation and has more recently been applied to school-based efforts to increase student interest in STEM related fields. Rooted in Social Cognitive Career Theory, this study examined changes in students' self-reported general self-efficacy and interest in STEM fields following a four-week Project-Based Learning experience focused on career pathways in advanced manufacturing. Thirty students across four high schools participated in a month-long Project-Based Learning experience to introduce them to the field of advanced manufacturing. Findings from a 15-item online survey distributed at the beginning and end of a virtual four-week PBL workshop revealed significantly higher self-reported general self-efficacy scores following the PBL experience. While overall findings revealed a positive correlation between students' self-reported general self-efficacy and STEM interest, the relationships varied by student demographic groups. Recommendations for further research and applications to practice are provided.

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Chapter I: Introduction

An Unresolved Issue in Education

There are many opportunities that students can pursue after high school. However, extensive research suggests that racial, ethnic, and gender disparities persist in the extent to which students pursue advanced study and career paths in Science, Technology, Engineering, and Mathematics (STEM). Underrepresented groups including women are less likely to participate and persist in STEM (Olitsky, 2014). While pervasive systemic opportunity gaps are important to consider as base conditions upon which these inequities exist, schools are engaging in strategies to address motivational and access barriers that relate to these pervasive gaps. Increasing concerns about an insufficient workforce in STEM fields have driven a growing interest in the relationships between STEM learning and career trajectories (Cantrell & Ewing-Taylor, 2008; Hayden et al., 2011; X. Wang, 2013). With economic perspectives, leaders in STEM-related industries have taken action in highlighting the need for more students to pursue STEM-related fields. According to the United States Department of Labor, Bureau of Labor Statistics, employment projections in STEM occupations are expected to increase by 8% from 2019-2029 (*Employment in STEM Occupations*, 2019). Students with bachelor's degrees or higher in STEM fields tend to have higher median earnings than do those with degrees in non-STEM fields. However, a lower percentage of bachelor's degrees in STEM fields were awarded to females than to males (36 vs 64 percent) even though a higher percentage of bachelor's degrees were awarded to females than males in 2015-16 (58 vs 42 percent) (de Brey et al., 2019).

While there may be many STEM positions open and emerging for students to pursue STEM fields, structural inequities have created an imbalance in opportunities and experiences for students from historically marginalized and underrepresented groups. Netherlands researchers van Tuijl and van der Molen (2016) and British researchers Archer et al. (2020) acknowledged that even though STEM studies and careers may not be appropriate for everyone, the opportunities that STEM provides should be drawn to the attention of all students. Providing an extra-curricular project-based learning experience may be a potential catalyst to bridge both opportunities and increase interest in STEM fields.

The study had initially been designed to include a larger sample of students, however, was adapted for online administration following the pandemic shutdown of Spring 2020, resulting in a small participant base with limited generalizability of findings. As such, it is to be considered a pilot investigation that may lead to more extensive qualitative or mixed-methods studies with larger samples and more robust statistical findings that would provide additional context. The purpose of this pilot study was to examine the effects of an extra-curricular project-based learning experience on high school students' self-efficacy and interest in STEM fields. The research study also examined the relationship between students' demographic backgrounds, their self-reported self-efficacy, and their interests in pursuing a STEM field.

Research Questions

The following research questions guided this study:

RQ 1: Does participation in a four-week Project-Based Learning program, with a focus on entrepreneurship and advanced manufacturing, relate to differences in high school students' sense of self-efficacy?

RQ 2: What are the relationships between students' demographic backgrounds, self-reported self-efficacy, and interest in STEM fields following the Project-Based Learning experience?

Chapter II: Review of the Literature

Introduction

This chapter includes historical frameworks for the study and a review of the extant research literature on Project-Based Learning, self-efficacy, and students' interest in STEM fields of study. The first section begins with a focus on the history of Project-Based Learning (PBL). The second outlines PBL and its relationship to the pursuit of STEM-related study. Next, a review of the literature explores research on underrepresented groups in STEM. The fourth section reviews self-efficacy as a motivational construct. And finally, the last section describes the theoretical framework for the study.

Project-Based Learning and its History

Society is rapidly advancing with the advent of science and technology. For decades, the United States has been a global leader in large part due to the contributions of scientists, engineers, and innovators. The abilities to solve complex problems, gather and evaluate evidence, and make sense of information are becoming increasingly important (U.S. Department of Education, 2019). Classroom instruction has been a key component in the success of preparing students with the skills needed to contribute to society and for providing equitable learning opportunities for all students. While the U.S. continues to be a leader in the advancement of science and technology, researchers have noted an underrepresentation of some ethnic groups and a participation gender gap in STEM fields (De Melo Bezerra et al., 2018; Russell et al., 2018). To address these needs, many industry leaders have argued the value of both increasing and strengthening the pipeline between schools and the STEM fields (Consumer Technology Association, 2020; Wells, 2016).

Contextual Framework

Project-Based Learning (PBL) is an instructional model that contributes to increased student engagement, critical thinking skills, and intrinsic motivation, especially for underrepresented youth who have had academic challenges (Holmes & Hwang, 2016). While PBL has gained popularity in the past few decades, it is not a revolutionary new approach to instructional pedagogy. Its origin can be traced back over a hundred years, to the work of educator and philosopher John Dewey (1959), whose Laboratory School at the University of Chicago was based on the process of inquiry. Dewey argued that students will develop personal investment in the material if they engage in real-world tasks and problems (Krajcik & Blumenfeld, 2006).

There are different variations on the pedagogical practices of Project-Based Learning. Behizadeh (2014) described PBL as a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks. According to Blumenfeld et al. (1991), previous attempts at hands-on and discovery learning curricula failed to reach widespread acceptance because developers did not base their programs on “the complex nature of student motivation and knowledge required to engage in cognitively difficult work,” (p. 373) nor did they give sufficient attention to students’ point of view.

In Project-Based Learning, learning is contextualized in the form of a project that answers a question that is engaging, authentic, and complex (Behizadeh, 2014). By incorporating these aspects into the design of lessons, those implementing PBL instruction anticipate that learners will both engage more fully with the subject matter at hand,

facilitating deep understanding and the ability to use acquired information in new scenarios, and develop important reasoning skills (e.g., critical thinking, problem solving, prioritization, etc.) in the process (Gallagher & Stepien, 1996; Hmelo & Ferrari, 1997).

Project-Based Learning approaches commonly reflect how problems are solved in the real world and necessitate shifts from teacher-centered to student-centered pedagogy. Hence, the role of the teacher in PBL requires a change in traditional methods of instructions where the teacher is the “expert,” to a role of facilitator where they are assisting rather than taking the lead on the learning (Ferreira & Trudel, 2012; Gallagher et al., 1995; Kumar & Natarajan, 2007).

A recent shift in the approach of project-based learning has been from live in-person collaborative settings to online distance learning collaborative settings, in large part necessitated by the massive shifts to online learning as a result of the 2020 COVID-19 pandemic. While Project-Based Learning has traditionally been implemented in face-to-face settings, less is known regarding the successful implementation and facilitation of PBL online. Some researchers have suggested that facilitating the PBL experience online may allow for the learning process online to be more engaging and increase student motivation, interdisciplinary skills, critical thinking, communication skills, self-confidence (Rodríguez et al., 2015; Siddiq, 2021; Zewail-Foote, 2020). Heo and colleagues (2010) investigated how online interaction in PBL is influential in obtaining successful learning performances. They utilized social network analysis and content analysis on 49 undergraduate students in an educational technology course at a woman’s university in South Korea. They found that interactions among participants online may be essential in PBL. Furthermore, they confirmed

that high interaction affects communication, mutual support, and cohesion within team members.

Given that we are still in the relatively early years of the pandemic, we have yet to see an extensive literature evaluating online Project-Based Learning experiences in high school distance learning environments. This study was intended to be among the first to formally investigate the experiences of students in Project-Based Learning in high school with the distance learning format.

Project-Based Learning and its Relationship with STEM

ChanLin (2008) and Karaman and Celik (2008) argued that learners in Project-Based Learning performed better in skill development, general ability, and knowledge compilation than those who did not use Project-Based Learning. Moreover, PBL has been found to increase students' positive learning attitudes towards technology (Mioduser & Betzer, 2008). Tseng and colleagues (2013) found that ninth grade students with engineering-related backgrounds had the most significant changes in attitude towards engineering before and after the PBL activity. In their mixed method study, the researchers employed surveys and semi-structured interviews to examine the beliefs and experiences of 30 high school freshmen who were recruited from five different technology institutes in Taiwan. The researchers suggested that combining PBL with STEM can increase effectiveness, generate meaningful learning, and influence student attitudes in future career pursuits. Furthermore, they concluded that educators might be able to design appropriate PBL teaching strategies to raise students' learning interest toward STEM fields.

Project-Based Learning may also offer a strategy for narrowing the gender disparity gaps in STEM-related fields. Women remain considerably underrepresented in STEM fields, specifically in computer science and engineering, two areas that are both high paying and highly in-demand (England, 2010; Institute of Medicine, 2007; U.S. Bureau of Labor Statistics, 2020). In one study, it was found that exposure to higher percentage of eighth grade male peers in the classroom who endorsed explicit gender/STEM stereotypes significantly and negatively predicted girls' later intentions to pursue computer science/engineering major (Riegle-Crumb & Morton, 2017). This underscores the importance of the peer climate and dynamics in learning experiences that may shape students' motivation, particularly among female students.

Bottia and colleagues (2015) investigated how learning experiences of inspiration/reinforcement/preparation toward STEM explained differences in involvement in STEM by gender and ethnicity among high school students in North Carolina. The researchers analyzed matriculation rates of North Carolina's 2004 high school graduating into 16 campuses of the University of North Carolina system. The study was broken down into two stages. In the first stage, they utilized multilevel binomial models to examine students' intent to declare a STEM major in their last year of high school. In the second stage, they used multilevel multinomial models to analyze choice of declaring a STEM major when the students were in college. They found that taking physics and intending to major in STEM in high school are the variables most closely linked with students' choice of STEM as a major. The researchers suggested that STEM experiences of inspiration, reinforcement, and preparation during high school interact with demographic variables to have a vital association

with students' interest in STEM. Moreover, the researchers also suggested that high schools provide a variety of STEM learning experiences that will link and augment students' interest in STEM and increase the availability of more STEM-related co- and extracurricular experiences available to youth.

Many researchers have documented patterns of declining motivation in math and science as students progress through the educational system (Anderman & Maehr, 1994; Sadler et al., 2012). Le and Robbins (2016) looked to address the need for strengthening the STEM workforce by examining middle school students' motivation and achievement in STEM fields up to six years after their first enrollment in a four-year college. Their study looked at two individual difference predictors of STEM success based on the Person-Environment Fit (P-E fit) model, quantitative ability (measured by math and science tests) and STEM interest fit. To determine STEM interest fit, the researchers used students' responses to an ACT's Interest measure, which consisted of 90 activities to which the participants indicate their preference on a three-point scale (dislike, indifferent, or like). The measure included six scores: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional, which followed the Holland's model of occupational interests (Holland, 1997). The pattern of scores by the students creates their interest profile. Le and Robbins used the students' interest profile and compared it to the typical profile of STEM students which was created by Le and colleagues (2014). The results of the study showed that the individual difference factors are reciprocally related and thus mutually develop over time. The researchers found that the quantitative ability and interest fit are similar for both men and women, suggesting that they can be useful to identify future STEM participants at early age.

In another study, Le et al. (2014) examined the combined effects of two individual difference factors, ability-demand fit and interest-vocation fit, in predicting college student choice of and persistence in STEM fields. Ability-demand fit was described similarly to academic ability and interest-vocation fit was described as the similarity between the individuals' interest profile and the interest profile of the environment. These matched alignments were hypothesized to relate to students' choice and persistence in STEM fields. Indeed, findings from their study concluded that academic ability and interest fit were significant determinants of STEM field choice and persistence. Furthermore, they also found that gender moderated the effects of these individual difference predictors—the effects were weaker for females than for males in predicting STEM choice.

Social Justice and Underrepresented Groups in STEM

While STEM is a broad term that encompasses a wide array of majors and careers, the proportion of underrepresented groups such as women and racial-ethnic minorities in the field varies greatly. Fouad and Santana (2017) described both decision and retention gaps for women and underrepresented racial-ethnic groups. Fewer women and racial-ethnic minorities are choosing to enter STEM careers, or to stay in them once they have participated. Byars-Winston and colleagues (2015) examined census data from 1970 to 2010 to determine the distribution of women and underrepresented groups within 35 benchmark occupations across four decades. Specifically, in the STEM field, they found that three STEM occupations (engineers, scientists, and pharmacists) did not have proportional distribution for underrepresented groups compared to their distribution in the population.

While there is an increase in representation of underrepresented groups in some STEM occupations, women and underrepresented groups continue to be underrepresented in many STEM fields (U.S. Bureau of Labor Statistics, 2020; M.-T. Wang & Degol, 2017). The employment status of underrepresented groups in STEM occupations is equally concerning as it uncovers another layer of disparity in comparison to White and Asian males.

Underrepresented women and racial-ethnic minority engineers and scientists experience higher rates of unemployment than their White male counterparts (National Science Foundation & National Center for Science and Engineering Statistics, 2019). Furthermore, these groups are also underemployed with a higher percentage of them working part-time in STEM fields (National Science Foundation, 2019). For example, data from 2017 show that nearly twice as many women were employed part time (2.9 million women versus 1.5 million men) and for full time employment, almost 70% of scientists and engineers employed full time are White (National Science Foundation & National Center for Science and Engineering Statistics, 2019).

In considering learning opportunities in schools, it is important to note that students may be provided with similar or equivalent STEM-related experiences, yet not experience them in the same ways. There may be other aspects of learning and motivational environment that could also lead to unintentionally or unknowingly excluding underrepresented students.

Underrepresented students may not have the same opportunities as White students, and thus may not have achieved the same outcomes as their White peers. Riegle-Crumb and Morton (2017) found that in higher education there is evidence of persistent racial/ethnic inequality in STEM degree attainment not found in other fields. The study utilized national data to

investigate whether Black and Latinx youth who begin college as STEM majors are more likely to depart than their White peers, and whether patterns of departure in STEM fields differ from those in non-STEM fields. The study found that Black and Latinx youth are significantly more likely than their White peers to switch and earn a degree in another field. The researchers were grounded in the theory on opportunity hoarding (Tilly, 1997) and stereotype threat as potential factors that may contribute to underrepresented students' experiences and feelings of exclusion. Riegler-Crumb and colleagues (2019) stated that "STEM fields are highly esteemed and perceived as economically prosperous," and argued that "they stand out amidst potential college majors as a highly valuable resource that leverages tangible earning and status potential" (p. 134). The researchers noted various ways that racial/ethnic inequality in STEM negatively affects society. Less representation in STEM from underrepresented groups can result in missed opportunities of the group to make significant societal contributions in STEM.

Participation in STEM has historically been a White male endeavor in the United States, with women and people of color far less likely to pursue related fields (Campbell et al., 2000; Seymour & Hewitt, 1997). It has been difficult to tease apart the extent to which the gaps are related to structural inequities in opportunities to pursue STEM, to social factors involved in the cultures within STEM fields, to individual characteristics of individuals who pursue STEM, or to a combination of these factors. It is important that all students, particularly those from underrepresented groups, are competent in STEM and have opportunities to pursue STEM fields should they choose (Hall & Miro, 2014). There have been numerous efforts to determine factors influencing students' major selection in post-secondary education. Buxton

(2001) examined how secondary students' participation in a STEM-related activity positively affected their development in STEM interest and found that providing all students with a more accurate and vivid portrayal of what careers in STEM are like should be a part of STEM education.

Researchers have also considered how experiences in one school level can affect interest in future study at the next. Maltese and Tai (2011) performed a pipeline study that assessed school-based factors related to students completing a major in STEM. The school-based factors included high school experiences, classroom experiences, and college course enrollment. Maltese and Tai analyzed data from the National Education Longitudinal Study of 1988 (NELS:88) of 4700 students in U.S. schools. The researchers found that the most influential school-based factor related to students choosing to complete a major in STEM occurs in high school and correlates with growing interest in mathematics and science. Moreover, they suggested that policies focus on advanced-level course taking and achievement as ways to increase the flow of students into STEM may be misleading. Maltese and Tai recommended facilitation of more discussions in classrooms about the types of jobs available in STEM and when possible, to have students engage with local representatives of organizations in STEM, to bring career awareness.

Gender is an important factor as there are stark disparities between the number of males and females in STEM fields (Joyce & Farenga, 2000; National Science Foundation, 2019). Disparities also exist by sexual orientation as individuals who identify as LGBTQ are also statistically underrepresented in STEM fields with bias and discrimination being described as potential factors (Freeman, 2020). Xie and Shauman (2003) conducted research on

motivational factors in STEM and found that the underrepresentation of females in STEM fields was not related to any differences in ability or aptitude, rather that students' expectations of having a career in STEM was the strongest factor explaining their likelihood to pursue a STEM major in college. Women are noticeably absent from the STEM pipeline, and evidence suggests that self-selection of girls away from STEM fields starts at an early age (Falco & Summers, 2019; Milam, 2012; Sadler et al., 2012). Sadler and colleagues (2012) examined 6,000 students across 34 two- and four-year colleges taking mandatory college English courses and how interest in STEM changed during high school. Results indicated large gender differences in career plans, with males showing significantly more interest, particularly in engineering, while females showed more interest in careers in health and medicine. The researchers concluded that the key factor predicting STEM career interest at the end of high school was interest at the start of high school. Furthermore, the researchers noted that there is both a lower retention of STEM career interest among females and a greater difficulty in attracting females to STEM fields during high school. The percentage of males interested in STEM remained stable (from 39.5 to 39.7), while females showed a decline (from 15.7 to 12.7).

Taking courses in STEM and participation in informal learning activities, such as after-school clubs, have also been found to be instrumental in students' STEM major selection (Maltese & Cooper, 2017; X. Wang, 2013). Maltese and Cooper (2017) found that males were mainly depending on their self-interest while females relied mainly on external support from others (such as teachers, peers, and mentors) in their STEM interest development. They indicated that communication by adults plays an instrumental role in encouraging or

discouraging female students' interest in STEM. The researchers surveyed almost 8000 individuals in and outside of STEM fields. Approximately 70% of the sample was from colleges and universities, 51% of the sample were female, and 63% were students. Maltese and Cooper developed a survey that included items such as common sources of early interest, factors related to respondents' persistence in STEM fields from middle school through college, experiences they had with STEM in informal settings, any reasons for considering leaving STEM, and the amount of support they received for their STEM and non-STEM interests from parents and others. The study revealed that majority of the respondents' initial interest in STEM was initiated prior to sixth grade. Furthermore, in high school, significantly more males than females mentioned independent interest as their primary reason for STEM interest.

Both STEM career knowledge and career interests are also influenced by society at large. These societal influencers include role models that students are exposed to either in person or through the media, the individuals students interact with on a daily basis such as teachers, family members, peers, and individuals involved in students' extracurricular experiences (Dabney et al., 2012; Harackiewicz et al., 2012; Sjaastad, 2012). Therefore, offering a STEM-related PBL experience in classes and communicating to parents of students the value it brings may be beneficial to the development of students' interests in STEM fields.

Self-Efficacy as a Motivational Construct

Bandura (1994) defined self-efficacy as belief in one's own ability to succeed in specific situations or accomplish a task. A person's sense of self-efficacy can play a major role in their approach of goals, tasks, and challenges. Students who are confident in their academic

capabilities manage their work time more effectively, are more efficient problem solvers, and exhibit more persistence than do equally able peers with low self-efficacy (Usher & Pajares, 2008). Furthermore, students need confidence in their own ability to interact effectively with others in order to achieve their goals (Patrick et al., 2002). According to Patrick and colleagues (2002), adolescents' confidence to interact effectively with classmates during classroom activities is important for a range of academic beliefs and behaviors. The researchers referenced this confidence as social efficacy.

Bandura (1997) posited that self-efficacy beliefs are created and developed as students interpret information from four sources: (1) mastery experience, (2) vicarious experience, (3) social persuasions, and (4) emotional and physiological state. The most influential source is the mastery experience, or the interpreted result of one's previous performance. Individuals perform a task or activity, interpret the result of the task or activity, use the interpretations to develop a belief about their capability to perform the task or activity. Typically, outcomes interpreted as successful increase self-efficacy and those interpreted as failures decrease it (Bandura, 1997; Pajares, 2005).

Bandura (1997) stated that the fundamental goal of education is to equip students with self-regulatory capabilities that enable them to educate themselves. Self-efficacy has been found to be predictive of academic and career-related choice and performance indices (Hackett & Lent, 1992; Multon et al., 1991). Multon and colleagues (1991) conducted a meta-analysis of self-efficacy beliefs to academic performance. The researchers identified and included 39 studies with 41 different samples of subjects. They concluded that the relation of self-efficacy to academic performance varied by students' achievement status. The

relationship between self-efficacy and academic performance was found to be stronger among low-achieving students than among students making regular academic progress. Their finding suggests that self-efficacy effects may be particularly instrumental for low-achieving students and highlights the value of further development and studies of methods to promote academic self-efficacy of such students. Domain-specific nature of self-efficacy have also been explored. A study by Stewart and colleagues (2020) found that STEM self-efficacy changes with time in response to students' experiences. Self-efficacy may also vary by academic domain.

There are many studies that found gender differences in self-efficacy (Bandura et al., 2001; Eccles, 2009; Eccles et al., 2004; Else-Quest et al., 2013; Ma et al., 2015; M.-T. Wang et al., 2013). Several studies have found that boys tend to have higher self-efficacy and outcome expectations for math and science than do girls (Pajares, 2005; M.-T. Wang et al., 2013). In the study by M.-T. Wang and colleagues (2013), the researchers looked at 1,490 participants in a national longitudinal study. The participants were surveyed twice—the first round was when participants were in the twelfth grade, and the second round was when participants were age 33. The survey included self-reporting their occupation over a phone interview. The researchers then coded their responses that involved the mathematical, health, biological, medical, physical, computer, and engineering sciences as STEM occupations. For intellectual aptitude, they used scores on the SAT to assess participants' verbal and math abilities in twelfth grade. Results revealed that individuals who exhibited high math capability and verbal skills were less likely to pursue STEM careers than individuals who had high math skills and moderate verbal skills. The finding that females exhibited higher math

and verbal skills than males may partially explain the trends they found in their relative interests to pursue STEM careers.

Theoretical Framework

Several scholars who studied students' interest in pursuing STEM (Beier et al., 2019; Bottia et al., 2015; Chachashvili-Bolotin et al., 2016; Ocumpaugh et al., 2016; X. Wang, 2013) were guided from the theoretical framework of Social Cognitive Career Theory (Lent et al., 1994). Social Cognitive Career Theory (SCCT) has three interconnecting models that explain how people develop career and educational interests (interest model), make choices about careers (choice model), and perform and persist in their chosen careers (performance model) (Lent et al., 1994).

Social Cognitive Career Theory posits that a learner's accumulated experiences, impacted by their background characteristics and predispositions, lead to greater self-efficacy beliefs and interests in higher levels of education. SCCT is derived from Albert Bandura's general social cognitive theory (1986), and its three central variables of self-efficacy beliefs, outcome expectations, and goal representations are fundamental to both theories. In SCCT the interaction of the social cognitive variables with other variables describing personal characteristics and the social environment are used to help explain the career paths people follow (Atadero & Rambo-Hernandez, 2015; Lent et al., 1994).

Bandura (1997) argued that because mathematics is an essential entry skill for scientific and technological occupations, such as STEM, a low sense of mathematical efficacy operates as a barrier to a wide range of occupational pursuits requiring quantitative skills. Moreover, perceived mathematical efficacy contributes more significantly to educational and career

choices making use of quantitative skills than does amount of mathematical preparation in high school, level of mathematical ability and past achievement, anxiety over mathematical activities (Hackett & Betz, 1989).

In another study, Blotnicky and colleagues (2018) found that students in middle school with higher Math Self-Efficacy (MSE) and STEM career knowledge were more likely to choose a STEM career, and students with low MSE were more likely to experience declining interests in STEM careers. They found that exposure of students to STEM careers was related to increased interests in pursuing careers in STEM (Blotnicky et al., 2018). The research design was an intervention study in Canada comparing data from a sample of seventh grade female students that attended a week-long science summer camp in Nova Scotia to a subset of seventh grade girls in the public school cohort that did not attend the science camp. One of their findings revealed that statistically more girls than boys indicated that they did not know what engineers did for a living, suggesting that girls may have had less experience or exposure to what the profession entails. Not knowing about various professions can be among the factors that affect interest in pursuing STEM.

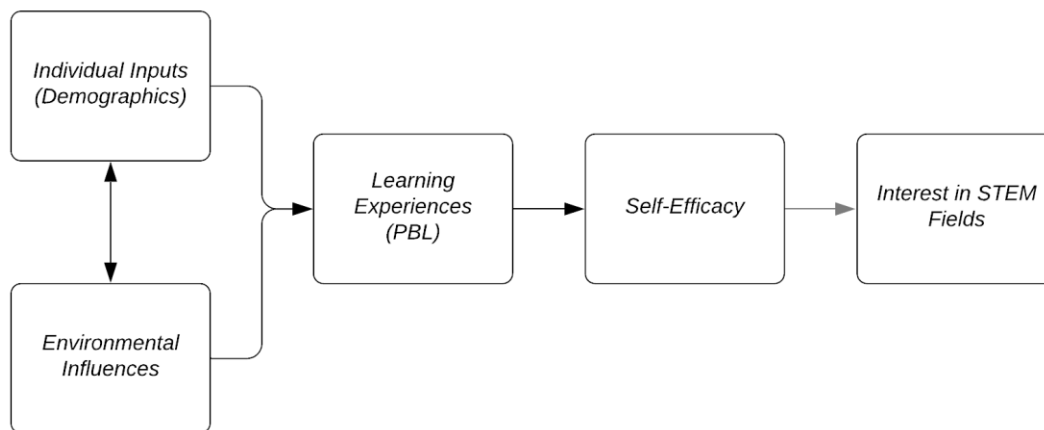
Another key theory that informs this study is Self-Determination Theory (SDT), which postulates three innate psychological needs—competence, autonomy, and relatedness (Deci & Ryan, 2008; Ryan & Deci, 2000) are essential in maintaining intrinsic motivation and self-regulation of extrinsic motivation (Adams et al., 2017; Deci & Ryan, 2000). SDT is a metatheory positing that social and cultural factors facilitate people's sense of choice and volition, in addition to their well-being and the quality of their performance. Guay and colleagues (2008) concluded that the various motivation types in SDT are important in

understanding how students succeed in school. The desire to master an experience, along with the need for choice, coupled with the sense of belonging, may lead to students being more motivated, and thus act as an environmental influence that shapes the learning experience. This experience, in turn may influence students' self-efficacy beliefs and their interests and motivations.

This research study examined participants' self-efficacy beliefs and interest in STEM fields before and after participation in an extra-curricular Project-Based Learning experience with a focus on advanced manufacturing. According to Social Cognitive Career Theory, students' interest in STEM would be influenced by self-efficacy and outcome expectations formed by one's learning experience (project-based learning in STEM). Figure 1 provides a visual display of how interest in STEM is developed in the SCCT.

Figure 1

Interest in STEM through PBL



Note. Interest in STEM through PBL is shown based on SCCT. Adapted from “Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and

Performance,” by R. W. Lent, S. D. Brown, and G. Hackett, 1994, *Journal of Vocational Behavior*, 45(1), p. 88 (<https://doi.org/10.1006/jvbe.1994.1027>).

The two research questions within the study explored the effects of a Project-Based Learning experience on students’ self-efficacy and interest in pursuing a STEM field post-high school.

Research Gaps and Opportunities

Many studies are designed to determine what factors motivate students to select STEM focus on engineering classes or classes that are STEM oriented (Stewart et al., 2020). Lopez and Lent (1992) demonstrated the importance of helping students experience success in math and sciences, as performance accomplishments were found to be strongly related to the development of self-efficacy. Notable studies that include important precollege experiences and characteristics in their analyses of students’ choice of STEM majors include evaluations conducted by Crisp et al., (2009), Engberg & Wolniak (2013), and X. Wang (2013). These researchers all revealed findings that suggested interest in STEM was largely derived from greater self-efficacy, particularly in mathematics. Crisp and colleagues examined factors that impact students’ interest in and decision to earn a STEM degree among students attending a Hispanic Serving Institution (HSI).

While math and science are subjects that have been heavily studied as factors in STEM motivation, interventions in other subjects have yet to be the focus of such studies. High school settings have also been the focus of a subset of the STEM motivation research (Bottia et al., 2015; Maltese & Tai, 2011), however, much of the extant literature is focused primarily on students’ experiences during the college or middle school years (Baran et al.,

2019; Le et al., 2014). Furthermore, a major shortcoming regarding research on students' interest in STEM fields through an extra-curricular Project-Based Learning experience has been a lack of theoretically informed empirical work. As such, theoretically informed work is needed to better understand studies around PBL experiences and the factors influencing STEM field interest.

Many studies on Project-Based Learning and STEM interest have been conducted in settings that involve live interaction with students in the same physical space. This study was unique due to the COVID-19 pandemic in 2020 whereby all interactions were held entirely through Zoom-mediated online settings. Rooted with both Social Cognitive Career Theory and social justice in mind, this study aimed to compare the effects of a Project-Based Learning experience that is focused on advanced manufacturing, on students' self-efficacy and interest in pursuing a STEM related field.

Research Questions

The following research questions guided this study:

RQ 1: Does participation in a four-week Project-Based Learning program, with a focus on entrepreneurship and advanced manufacturing, relate to differences in high school students' sense of self-efficacy?

RQ 2: What are the relationships between students' demographic backgrounds, self-reported self-efficacy, and interest in STEM fields following the Project-Based Learning experience?

Chapter III: Methodology

Research Design

This study examined changes in students' self-reported self-efficacy and interest in STEM fields following a Project-Based Learning (PBL) experience focused on career pathways in advanced manufacturing. The study employed quantitative methods with surveys distributed at the beginning and end of a four-week PBL workshop whereby students from six classes across four different high schools participated in the study. Each school had either one or two classes participating in the PBL program.

Sample / Participants

The sample for this study included 30 total participants across four different high schools in a large urban K-12 school district in northern California. Participants were from grades 9, 11, and 12, across a variety of course disciplines including American Government, Advanced Placement Biology, Student Leadership, and English Language Development. Given their ages as minors, their participation in the study required parent or guardian consent to be provided (via DocuSign) prior to the start of the workshop sessions.

Procedures

Due to the COVID-19 pandemic and local public health requirements, all communication and workshop sessions for this study were done electronically and virtually. Participants in this study were from six classes across four high school sites whose teacher had opted to have their class participate in NextFlex's experiential four-week Project-Based Learning program, *FlexFactor*. NextFlex is an advanced manufacturing consortium with a focus on advancing U.S. manufacturing of Flexible Hybrid Electronics (FHE). FlexFactor is a four-

week long Project-Based Learning program that facilitates opportunities for students to have increased awareness of the breadth of education and career pathways associated with advanced manufacturing.

Recruitment into the Workshops

Administrators from each participating high school site identified classes that were willing to participate in the FlexFactor Project-Based Learning experience. Teachers from identified classes received an email invitation (Appendix A) that included the introduction of the study and options on how to distribute the surveys.

Parental Consent

An electronic letter of information about the study with an informed consent form was distributed to participants' parents/guardians with an invitation for their student to participate in the study (Appendix B). The letters were provided in both English and Spanish and were distributed by the researcher. Consent forms were collected through DocuSign. Students were invited at the start of the first session to participate in the research with a question embedded in the Qualtrics survey that assured informed assent. Students who did not complete the survey or provide a response to the assent question were not included in the study.

Survey Distribution

For distribution of the surveys before and after the PBL experience, participating students were directed to enter a separate virtual breakout room on Zoom where the researcher provided the link to the Qualtrics survey so the students could complete the survey electronically. The survey (Appendix C) included items from the adapted NGSE, adapted

STEM-CIS surveys, and demographics. Data were collected via the Qualtrics online survey platform. The Qualtrics website states that all information stored on their servers are highly protected and secured (Qualtrics, 2020b). Qualtrics does not sell participant data or share data with third parties (Qualtrics, 2020a). Study was approved by San José State University's Human Subjects Institutional Review Board (Appendix D).

Project-Based Learning Experience

For the duration of the workshops, students were self-selected into teams of 3-4 people. The program began with a segment focused on Career Readiness. For this section, participants were presented with several career readiness topics. In addition, they learned several professional skills including email etiquette, how to create effective résumés, and how to navigate a digital professional networking platform, LinkedIn. For the initial workshop session, presenters from NextFlex's workforce development team gave a presentation overview of NextFlex, the project students would be working on, and various resources that each team could use. Each team was guided to identify an existing real-world problem in which they would incorporate Flexible Hybrid Electronics as part of their solution to the problem. The teams were instructed to work together collaboratively to create a product and develop a business model for the product that would utilize Flexible Hybrid Electronics. Finally, each team prepared a Final Pitch that would be presented virtually to a panel of industry representatives. Table 1 describes the timeline:

Table 1*FlexFactor Program Timeline*

Week	Phase	Activities	Description
1	Problem Identification	Career Readiness Workshop and In-Class Kick-Off; Problem Identification Workshop and Industry Engagement	<p>Career Readiness Workshop – NextFlex team created a presentation that gave a brief overview of several career readiness topics. An introductory video from NextFlex produced with Nick Uhas, then a PowerPoint presentation with interactive activities that reviewed professional email etiquette, a good and bad example of a résumé, and the benefits of using LinkedIn.</p> <p>In-Class Kick Off – NextFlex instructors gave a presentation that went over NextFlex, the project, and different resources participants could use that would help them through the PBL experience.</p> <p>Industry Engagement – An industry partner provided an overview of the company they represented and included interesting information about their technology and what it is used for along with information about their own career path.</p>
2	Product Development	Product Development Workshop & College Engagement	<p>In teams of 3-4, researched and conceptualized a flexible hybrid electronic (FHE)-based advanced hardware product.</p> <p>College Engagement – Virtual hour-long meeting with participants. In this meeting, NextFlex hosted a college & career panel. NextFlex presenters shared several different pathways and provided insight into community college, transfer programs, online degrees, and four-year university pathways.</p>
3	Business Model Creation	Business Model Workshop & Slide Deck Workshop	Each team worked on creating their business model and a slide deck to pitch their product in a shark tank style.
4	Finalize Pitch & Rehearse	Presentation rehearsal for the Final Pitch	The Final Pitch was an exciting event where each team showcased their hard work and creativity. It was an opportunity for the members of the education community to engage with the members of the business community.

Independent Variables

The independent variables in this study were: (1) Participation in the FlexFactor program (indicated as Time 1 and Time 2 to reflect pre vs. post participation), (2) Demographics (i.e. gender, ethnicity/race), and (3) Grade level.

Demographics

Demographic information was self-reported by the students, obtained from the survey, and included gender identity and ethnicity. The gender categories initially mirrored the same groups indicated from the school district's enrollment form. Categories included Female and Male. While the terms "female" and "male" generally refer to biological sex assignment, they were included in the study as gender identity. Recognizing diversity across gender identification, the category of nonbinary was added for participants who do not identify with one of the binary cisgenderers. Students who reported their gender identification as female or nonbinary were included in the aggregate analyses for underrepresented students. The study did not obtain nor include information regarding students' sexual orientation.

Ethnicity descriptions were taken from the district's Student Information System, Spring 2021. Options included American Indian or Alaskan Native, Asian Indian, Black or African American, Cambodian, Chinese, Hispanic or Latino, Filipino, Guamanian, Hawaiian, Hmong, Japanese, Korean, Laotian, Other Asian, Other Pacific Islander, Samoan, Tahitian, Vietnamese, and White. The category of Mixed Race/Ethnicity was also added for participants who identify with more than one race and/or ethnicity. If a student selected any one of the categories from an underrepresented group, they were included in the aggregate analyses for underrepresented students.

Defining Grade Level

The participants' grade level was also considered. Grade level came from school records that include: 9, 10, 11, or 12.

Dependent Variables

The dependent variables in this study were General Self-Efficacy and STEM Interest.

General Self-Efficacy

For RQ1, this study utilized the *New General Self-Efficacy Scale (NGSE)*. This scale is comprised of seven fixed choice questions that were slightly adapted to measure the extent to which participants believed they can achieve their goals, despite difficulties. The scale was scored on a 5-point Likert-type scale from *strongly disagree* (1) to *strongly agree* (5) (Chen et al., 2001). The NGSE has been found to have high psychometric validity and reliability. NGSE was developed by Chen et al., (2001) that incorporated the General Self-Efficacy (GSE) scale developed by Eden. Internal consistency reliability is with Cronbach's alpha 0.86. Test-retest coefficients show that the scale is stable ($r = 0.67$).

STEM Interest

For RQ2, the study utilized an adapted subset of the *STEM-Career Interest Survey (STEM-CIS)* (Kier et al., 2014). The full STEM-CIS survey included 44 questions across four subscales (science, mathematics, technology, and engineering). Two out of the 11 questions from each subscale were selected that specifically measured interest for each of the four STEM subscales. The eight questions were then adapted to be grade level appropriate and applicable to the study. To determine students' interest in pursuing a STEM field in the future, students were queried regarding their level of interest in a pathway that is STEM-

related (including science, mathematics, engineering, or technology). Interest was measured using the following 5-point Likert scale: (1) Strongly Disagree, (2) Disagree, (3) Neither Agree nor Disagree (4) Agree, and (5) Strongly Agree.

The STEM-CIS has also been found to have high psychometric validity and reliability. The STEM-CIS was developed by Kier et al., (2014) that incorporated Self-Efficacy (Bandura, 1997) and Social Cognitive Career Theory (Lent et al., 2008). Kier's model encompassed four subscales (science, mathematics, technology, and engineering). Kier's subscales are incorporated in the STEM-CIS. Reliability evidence included an internal consistency (Cronbach's alpha) of 0.762 for the self-efficacy scale and 0.613 for the career interest. The internal consistency for each of the four subcategories (science, mathematics, engineering, technology) ranged from 0.77 to 0.89. The validity evidence for this scale was demonstrated through a factor analysis and a confirmatory analysis (Kier et al., 2014).

Data Analyses

The quantitative data analyses included descriptive statistics for responses from both the adapted Self-Efficacy and STEM interest scales. Inferential statistics were applied using SPSS (Statistical Package for the Social Sciences). Analyses included paired *t*-tests, Mann-Whitney *U* tests, correlations, and linear regressions to determine relationships between variables and differences between pre- and post-workshop scores for participants in the NextFlex FlexFactor program. Table 2 shows which primary analyses were used per research question.

Table 2*Statistics by Research Question*

Question	IV (Data Type)	DV (Data Type)	Analysis
RQ 1	Participation in FlexFactor workshops (CA)	NGSE (CO)	Paired <i>t</i> -test
RQ 2	Demographics (CA)	NGSE (CO) STEM-CIS (CO)	Mann-Whitney <i>U</i> test Mann-Whitney <i>U</i> test

Note. RQ = research question, IV = independent variable, DV = dependent variable, CO = continuous data. CA = categorical data.

A paired *t*-test was used to compare differences between two groups. In this study, the *t*-tests compared differences in self-efficacy and career interest in STEM before and after the Project-Based Learning experience. A Mann-Whitney *U* test was used as an alternative for the independent samples *t*-test when the normality assumption was not met in a small sample. The small overall sample and subsets were study limitations and are discussed in Chapter V. For the study, a *p*-value of $\leq .05$ was used to determine statistical significance. After conducting basic descriptive analyses of differences in self efficacy and STEM interest (before and after the PBL experience), additional analyses were conducted to determine if demographic differences may exist in the patterns of responses.

Chapter IV: Findings

Introduction

This study examined changes in students' self-reported self-efficacy and interest in STEM fields following a Project-Based Learning (PBL) experience focused on career pathways in advanced manufacturing. This chapter will discuss the findings of the study as they relate to the research questions. First, statistics on demographics of the students will be explored. Next, data for each research question will be examined. Finally, a comprehensive summary of the key findings and results will be presented.

Students' Demographics

The surveys were distributed based on when each school was participating in the Project-Based Learning workshop and ranged from March 16, 2021, to June 3, 2021. The pre-workshop survey was provided prior to the start of the workshop on the first day of the FlexFactor Project-Based Learning workshop. The post-workshop survey was distributed immediately following the conclusion of the final pitches by all the teams. In total, 74 students opened the survey. Of those who opened the survey, 30 students completed the four-week Project-Based Learning experience and completed both surveys ($N = 30$). Students from four public high schools in the same school district completed the surveys.

Ethnicity, Gender, and Grade Level

Eighty percent of respondents identified as cisgender female. One respondent identified as nonbinary. Students that completed the surveys were in Grades 9, 11, and 12. Unintentionally, there were no tenth-grade students that participated in the study. Majority of the students surveyed were in the 12th grade.

Table 3 provides a visual description of students' self-reported demographic characteristics.

Table 3

Demographic Characteristics of Participants

Demographic Characteristics	Full Sample	
	<i>n</i>	%
Ethnicity		
Hispanic or Latino	13	43.3
White	11	36.6
Mixed Race / Ethnicity	2	6.7
Vietnamese	1	3.3
Filipino	1	3.3
Korean	1	3.3
Prefer not to say	1	3.3
Gender		
Female and nonbinary	25	83.3
Male	5	16.7
Grade Level		
12 th	15	50.0
11 th	10	33.3
9 th	5	16.7

Note. $N = 30$.

General Self-Efficacy

Thirty students completed the survey with the adapted NGSE scale items. Table 4 displays the descriptive statistics of the pre- and post-workshop scores for self-efficacy.

Table 4*Mean Self-Efficacy Score between Pre and Post-PBL Experience*

Experience	Range	Mean	Median	SD	Skewness	Kurtosis
Pre-PBL	2.29-5.00	3.88	3.93	± 0.603	- 0.507	0.343
Post-PBL	2.71-5.00	4.18	4.14	± 0.564	- 0.431	0.672

Note. SD = Standard Deviation**STEM Interest**

Thirty students completed the adapted STEM-CIS. Table 5 displays the descriptive statistics of the pre- and post-workshop scores for STEM Interest.

Table 5*Mean STEM Interest Score between Pre and Post-PBL Experience*

Experience	Range	Mean	Median	SD	Skewness	Kurtosis
Pre-PBL	1.50-4.88	3.31	3.38	± 0.921	- 0.334	- 0.358
Post-PBL	1.38-5.00	3.38	3.50	± 0.956	- 0.358	- 0.412

Note. SD = Standard Deviation**Inferential Statistics*****Research Question One***

The first research question guiding the study was, “Does participation in a four-week Project-Based Learning program, with a focus on entrepreneurship and advanced manufacturing, relate to differences in high school students’ sense of self-efficacy?”

Project-Based Learning Program and General Self-Efficacy. A paired samples *t*-test revealed a significant difference in self-efficacy scores between pre- and post-Project-Based Learning experiences; $t(29) = 5.03, p < .001, d = 0.33$. The effect size ($d = 0.33$) for this analysis was suggested to be a small to medium effect by Cohen's (1988) convention. Refer to Table 6 for effect size.

Table 6

Cohen's Effect Size: Difference Between Two Means

<i>d</i>	Size of effect
0.2	Small
0.5	Medium
0.8	Large

Note. Adapted from *Statistical Power Analysis for the Behavior Sciences*, by J. Cohen, 1988, pp. 25-26.

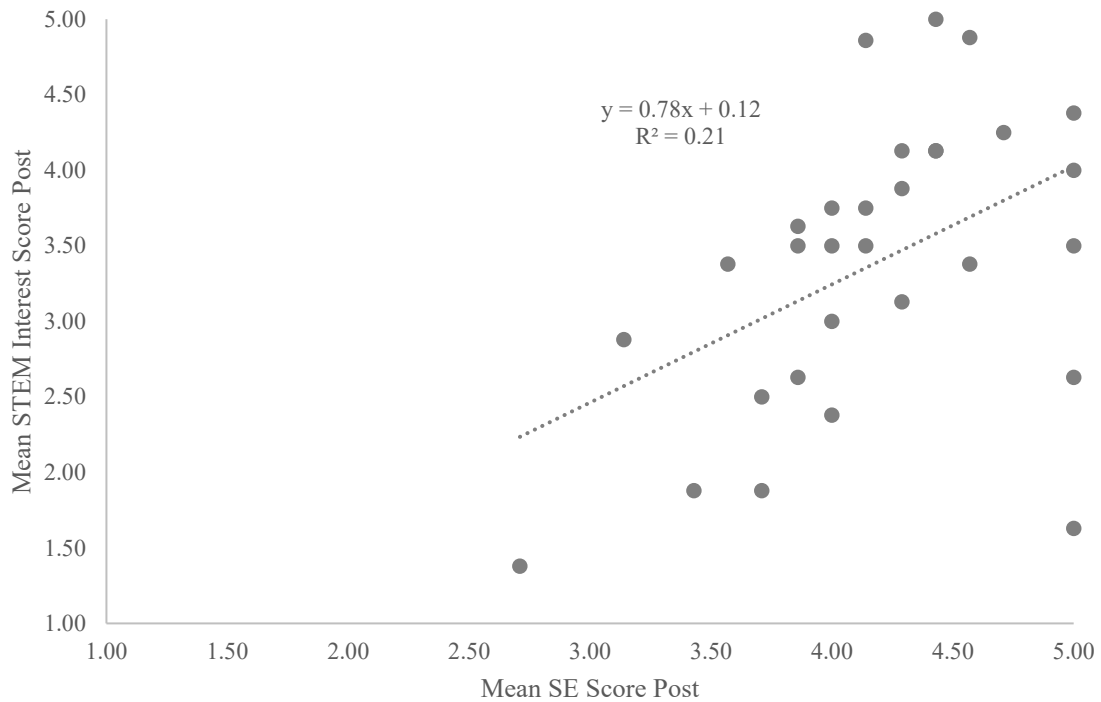
Research Question Two

The second research question guiding the study was, “What are the relationships between students’ demographic backgrounds, self-reported self-efficacy, and interest in STEM fields following the Project-Based Learning experience?”

General Self-Efficacy and STEM Interest. A Pearson correlation analysis revealed a highly positive linear relationship between students’ reported sense of self-efficacy and their interest in STEM, $r(28) = .46, p = .010$. A linear regression analysis revealed that self-efficacy post-PBL scores were related to STEM interest post-PBL scores, $R^2 = .21, F(1, 28) = 7.60, p = .010$. Refer to Figure 2.

Figure 2

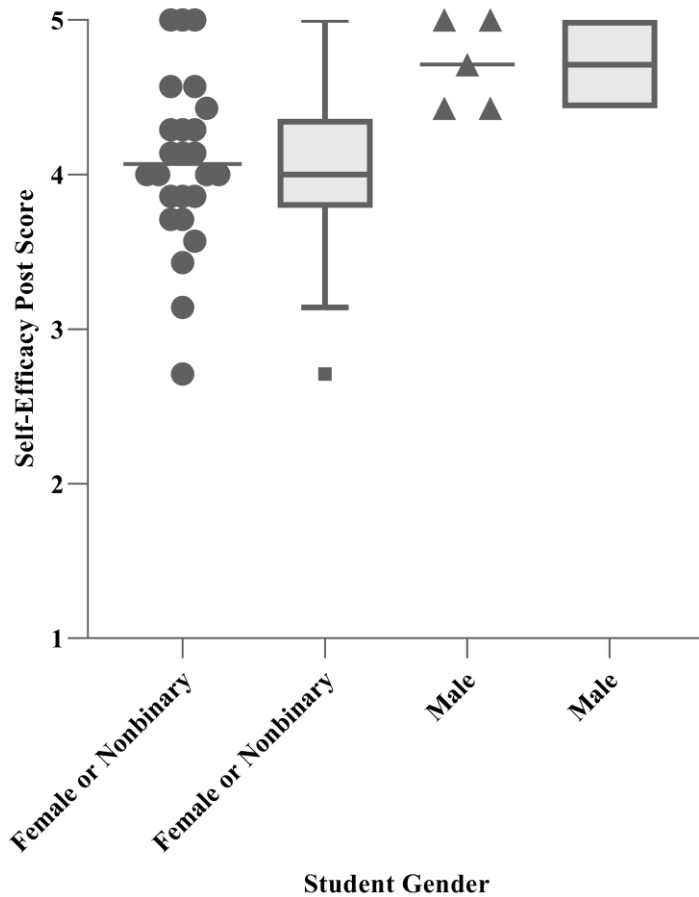
Relationship between Mean SE Scores and Mean STEM Interest Scores



Ethnicity and General Self-Efficacy. A Mann-Whitney U test was conducted to determine whether there is a difference in mean Self-Efficacy post scores between White students ($n = 11$) and non-White students ($n = 19$). The results indicated non-significant differences between groups, $U = 83.00$, $z = -.930$, $p = .363$. Furthermore, the reported data suggests that underrepresented groups provided comparable reports of self-efficacy as the White students following the Project-Based Learning experience. Refer to Figure 3.

Figure 5

Distribution of Self-Efficacy Post Scores by Student Gender



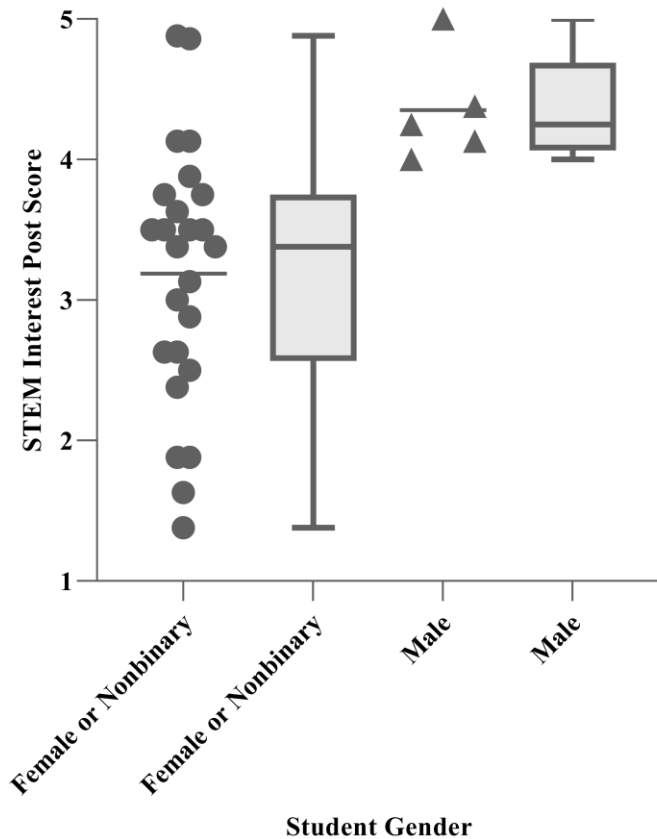
A paired samples *t*-test was conducted to determine whether there is a difference in mean Self-Efficacy scores for before and after the PBL workshop experience of Female or Nonbinary students. The results revealed statistically significant differences in Self-Efficacy scores, $t(24) = 4.71, p < .001, d = 0.34$. The effect size ($d = 0.34$) for this analysis is within the small to medium range according to Cohen's (1988) convention.

Gender and STEM Interest. A Mann-Whitney *U* test was conducted to determine whether there is a difference in mean STEM interest post scores between Female or

Nonbinary students ($n = 25$) and Male students ($n = 5$). The results indicated non-significant differences between groups, $U = 48.00$, $z = -.809$, $p = .439$. Refer to Figure 6.

Figure 6

Distribution of STEM Interest Post Scores by Student Gender



Ethnicity, Gender, Grade Level, General Self-Efficacy, and STEM Interest. A Pearson correlation analysis revealed a strong positive linear relationship between self-efficacy and interest in STEM for White students, $r(9) = .87$, $n = 11$, $p < .001$. The correlation was not statistically significant for non-White students, $r(17) = .17$, $n = 19$, $p = .493$. For gender, a Pearson correlation analysis revealed a positive linear relationship

between self-efficacy and interest in STEM for Female or Nonbinary students, $r(23) = .48, n = 25, p = .016$. In contrast, the correlation was not statistically significant for Male students, $r(3) = .87, n = 5, p = .053$. For Grade Level, a Pearson correlation analysis revealed a strong positive linear relationship between reported sense of self-efficacy and interest in STEM for eleventh grade students, $r(8) = .78, n = 10, p = .008$. Correlations between self-efficacy and interest in STEM were not found to be statistically significant for ninth grade students, $r(3) = .76, n = 5, p = .133$, or 12th-grade students, $r(13) = .33, n = 15, p = .224$. Table 7 displays the correlation coefficient values as provided by Al-Samman (2012), and Table 8 displays the suggested interpretations of the Pearson Correlations.

Table 7

Correlation Indication

Correlation Coefficient (r) Value	Indication
± 0.8 to ± 1.0	High correlation
± 0.6 to ± 0.79	Moderately high correlation
± 0.4 to ± 0.59	Moderate correlation
± 0.2 to ± 0.39	Low correlation
± 0.1 to ± 0.19	Negligible correlation

Note. Correlation Indication. Adapted from *The Influence of Transparency on the Leaders' Behaviors* by E. N. Al-Samman, 2012, p. 31.

Table 8*Pearson Correlations between Self-Efficacy and STEM Interest*

Variable	Correlation
Ethnicity	
White	.87***
Non-White	.17
Gender	
Female and nonbinary	.48*
Male	.87
Grade Level	
Grade 9	.76
Grade 11	.78**
Grade 12	.33

Note. $N = 30$.* $p < .05$. ** $p < .01$. *** $p < .001$.**Key Findings**

There were five notable findings from this study. First, the positive differences in the self-reported self-efficacy mean scores were statistically significant. Second, there was a positive correlation between the self-reported post self-efficacy scores and post STEM Interest scores following the workshops. Third, there was a positive correlation between post self-efficacy scores and STEM interest scores for White students. Fourth, there was a positive correlation between post self-efficacy scores and STEM Interest scores for female and nonbinary students. Lastly, there was a positive correlation between post self-efficacy scores and STEM Interest scores for eleventh grade students. Although there were notable statistical findings, subgroup results should be interpreted with caution due to low sample size. Table 9 displays a summary of the key findings.

Table 9*Summary of Key Findings*

Key Findings	<i>p</i> -value	Significance
Pre-Post Self-Efficacy mean score difference	$p < .001$	Yes
Correlation		
Post Self-Efficacy and STEM Interest scores	$p = .010$	Yes
White students, post SE and STEM Interest scores	$p < .001$	Yes
Female & nonbinary students, post SE and STEM Interest scores	$p = .016$	Yes
Grade 11 students, post SE and STEM Interest scores	$p = .008$	Yes
Ethnicity		
Post Self-Efficacy scores	$p = .363$	No
Post STEM Interest scores	$p = .053$	No
Gender		
Post Self-Efficacy scores	$p = .530$	No
Post STEM Interest scores	$p = .439$	No

Chapter V: Discussion

The purpose of this pilot study was to examine the relationship between students' demographic backgrounds, their self-reported general self-efficacy, and their interests in pursuing a STEM field prior to and following a Project-Based Learning experience in advanced manufacturing. Results from this study may inform further research and integration of instructional practices that can support the development of students' self-efficacy and interest in pursuing STEM fields. Findings from this research may provide insights for STEM industry professionals interested in collaborating with schools and developing more effective recruitment strategies.

Research Question One

The first research question that guided the study was, "Does participation in a four-week Project-Based Learning program, with a focus on entrepreneurship and advanced manufacturing, relate to differences in high school students' sense of self-efficacy? The findings in this study yielded a statistically significant positive change in the high school students' sense of self-efficacy through their participation in the FlexFactor Project-Based Learning experience. This finding is consistent with Samsudin and colleagues (2020) reporting that PBL positively affects high school students' self-efficacy. The intervention study included 120 high school students in Malaysia where they compared the effect of STEM-PBL to conventional teaching on self-efficacy in learning mechanic physics. Dunlap (2005) found that undergraduate students' General Perceived Self-Efficacy scores increased significantly from the pretest to the posttest in a capstone course involved in a problem-based learning environment. In addition, the finding from this study is also in alignment with

Krsmanovic (2021) who saw that PBL improved students' belief in their ability to be active agents of their learning. The study examined a first-year college elective course that implemented PBL to promote students' self-efficacy. Anecdotally, many of the students responded in the post-survey questions reflecting on the experience, that they enjoyed working collaboratively in a team to create their product, with one student who identified herself as a Latina female indicating that she "can work as a team." While emphasis was on quantitative shifts of self-efficacy, 14 out of the 30 students mentioned working on a team as something they will remember the most about the FlexFactor PBL experience. This further supports studies by Rodríguez and colleagues (2015), Siddiq, (2021), and Zewail-Foote (2020) where online PBL experience can foster high engagement and develop students' problem-solving and communication skills as they work collaboratively.

Specifically, the female and nonbinary students reported statistically significant differences in self-reported mean scores of their general self-efficacy before and after their participation in the FlexFactor PBL workshop, while it was not reported for the male students.

Research Question Two

The second research question that guided the study was, "What are the relationships between students' demographic backgrounds, self-reported self-efficacy, and interest in STEM fields following the Project-Based Learning experience?" A Pearson correlation analysis found statistically significant relationships between general self-efficacy and STEM interest among White students, female or nonbinary students, and students that were in grade 11.

Ethnicity

The two most represented ethnicities from this study were Hispanic (43%) and White (37%). For White students, 64% reported an increase in their Self-Efficacy scores between pre- and post-PBL experience. For Non-White students, 79% reported an increase. The difference between the mean post-SE scores of White and non-White students was less than 2%. This would suggest that the means are close for the underrepresented groups compared to the White students. There was a significant relationship between general self-efficacy and STEM interest among White students. There was high correlation between the two variables ($r = .87$) which may suggest that strong belief of one's own ability may relate to higher interest in the STEM field for White students.

For interest in STEM, 45% of the White students reported an increase in their scores and 42% of the Non-White students reported an increase in their scores. However, descriptive data suggested that there is an interrelationship between self-efficacy and STEM interest for White students only.

Gender

Given that the participants for this study were from a variety of different courses and subjects (including Student Leadership, AP Biology, American Government, and English Language Development) the gender proportions of the final sample varied across classroom settings and by willingness to participate. Eighty percent of the participants self-reported their gender as female. There were no significant gender differences in students' reports of general self-efficacy scores. These findings are inconsistent with prior research. Stewart and colleagues (2020) found that STEM self-efficacy differed significantly between men and

women, with women expressing lower self-efficacy. Ma and colleagues (2015) revealed in a study that examined adolescents' subjective well-being that adolescent girls had lower self-efficacy than adolescent boys.

The relationship between students' general self-efficacy and their STEM interest was significant for female and nonbinary students. This may suggest that for underrepresented groups, specifically females and nonbinary students, self-efficacy may be related to STEM interest. It should be noted that there was high correlation between self-efficacy and STEM interest for males ($r = .87$), however it was not statistically significant. This may be due to the low sample size for males ($n = 5$).

Grade Level

The grade level of students surveyed included Grades 9, 11, and 12. There were no students in Grade 10 who participated in the survey. Fifty percent of the students ($n = 15$) were in Grade 12. Self-efficacy scores were statistically related to STEM interest scores for students in Grade 11. This may suggest that Grade 11 is an important grade level for the development of STEM interest. An intriguing finding is that both students in Grades 9 and 11 had similar correlation values ($r = .76$ and $r = .78$) respectively. However, for Grade 12 students, the correlation was much lower ($r = .33$). It is unclear to what extent these differences may have been a result of the low sample size or if there were other factors influencing the patterns.

Implications

There are several potential implications for this research. Educational leaders and administrators in high school settings interested in integrating PBL experiences focused on

entrepreneurship and advanced manufacturing may use these findings as a model from which to build. Moreover, the study revealed that the students' sense of self-efficacy had a positive increase following the FlexFactor PBL experience. This is noteworthy, given the relatively low sample size and distance learning environment that the students were in. Furthermore, in this unique pandemic online experience, students still reported high levels of engagement and interest, based on the additional comments from the post-PBL experience survey. The findings appear to align with work by Siddiq, (2021) who suggested that online PBL can make the learning process exciting and increase student motivation, and self-confidence. In the post-PBL survey, when students were asked, "What will you remember the most about the FlexFactor PBL experience," many shared how they enjoyed working with people on a team and collaborating to produce a product.

These findings suggest that underrepresented groups, such as female and nonbinary students, may benefit from the FlexFactor Project-Based Learning experience. Furthermore, given that this study included a higher ratio of female and nonbinary students to male students, it may suggest an ideal gender balance for similar PBL experiences.

The study revealed that Grade 11 students reported a positive relationship between self-efficacy and STEM interest. This may suggest that Grade 11 may be the appropriate grade level to implement the PBL workshop, while Grade 12 may be too late. Additionally, students in Grade 9 reported experiences with similar patterns as those in the Grade 11, which may suggest that Grade 9 may be an appropriate time frame as well to implement the PBL workshop.

Overall, the study revealed that students reported higher self-efficacy scores following the four weeklong PBL experience. As such, it appears that the FlexFactor PBL experience yielded effective outcomes even in an online distance learning setting. With the right tools and guidance from instructors, students were provided opportunities in remote settings to be able to collaborate and work together to create a product with guidance from the PBL course guides.

In addition to the focus of career choice, the findings from this study also revealed students' sense of satisfaction with the online PBL experience. This may help with curriculum planning by considering designing and implementing similar PBL experiences in a virtual setting. With the COVID-19 pandemic necessitating the shift to distance learning for students, the PBL experience shifted as well. Except for in-person and on-site experiences, students were able to collaborate with each other to the greatest extent possible, with the support of remote communication tools such as Zoom. Online PBL experiences may offer an effective alternative method when opportunities for in-person experience is not possible.

Study Limitations

The study had several limitations, including survey design, distribution processes, sample size, and analyses that should be considered when interpreting the results. There were several limitations related to the survey administration process. First, the survey was distributed as an anonymous Qualtrics link to participating students in an online breakout room. Several students were not present in the breakout room, and therefore, missed the opportunity to complete the survey. Furthermore, to allow the survey to remain anonymous, the only identifying information that was requested was the last four digits of the students' phone

number. It is possible, that a student inputted a different set of digits for the post-survey than the pre-survey, which may have been a contributing factor for the reduced response rate.

A second limitation was the variation in the types of courses that students were enrolled in and their self-selection or assignment into those courses. Students who participated in the study were from a variety of different courses, including Student Leadership, Advanced Placement Biology, American Government/Economics, and English Language Development. Student participation and prior interest in and/or orientation to STEM topics given course enrollments as required or elective may have been factors related to students' reports of general self-efficacy and/or STEM interest.

A third limitation to the study was the overall PBL experience being delivered in a distance learning format due to the pandemic. Prior to the pandemic, the FlexFactor PBL experience was conducted entirely in an in-person environment, which included field trips to a partnering company where students had the opportunity to see an advanced manufacturing facility. Students also had the opportunity to visit a local community college and learn about program pathways that prepare students for the advanced manufacturing sector. This difference is highlighted as a possible recommendation for future research in the next section.

The fourth limitation to the study was the small sample size; both for the full study and for the demographic subgroups. The conditions required to conduct independent samples *t*-tests include independent observations, normal distribution of data, and homogeneity of variance. The smaller the sample size, the greater the influence of the values of the individual scores on the variance. To ensure statistical power in the normality test, sufficient sample size is required. As this was a pilot study, the sample size was small, which made it very

challenging to present robust statistical findings especially when analyzing the various demographic subgroups and their relationship to self-efficacy and STEM interest.

Recommendations for Future Research

Based on the statistically significant findings between general self-efficacy and STEM interest in a Project-Based Learning experience, more research is needed to investigate the impact of these kinds of learning experiences among high school students. From this study, there are five recommendations for future research: (1) study a larger sample size, (2) extend workshop timeline, (3) provide an in-person experience option, (4) include domain-specific self-efficacy, and (5) extend motivational constructs beyond career choice. As noted in Chapter III, due to the COVID-19 pandemic and changing educational policies and guidelines, both at the state, county, and local district level, all interactions had to be done in a virtual setting.

Sample size

As noted in the study limitations, based on the findings between the students' self-reported general self-efficacy and STEM interest, the first recommendation for future research is to incorporate a larger sample size to determine the reliability of the sample means as a predictor of general parameter. A larger sample size will help identify potential outliers in the sample and offer less ambiguity in interpreting the data. To have statistical power of .8 and effect size of 0.5 at 95% confidence level, the sample size required for a one-to-one sample size ratio between two groups would be 128. It was challenging to invite students to participate in the study given the abrupt change from face-to-face to a distance learning format due to the COVID-19 pandemic. Future research with a much larger, robust

sample size would allow for the more extensive study of learning experiences among a wider variety of underrepresented students who are often discriminated against in STEM spaces (Linley et al., 2018). While research studies on underrepresented groups in STEM have predominantly focused on racial, ethnic, and gender minority experiences, sexual orientation as a demographic subset may also be recommended to further improve research and strengthen supportive climates for inclusion in STEM.

Lengthen workshop experience

Rooted in the Social Cognitive Career Theory (SCCT) framework where self-efficacy may be positively correlated to interest in STEM fields, a Project-Based Learning experience with a duration longer than four weeks may yield additional increases in either general self-efficacy or STEM interest. Therefore, the second recommendation would be to extend the workshop timeline. A longer workshop timeframe may be related to greater differences in self-efficacy and STEM interest of students. Studies on varying lengths of the workshop can better inform stakeholders on curriculum planning and workshop delivery lengths.

In-person versus online workshop comparison

Given the COVID-19 pandemic, the setting for this study and the FlexFactor workshop required a virtual format. A similar study for students participating in the FlexFactor PBL program in an in-person setting, specifically, a comparative study on students' self-efficacy and STEM interest scores for in-person experience versus an online experience may yield important data. Notably, the in-person FlexFactor PBL workshop includes a visit to an advanced manufacturing facility, which may be a factor in increasing students' STEM interest.

Domain self-efficacy specificity in STEM

The fourth recommendation suggests measuring domain-specific self-efficacy as students participate in the PBL experience. Domain-specific self-efficacy could include math or STEM self-efficacy. Moreover, participation in the FlexFactor workshops can be from the domain-specific classes, such as math or science. A study by Stewart and colleagues (2020) found that STEM self-efficacy had three tiers: self-efficacy toward students' current STEM class, a general STEM self-efficacy, and self-efficacy toward their intended STEM profession. Understanding domain-specific self-efficacy through the workshop may provide insight on pedagogical strategies in STEM-based courses.

Motivation beyond career choice

Exploring motivation beyond career choice is the final recommendation. This study focused on the interaction between general self-efficacy and interest in STEM. Further research may explore additional aspects of students' experiences or interests that lead students into STEM fields. A study by Marcionetti and Rossier (2021) revealed that general self-efficacy and career adaptability showed a strong interrelationship. The results from the study suggested that in adolescents, higher levels of general self-efficacy are conceptually related to higher levels of self-confidence. Thus, higher self-esteem may generate higher levels of life satisfaction. A study that investigates students' self-efficacy and their well-being as they participate in the PBL experience may contribute to data regarding self-efficacy and student selection of a STEM field. While the focus of this research was on interest in STEM, leading to continued education in STEM in higher education, and entry into STEM-

related workforce, future research can focus on broadening the focus beyond career interest and decision.

Considerations should be made for the long-term implications of larger systemic inequities that exist in attracting and retaining underrepresented groups in STEM fields. In addition to efforts to create, adopt, and implement a PBL experience to attract students to the STEM field, there should be parallel efforts for retaining and supporting leadership opportunities for students in STEM fields, particularly students from underrepresented groups. There are numerous studies that indicate while underrepresented groups, specifically females, account for greater than 50% of the overall undergraduate enrollment, the percentage in STEM are far below 50% with a STEM pipeline that is leaky, whereby there is an unintended attrition of people from the disciplines, most notably from underrepresented groups (Allen-Ramdial & Campbell, 2014; de Brey et al., 2019). There is general agreement from both the educational research and workforce community about the need to raise awareness on increasing diversity and interest in STEM along with entry into the field. However, controversies abound regarding retention of diverse professionals as work climates have not supported diverse talent within the sector. Many underrepresented groups, including women, leave STEM occupations, citing work culture as the main reason (St. Fleur, 2014). The common narrative of a pipeline shortage of qualified people to fill open STEM positions may be met with a rivaling narrative that the diverse talent pipeline is robust, yet that problems with workplace culture are the root deterrent for applications to such open positions (Bui & Miller, 2016).

Summary

This study examined the effects of an extra-curricular project-based learning experience on high school students' self-efficacy and interest in STEM fields, and examined the relationship between students' demographic backgrounds, their self-reported self-efficacy, and their interests in pursuing a STEM field. Findings from this study revealed statistical significance in the differences of the reported mean self-efficacy scores following the FlexFactor Project-Based Learning experience, with higher scores being reported following the PBL experience. While positive correlations were found between self-efficacy scores and STEM interest scores overall, sample size limitations did not allow for conclusions to be made for statistical relationship among demographic subgroups. A larger follow up study with a more robust sample would be of value to build upon this initial inquiry.

The study was important because there are structural inequities that have created an imbalance in opportunities and experiences for historically marginalized and underrepresented groups. Understanding the effects of a project-based learning experience in high school students can assist in curriculum development, program adoption, and professional development with the goals of increasing self-efficacy and interest in STEM fields.

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Appendices

Appendix A. Teacher Email

Dear _____,

My name is Kevin Wan, and I am a doctoral student at San José State University. I am also Principal at Gunderson High School. As a student, I am currently engaged in a doctoral dissertation research project investigating the effects of extra-curricular project-based learning experiences on self-efficacy and interest in STEM fields in high school through the NextFlex FlexFactor program.

As your class participates in the program, I hope you will consider allowing your students to participate in a brief (5 minute) survey. This study has been approved by the San José State University Institutional Review Board (IRB).

Survey distribution options include the following:

- a. You can distribute the survey via the email below
- b. I can distribute the survey in your course
- c. Any additional way you prefer

I sincerely appreciate your consideration, and please let me know if I can answer any additional questions.

Best regards,

Kevin Wan

Appendix B. Parent Consent Form (via DocuSign)

REQUEST FOR YOUR CHILD'S PARTICIPATION IN A RESEARCH STUDY

EFFECTS OF EXTRA-CURRICULAR PROJECT-BASED LEARNING EXPERIENCES ON SELF-EFFICACY AND INTEREST IN STEM FIELDS IN HIGH SCHOOL

NAME OF RESEARCHERS

Kevin Wan, Graduate Student

Dr. Roxana Marachi, Supervising Professor

San José State University, Connie L. Lurie College of Education

PURPOSE

You are invited to permit your child to participate in a research study to investigate student experiences in schools that may affect self-efficacy and interest in STEM. The following information is provided to help you make an informed decision about whether or not to allow your child to participate. If you have any questions, please do not hesitate to ask.

PROCEDURES

In this study, your child will be asked to complete two short surveys that will be given at the beginning and the end of a four-week long project-based learning program. The survey should take approximately ten minutes to complete and will be done remotely.

POTENTIAL RISKS

There are no direct foreseeable risks anticipated other than those normally encountered in daily life.

POTENTIAL BENEFITS

Participants will not directly benefit from the study procedure. However, this study can help us better understand how learning experiences in school may be able to motivate youth to engage in STEM fields (Science, Technology, Engineering, and/or Math).

COMPENSATION

No compensation is being offered for participation in this study.

CONFIDENTIALITY

The information obtained from this study may be published in scientific journals or presented at scientific meetings, but no information that could identify your child will be shared. Your child's identity will remain strictly confidential. Results of the study will be reported collectively and will not contain information that could be traced back to individual participants. The researcher is also a mandated reporter and by law is required to report suspected abuse of minors. Organizations that may look at and/or copy research records to make sure that the study was done properly include: San José State University, Connie L. Lurie College of Education and San José State University, Institutional Review Board.

PARTICIPANTS' RIGHTS

You are free to decide whether or not to permit your child to participate in this study. You may refuse to allow his or her participation in the entire study or any part of the study without any negative effect on your relations with your child's school or San José State University. Your child may also decide to stop at any time.

This consent form is not a contract. It is a written explanation of what will happen during the study if you decide to allow your child to participate. You will not waive any rights if you choose not to allow your child to participate and there is no penalty for stopping your child's participation in the study.

QUESTIONS OR PROBLEMS

You and your child may ask any questions about this research and have those questions answered before agreeing to participate. You or your child may also ask questions during the study.

- For further information about this study, please contact Dr. Roxana Marachi, Department of Ed.D. Leadership Program, San José State University, at roxana.marachi@sjsu.edu
- Complaints about the research may be presented to Dr. Brad Porfilio, Director of the Ed.D. Leadership Program, San José State University, at brad.porfilio@sjsu.edu.
- For questions about participants' rights or if you feel your child has been harmed by participating in this study, please contact Dr. Mohamed Abousalem, Vice President for Research & Innovation, San José State University, at 408-924-2479 or irb@sjsu.edu.

DOCUMENTATION OF INFORMED CONSENT

Parent/Guardian Signature

Your signature indicates that you voluntarily agree to allow your child to be part of the study, that the details of the study have been explained to you and your child, that you have been given time to read this document, and that your questions have been answered. You will be given a copy of this consent form, signed and dated by the researcher, to keep for your records.

Name of Child or Minor

Parent or Guardian Name (printed)

Relationship to Child or Minor

Parent or Guardian Signature

Date

Student ID# (printed)

School (printed)

Researcher Statement

I certify that the minor's parent/guardian has been given adequate time to learn about the study and ask questions. It is my opinion that the parent/guardian understands his/her child's rights and the purpose, risks, benefits, and procedures of the research and has voluntarily agreed to allow his/her child to participate. I have also explained the study to the minor in language appropriate to his/her age and have received assent from the minor.

Signature of Person Obtaining Informed Consent

Date

Appendix C. Survey Instrument

EFFECTS OF EXTRA-CURRICULAR PROJECT-BASED LEARNING EXPERIENCES ON SELF-EFFICACY AND INTEREST IN STEM FIELDS IN HIGH SCHOOL

Start of Block: Consent

REQUEST TO PARTICIPATE IN RESEARCH CONSENT NOTICE

EFFECTS OF EXTRA-CURRICULAR PROJECT-BASED LEARNING EXPERIENCES ON SELF-EFFICACY AND INTEREST IN STEM FIELDS IN HIGH SCHOOL

NAME OF RESEARCHERS

Kevin Wan, Graduate Student

Dr. Roxana Marachi, Supervising Professor

San José State University, Connie L. Lurie College of Education

PURPOSE

You are being asked to participate in a research study investigating the effects of Project-Based Learning on self-efficacy and interest in STEM fields. If you decide to participate in this study, you will be asked to complete a survey that asks about your belief to do well on a task and your interest in STEM fields.

PROCEDURES

Please read through the following information about your rights as a research participant. If you agree to take the survey, please select the agree button at the bottom of this page.

POTENTIAL RISKS

There are no direct foreseeable risks anticipated other than those normally encountered in your daily life.

POTENTIAL BENEFITS

We do not anticipate that there are any risks associated with participating in this study. You may benefit from being part of the study by learning more about your beliefs and interests in STEM fields. Your participation may also help us understand experiences in school that can motivate youth to engage in STEM.

COMPENSATION

There will be no compensation for participating in this study.

CONFIDENTIALITY

Although the results of this study may be published, no information that could identify you or your parents will be included. We will only report information in a way that could not be

traced back to a specific individual. To ensure the privacy of the information you provide, we will store all research materials in a password protected and encrypted file on a password-protected computer that only the research team has access to. The only exception to our confidentiality agreement is if there is a disclosure of abuse, or intent to harm self or others. We are required by law to report these disclosures to the appropriate authority.

YOUR RIGHTS

Your participation in this study is completely voluntary. You can refuse to participate in the entire study without any negative effect on your relations with your high school. You also have the right to skip any question you do not wish to answer.

QUESTIONS OR PROBLEMS

If you have questions at any time during the study, the people listed below can be contacted. Questions about this research may be addressed to Roxana Marachi, Ph.D. at roxana.marachi@sjsu.edu. Complaints about the research may be presented to Brad Porfilio, Ph.D., Director of the Ed.D. Leadership Program, at brad.porfilio@sjsu.edu. For questions about your rights or to report a research-related injury, contact Dr. Mohamed Abousalem, Vice President for Research & Innovation, San José State University, at 408-924-2479 or irb@sjsu.edu.

AGREEMENT TO PARTICIPATE

Please select from the choices below. Your consent below indicates that you voluntarily agree to participate in the study, that the details of the study have been explained to you, that you have been given time to read this document, and that your questions have been satisfactorily answered.

- I agree to participate in the research study (1)

- I do not agree to participate in the research study (2)

Skip To: End of Survey If REQUEST TO PARTICIPATE IN RESEARCH CONSENT NOTICE EFFECTS OF EXTRA-CURRICULAR PROJECT-BASED LEA... = I do not agree to participate in the research study

Please indicate the response that reflects most closely your beliefs about each statement.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
I will be able to achieve most of the goals that I have set for myself. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When facing difficult tasks, I am certain that I will accomplish them. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In general, I think that I can obtain outcomes that are important to me. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I believe I can succeed at almost any endeavor to which I set my mind. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I will be able to overcome many challenges. (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am confident that I can perform effectively on many different tasks. (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Even when things are tough, I can perform quite well. (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please indicate the response that reflects most closely your beliefs about each statement.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
I am interested in careers that use science. (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am interested in learning about science. (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am interested in careers that use math. (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like learning math. (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like learning about new kinds of technology. (12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am interested in careers that involve technology. (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am interested in careers that involve engineering. (14)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I like activities that involve engineering. (15)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

End of Block: Interest in STEM

Start of Block: Demographics



Please provide the last four digits of your phone number (please also remember this same four digit number for a follow-up survey in several weeks).

What is your current grade level?

- 9 (1)
- 10 (2)
- 11 (3)
- 12 (4)

What is your gender identification?

- Female (1)
- Male (2)
- Non-binary (3)
- Fill in the blank (4) _____
- Prefer not to say (5)

What is your ethnicity?

- American Indian or Alaskan Native (1)
- Black or African American (2)
- Cambodian (3)
- Chinese (4)
- Hispanic or Latino (5)
- Filipino (6)
- Guamanian (7)
- Hawaiian (8)
- Hmong (9)
- Japanese (10)
- Korean (11)
- Laotian (12)
- Other Asian (13)
- Other Pacific Islander (14)
- Samoan (15)
- Tahitian (16)
- Vietnamese (17)
- White (18)
- Mixed Race / Ethnicity (19)

Unknown (20)

Prefer not to say (21)

End of Block: Demographics

Start of Block: Additional comments (post experience survey):

What will you remember the most about the FlexFactor project-based learning experience?

Is there anything else you would like for us to know about your experiences in the FlexFactor workshops?

End of Block: Additional comments (post experience survey):

Appendix D. IRB Notice of Approval



Office of Research
Division of
Research and Innovation

San José State University
One Washington Square
San José, CA 95192-0022

TEL: 408-924-2272
officeofresearch@sjsu.edu
sjsu.edu/research

SAN JOSE STATE UNIVERSITY HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD

IRB Notice of Approval

Date of Approval: 3/5/2021

Study Title: Effects of Extra-Curricular Project-Based Learning Experiences on Self-Efficacy and Interest In Stem Fields In High School

Principal Investigator: Dr. Roxana Marachi

Student(s): Taihao (Kevin) Wan

Other SJSU Team Members:

Funding Source: None

IRB Protocol Tracking Number: 21055

Type of Review

- Exempt Registration: Category of approval §46.104(d)(1)
- Expedited Review: Category of approval §46.110(a)(i)
- Full Review
- Modifications
- Continuing Review

Special Conditions

- Waiver of signed consent approved
- Waiver of some or all elements of informed consent approved
- Risk determination for device:
- Other:

Continuing Review

- Is not required. Principal Investigator must file a [status report](#) with the Office of Research one year from the approval date on this notice to communicate whether the research activity is ongoing. Failure to file a status report will result in closure of the protocol and destruction of the protocol file after three years.

Is required. An annual [continuing review renewal application](#) must be submitted to the Office of Research one year from the approval date on this notice. No human subjects research can occur after this date without continuing review and approval.

IRB Contact Information:

Alena Filip
Human Protections Analyst
Office of Research
Alena.Filip@sjsu.edu
408-924-2479

Dr. Priya Raman
Institutional Review Board Chair

Dr. Mohamed Abousalem
Vice President for Research & Innovation
Institutional Official

Primary Investigator Responsibilities

- Any significant changes to the research must be submitted for review and approval prior to the implementation of the changes.
- Reports of unanticipated problems, injuries, or adverse events involving risks to participants must be submitted to the IRB within seven calendar days of the primary investigator's knowledge of the event.
- If the continuing review section of this notice indicates that continuing review is required, a request for continuing review must be submitted prior to the date the provided.