Correlation of STEM Interest and Career Intent in High-School Students

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Abstract
Understanding high school students' perceptions and dispositions toward STEM, and the role science and math self-efficacy play in establishing STEM career aspirations is imperative to preparing the STEM workforce of the future. Project STEMulate is an industry-aligned and technology-rich Problem-based Learning (PBL) model. The goal of this NSF ITEST grant-funded study (2018-2020) was to improve students' attitudes towards STEM. Project STEMulate focuses on Upward Bound students in Hawai`i and was implemented at three sites: Maui, Hilo, and Oahu. The participants voluntarily selected to participate in this program. The current study reviews year one data collected on the impact of Project STEMulate on low-income and underrepresented and/or native Hawaiian students' STEM career interest, and their science self-efficacy. Students' reactions to the STEM learning experience were extremely positive. 80% of students expressed a desire to pursue a career in STEM at the post test. High school students who listed their plan to pursue a career in STEM also showed a higher self-efficacy and motivation. Analysis of the results demonstrates this program was effective in empowering students with insights into careers, enhancing knowledge that would serve them in pursuit of a career in STEM. In addition, the project fostered a can-do attitude and increased students' science self-efficacy.

Keywords: Native Hawaiian Students, Underrepresented Students, Science Self-efficacy, Science Education, STEM, STEM Careers, STEM Camps

Introduction

Studies have repeatedly reported the gap observed in student interest in Science, Technology, Engineering, and Mathematics (STEM) and their desire to pursue STEM major or careers (ACT, 2015; Blotnicky et al., 2018; Christensen et al., 2015; Kier et al., 2013). This is despite the current recognition of STEM careers as the most versatile careers (Mokter Hossain & Robinson, 2012). Moreover, the rapid expansion of STEM careers demands an increase in the preparation of the high school graduates who are prepared for post-secondary education, training and careers in STEM (Hayes, 2017). However, many STEM-interested students are not prepared to succeed in the rigorous college math and science coursework required of STEM majors.

While many believe proficiency and interest in STEM should be initiated in middle school (Christensen et al., 2015), others selected later elementary school years as the right time (Tai et al., 2006). We agree that earlier engagement of students' interest in STEM is preferable, however, students who are already in high school and will be heading to college soon are also a concern. How can we help this group? Other researchers (Kitchen et al., 2018; Maltese & Tai, 2011) showed majority of students interested in STEM made that choice in high school. This puts us in agreement with Maltese et al. (2014) that many pathways toward STEM study and careers exist, with none being singularly preferred (p. 937). We want to present the results of a study showing that an out-of-school program, i.e., Upward Bound program, can provide opportunities—particularly to low-income and first-generation to college students—to promote their interest in STEM.

Lack of Interest in STEM Workforce

Although research on the relationship between student interest in and pursuit of STEM careers has been on the rise (Christensen & Knezek, 2017), the issue of increasing student interest in STEM is of greater magnitude when it comes to the achievement of underserved and underrepresented students in the STEM fields. The National Academy of Sciences (2011) reported less than 10% of minority students to be college educated in science and technology while they make up close to 30% of the population. It is a critical and growing need to draw minority students into STEM fields and to increase the number of minority graduates from STEM programs (May & Chubin, 2013). Numerous studies at the undergraduate level provide support for increasing minority students' retention in STEM majors (Carpi & Lents, 2013; Junge et al., 2010; Kardash, 2000). Nevertheless, preparing students to sustain study at undergraduate level is also important. Thus, intervention programs such as Project STEMulate, focusing on high school students, are imperative to ensure that minority students are learning the skills needed to be successful in completing college degrees, especially in STEM fields.

Native Hawaiian students are often underprepared, underrepresented, and underserved in STEM fields. Various national and international assessments show that Native Hawaiian students perform far below white students in STEM skills and reading (DeSilver, 2018; NAEP, 2017). Furthermore, in a report on Hawaiian students and STEM education, it was determined that these students are taught by inexperienced science and math teachers (Gay, 2013). Research also has demonstrated that students' lack of exposure to STEM career possibilities is a reason for why they are less likely to pursue STEM careers (Mokter Hossain & Robinson, 2012). The National Science Foundation (NSF) has clearly seen the need to address this problem and funded many studies where their goal has been to support, implement, and assess any program that fosters academic success of minority students majoring in a STEM field.

Informal or Out-of-School Education

Informal or out of school education refers to learning that occurs outside of traditional schooling (Dierking et al., 2003). Common informal learning environments include after-school and weekend and/or summer camp programs. Reports on such programs confirm they have increased students' interest in STEM majors (Bicer et al., 2015, 2018; Vela et al., 2020), improved students' mathematics and science vocabulary knowledge (Bicer et al., 2015), enhanced students' artistic self-efficacy in STEM (Capraro et al., 2014), enriched students' communication skills (Bicer et al., 2015), advanced students' self-identity (Barroso et al., 2016), and improved students' scientific reasoning (Gerber et al., 2001).

Upward Bound Program

The Upward Bound (UB) program, established in 1965, is designed to provide services to high school students identified as low income and first-generation-to-college and support their transition to, and enrollment in postsecondary educational institutions (U. S. Department of Education, 2012). The federal fund allocated to UB program is to address existing educational inequities, and to provide required resources and support to prepare students both academically and socially for enrollment and retention in postsecondary education (Strayhorn, 2011; Villalpando & Solorzano, 2005). Given the kind of preparation needed and the support required, a major goal of UB programs at all of their sites MUST be to offer instruction in math, laboratory science, composition, literature, and foreign language.

Perspective(s) or Theoretical Framework

Underrepresented students are a significant school population in the United States, and their educational access is particularly jeopardized and lag behind other students. The full power of ubiquitous learning for educational transformation can be conceptualized through the overcoming of challenges related to infrastructure, human learning and ability, and motivation. This paper focuses on the implementation of a STEM PBL program drawing on constructivism (Dewey, 1933/1998), social cognitive career theory (SCCT) as articulated by, Lent et al. (1994), and culturally relevant education (Dover, 2013). The tenet belief of constructivism is that learners actively participate in interpreting information and creating their own knowledge (Piaget, 1972). PBL provides an active learning environment (Dahlquist & Cutucache, 2013) that engages learners in their learning process by transferring some responsibilities from teachers to students (Nariman & Chrispeels, 2016). According to SCCT, the other theoretical basis of this study, individuals pursue college or career majors that are aligned with their interests and match with their academic and career goals (Lent et al., 1994). Therefore, career choices are influenced by the quality of educational experiences. Consequently, increasing the opportunity to engage students in STEM-related experiences will increase the likelihood of pursuing STEM majors and careers. Although recommendations on when to act in order to have an impact on students' college and career pathways are different, we agree with Beier and Rittmayer (2009), Bicer and Lee (2019), and Hansen (2011) that before and during high school is the most effective time. Seventy-eight percent of college students reported that they decided on their selection of a STEM major in high school (Microsoft Corporation, 2011).

Culturally Relevant Education (CRE)

The CRE emerged from the union of culturally responsive teaching (Gay, 2010) and culturally relevant pedagogy (Ladson-Billings, 1994). The goal for culturally relevant pedagogy is to create equal opportunity for students from diverse cultural backgrounds (Ladson-Billings, 1994) with the view of creating a meaningful connection between students' background knowledge (i.e., culture, language and previous life experiences) and what they learn at school so they can see the relevance of their learning. According to Gay's culturally responsive teaching "the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students," (2010, p. 31) have to come together to make meaning and find relevancy in what is learned. This connection only comes through providing all students with equal opportunities to be academically successful (Banks, 2008; Gay, 2010, 2013; Ladson-Billings, 1995). CRE supporters believe that valuing students' cultural backgrounds and cultural identities creates the optimal learning environment for students to thrive (Gay, 2010; Ladson-Billings, 1994; Nieto, 1999) because it demands a student-centered instruction (Irvine & Armento, 2001) where teachers are acting as facilitators with high expectations of students, creating a learning environment within the context of culture (Ladson-Billings, 1994). This requirement matches perfectly with PBL strategy and its tenets. PBL has proven to have the capabilities to help students in this process and to guide and inspire them to relate their previous knowledge to the present, and further connect it to their future studies and career selection. Therefore, the purpose of this project is to support Upward Bound students with a PBL intervention that encourages and motivates them to successfully navigate towards an undergraduate degree in a STEM field.

Problem-based Learning

PBL is an innovative learning and instructional approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem, a problem very relevant to the learners (Savery, 2006). Essential tenets of PBL include: 1) real-world focus; 2) collaboration; 3) student-driven and student-centered design; 4) open-ended outcomes; and 5) an interdisciplinary approach (Savery, 2006). In such a PBL setting, students actively participate in learning (individually or in small groups) to address real and relevant problems contributing to their own understanding and achievement of concrete outcomes (Barrows, 1985; Hmelo-Silver, 2004; Marx et al., 2004). Students are consequently better able to apply their learning to new problems in a variety of settings (Barrow, 1985). Furthermore, PBL has proven to be effective for teaching critical thinking, communication, collaboration, and applying knowledge to real-world situations (Walker & Leary, 2009; Darling-Hammond et al., 2008, Strobel & van Barneveld, 2009). The promising results of several high school PBL studies indicate PBL is "as or more effective" than traditional teaching approaches (Boaler, 1998; Mergendoller et al, 2006), especially with low-income students (Lynch et al., 2005; Cueva, 2005; Gallagher & Gallagher, 2013).

Need for New Programs

Many researchers agree that real-world hands-on problem/project-based learning that personally and locally connects to students is of value (Christensen & Knezek, 2015).

This study was guided by the following research questions:
1. What was the likelihood of students selecting a STEM career?
a. What role did gender play in the likelihood of selecting a STEM career?
2. What level of STEM career interest existed among high school students?
3. What was the correlation between student science self-efficacy and STEM interest?
4. How did Project STEMulate impact students' STEM career interest?

Methodology

Context of Study

Project STEMulate was organized as a STEM Problem-based Learning (PBL) curriculum and model that operationalizes key PBL tenets while meeting programmatic requirements and academic outcomes to develop motivation and interest in STEM. The primary goal of Project STEMulate was to develop Upward Bound (UB) high school students' interest in STEM content and to elevate their perceptions of STEM careers. The program focused on hands-on activities where students explored and researching solutions to a real-world industry-aligned problem. The context for this program was a five-week UB summer academy on three islands, Maui, Oahu, and Hawai`i during 2018-2020. This paper draws on year 1 data.

The integration of the culturally relevant research and Bandura's (1986, 2001) social cognitive theory and constructivist theoretical frameworks in a PBL setting were used as an analytical lens along with a mixed method approach. The data collection included: pre- and post-surveys, semi-structured focus group interviews, observation of participants' final presentation, and review of their final reports.

Participants

The target population was the low income, underrepresented, first-generation, and/or Native Hawaiian 9th through 12th grade students participating in the UB summer Academy. Data were gathered from students who participated in Project STEMulate and a comparison group who had a similar summer experience with traditional courses in math, science, and language arts. In total, 113 high school students participated in this study with 64 in STEMulate group and 49 in the comparison group. The breakdown of UB program participants at each participating site was: University of Hawai`i Maui College (UHMC) (n=51), University of Hawai`i at Hilo (UHH) (n=37), and the Windward Community College (WCC) - University of Hawai`i (n=25). Overall, there were 62% female and 38% male students. The STEMulate group comprised of 58% female and 42% male students and the comparison group had 67% female and 33% male students.

Problem Explored

The problem explored in Year 1 was: “How can the island of meet the statewide goal of 100% energy from renewable sources by 2045 considering different strategies along with pros, cons, and potential hurdles to overcome.”

Measures and Instruments

Science Self-Efficacy (SSE). This eight-item scale was used to measure student self-efficacy and ability in science, partially adapted from the science section of the STEM Career Interest Survey (Kier et al., 2013). SSE used a 5-point Likert scale and achieved high internal consistency at Time 1 (pre-survey) and Time 2 (post-survey) (SSE Pre = 0.75; SSE Post = 0.74). A composite score was created by averaging all items together, such that higher scores indicated greater SSE.

STEM Career Aspiration. Students responded to the prompt “I plan to have a career in...” by selecting one of the following: science, technology, engineering, math, or others.

STEM Career Interest (SCI). This twelve-item scale assessed students' career interest, adapted from Tyler-Wood, Knezek and Christensen (2010). SCI used a 5-point Likert scale and achieved high internal consistency at Time 1 and Time 2 (SCI Pre = 0.82; SCI Post = 0.85).

Findings

Research Question 1: What was the likelihood of students selecting a STEM career?

Students' responses to the question: “I plan to have a career in science, technology, math, or engineering” was calculated at the pre-post survey for comparison. As Figure 1 demonstrates, the percentage of STEMulate group students planning for a career in STEM increased at the end of the program. In particular, there was a 19% gain for the STEMulate students who aspire to have a career in science. However, Figure 1 demonstrates no consistency in the increase or the decrease of the likelihood of selecting a STEM career for the comparison group.

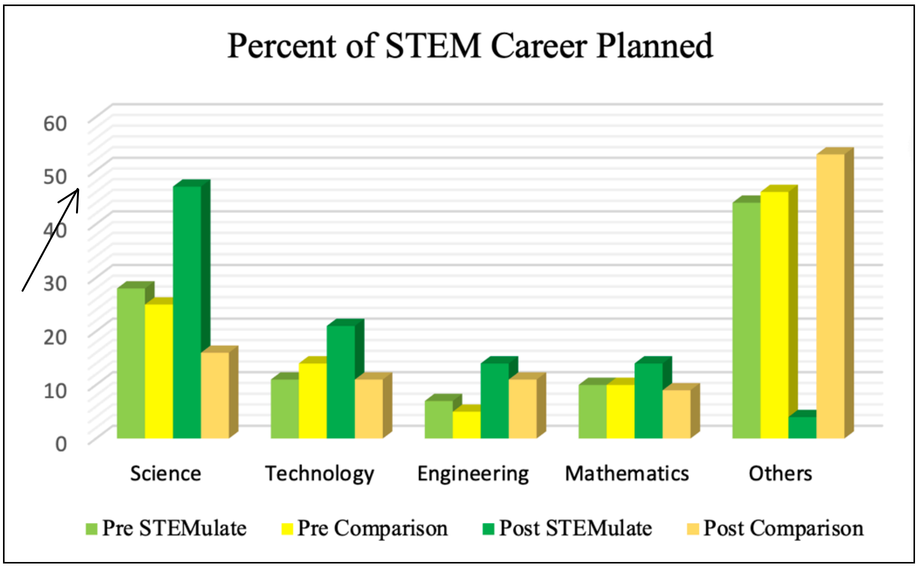

Figure 1: Percentage of STEM career planned for STEMulate and Comparison groups at T1 and T2

Furthermore, when students' responses were dichotomized to create two separate measures: STEM selection (i.e., science, technology, engineering, and mathematics) and non-STEM, a large impact was observed in the STEMulate group as those who planned for a career in STEM gained 39% compared to the comparison group that lost 7% (see Table 1 shows).

Table 1: Percent of Participants Planning STEM Career at Time1 (T1) and Time 2 (T2)

		GROUPS	
		T1	T2
STEMulate Group	STEM	57%	96%
	Non-STEM	43%	4%
Comparison Group	STEM	54%	47%
	Non-STEM	46%	53%

Research Question 1.a: What role gender played in the likelihood of selecting a STEM career?

When the data for the likelihood of selecting STEM career were further analyzed for gender, the program effects on girls were more noticeable. Table 2 shows the changes in students' planning for careers in STEM vs. non-STEM by gender, for both STEMulate and comparison groups. Overall, male students from both groups were equally divided into STEM and non-STEM careers while a greater percentage of females indicated preference for STEM careers at both the pre- post survey for both groups. In fact, both genders in the comparison group lost interest in planning for a STEM career, and the females in the STEMulate group showed more intention for pursuing a STEM career.

Table 2: Comparing Percentage of Different Gender in Planning for STEM Career at T1 and T2

		Comparing Gender			
		T1_Female	T2_Female	T1_Male	T2_Male
STEMulate Group	STEM	62%	97%	50%	95%
	Non-STEM	38%	3%	50%	5%
Comparison Group	STEM	55%	50%	50%	39%
	Non-STEM	45%	50%	50%	61%

Research Question 2: What level of STEM career interest existed among high school students?

Students' Career Interest was calculated as the average of the 12 items of the SCI scale. The parallel analyses revealed the extent to which SCI detected the effects of Project STEMulate on students' career interest. The internal consistency of the SCI scale for Time 1 and Time 2 was calculated, and SCI exhibited a high internal validity for both times: Time 1 ∝= .86, and for Time 2 was ∝= .89. The value of the Cronbach's Alpha falls in the range of "respectable" to "excellent" according to DeVellis's guidelines (1991).

SCI is also consisted of three subscales, *Support*: perception of being in a supportive environment for pursuing a career in science, *Education*: intent to pursue educational opportunities that would lead to a career in science, and *Importance*: perceived importance of a career in science. Table 3 shows the Mean and Standard Deviation for SCI and its subscale at both Time 1 and Time 2 for both groups. The mean of the subscales ranged from 2.11 to 4.17 across the subscales and groups. For both groups, SCI Part 1 (Support) had the lowest Mean while SCI Part 3 (Importance) had the highest Mean at both Time 1 and Time 2. The result of an independent sample t-test indicated a significant difference in career interest satisfaction between the STEMulate and comparison group, $t(108) = .834$, $p < .001$. Nevertheless, no difference in career interest was observed based on gender.

Furthermore, the results of a paired-samples t-test was statistically significant for the career interest score of the STEMulate group from Time 1 (M = 2.97, SD = .42) to Time 2 (M = 3.58, SD = .75), $t(62) = 9.40$, $p < .001$.

Table 3: Comparing STEMulate and Comparison Groups on Career Interest at Time 1 and Time 2

	STEMulate Groups				Comparison Groups			
	T1_M	T1_SD	T2_M	T2_SD	T1_M	T1_SD	T2_M	T2_SD
SCI- All	2.97	.42	3.58	.75	2.68	.43	3.05	.67
SCI -P1 Support	2.37	.66	2.99	1.1	2.11	.72	2.34	.95
SCI - P2 Education	3.26	.41	3.69	.8	2.88	.41	3.08	.81
SCI - P3 Importance	3.28	.44	4.17	.55	3.11	.37	3.95	.59

Research Question 3: What was the correlation between student science self-efficacy and their STEM interest?

For the science self-efficacy (SSE) scale, students' responses to the eight statements were dichotomized by assigning a value of "1" to those who were most agreeable with Likert scale ratings of 4 or 5 to the statements, and a value of "0" was assigned to those who disagreed or strongly disagreed (Likert scale ratings of 1 through 3) with the statements. These eight measures were finally summed to create a single SSE scale. The final SSE score ranged from 1 (Low self-efficacy) to 8 (High self-efficacy). The distribution of the Science Self-Efficacy Scale at Time 2 is shown for both groups.

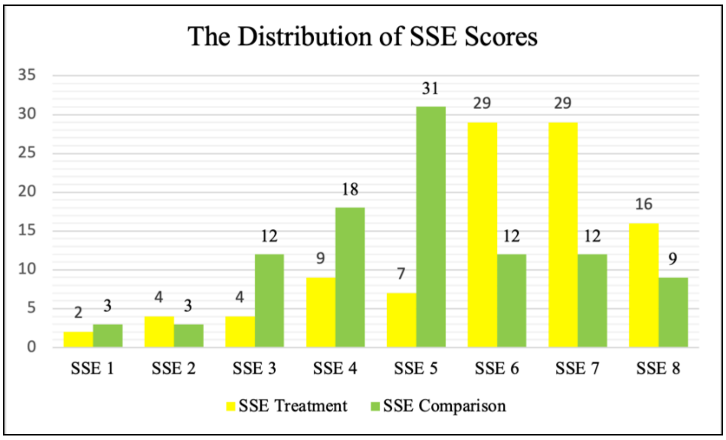

Figure 2: Distribution of Student Science Self-Efficacy (SSE) Scale for STEMulate and Comparison group at T2

For further analysis, the SSE scale were again divided into two subgroups: low SSE (scores of 1 - 4) and high SSE (scores of 5 - 8). This breakout identified students who were the most comfortable and confident in their science experiences. The results for the SSE scale were validated using confirmatory factor analysis (CFA) and reliability analysis. The factor analysis was statistically significant (KMO = .719, p <.001). These results suggested for students in the STEMulate group to have a higher SSE than the comparison group (see Figure 3).

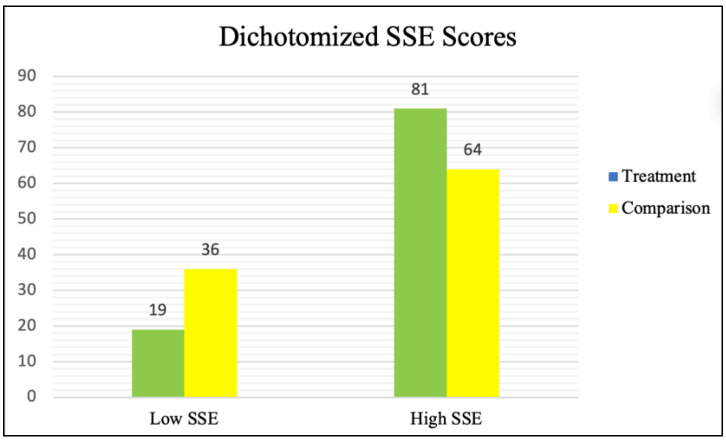

Figure 3: Comparing students' Science Self-Efficacy for STEMulate and Comparison groups at T2

Research Question 4: How did Project STEMulate impact students' STEM career interest?

To respond to this question, students' final reports were evaluated, in addition to their responses to the focus group interviews. All students engaged in a wide variety of activities that would support their competency to pursue STEM careers. Major examples included conducting experiments, performing mathematical calculations, doing research, administering surveys, and conducting interviews which will be further discussed.

Conducting Experiments. Students conducted experiments such as building a simple alternating current generator, using a voltmeter to measure the number of kilowatts per hour used by an old refrigerator vs. a newer energy-efficient model, and created a prototype of a concrete slab equipped with thermoelectric plates and then tracking and measuring the voltage generated over time. These and other experiments demonstrated students' engagement in skilled explorations relevant to their topics which required carefully executed scientific processes.

Mathematical Calculations. Students also engaged in complex and extensive mathematical calculations such as determining the amount of energy which could be generated by converting human waste into biogas, or calculating the price and amount of power generated by different types of solar cells. The various requirements of students' research made evident that they were learning important mathematical concepts essential to supporting their scientific inquiry.

Research. All of the groups conducted research related to their topics, the problems they were addressing, and their proposed solutions. The cited sources in their final papers included government and industry websites, scholarly journals, books, and a variety of online resources. Their work was well supported by the resources they relied on and it was presented in academically robust ways.

Surveys. Almost all the projects involved administering surveys, most often to assess awareness of and opinions about renewable energy issues. Students developed questions and conducted surveys with community members, experts, and local companies, often executing these online through email and social media. They also presented their quantitative results in graphs and charts. Their presentations and final papers reflected that their efforts in seeking out this kind of real-life data were principled and meaningful to them.

Interviews. Students also engaged with and interviewed a variety of professionals with positions in STEM fields, including government and industry representatives as well as relevant academics. By doing so, they obtained essential background information, got advice on how to conduct their research, and elicited comments relevant to the particular problems their projects focused on, for example by asking what these experts would say to those expressing concerns about the challenges inherent to switching to renewable energy resources (concerns that were raised by the community members they had surveyed). Having contact with those working in STEM fields—people who could serve as role models—provided opportunities for students to be exposed to and inspired by the kinds of careers they might one day pursue.

Additional Skills

In the focus groups, in addition to the skills discussed above, students specifically mentioned a number of other competencies they gained or improved upon by participating in the program. Examples include: presenting, critical thinking, time management, writing up papers, data collection, communicating ideas, and teamwork.

RQ 2. How did using technology-rich STEM PBL affect participating student's interest in STEM careers?

In the focus groups, 14 of 23 students explicitly indicated they were thinking about a STEM career, with examples including engineering, computer programming, forensics, aerospace, medicine, animation, and game design. Most responses were simple statements of career plans but many of the Maui students (aided by some probing by the interviewer) specifically indicated the impacts of this program on those decisions:

- STEMulate really opened new ideas towards science... like the hands on is really fun. I want to go into a job with lots of hands on. (Maui student)

The program also provoked student interest in STEM careers by affecting key steps along such path. The majority of focus group participants (19 of 23) agreed that the STEMulate program would help them be more successful at school, and over two-thirds said they were now more likely to take STEM classes in high school. One students said:

- I think I would want to take more STEM classes in my upcoming years, because this experience really gave me more insight on the different sides of STEM. (Oahu student)

Problem-based Learning

One of the major ways the program facilitated student interest in STEM and students' possible interest in STEM careers—was by making the learning relevant and focused on real life problems. Without exception, all the student projects addressed issues with both local and cultural relevance. Their problem-based explorations were rooted in things students could relate to, often involving existing controversies within the community. For example, an Oahu participant mentioned:

- With this STEM course, we dealt with real-world problems and I'm really interested in that.

Cultural Relevance

The cultural relevance of the work students engaged in was unmistakable throughout the focus group interviews.

- A lot of people think culture is more like hula and chatting and stuff, but there's more to it than that, there's culture to science. (Hilo student)

Likewise, in the final papers, students' respect for and investment in the cultural aspects of their research was apparent. For example, in the Maui groups, they acknowledged, valued, and proactively addressed community members' concerns:

- As we continue the process of getting to net-zero by 2045, we need to be aware of the deep historical meanings that the land possesses. By recommendation, it would be healthier … to place solar panels on houses/buildings rather than on the land itself, ensuring that we are not damaging the land and its historical roots. (Excerpt from Maui Group 6 Final Paper)

The solutions students proposed also drew upon culturally relevant connections. It is well established in educational research that cultural relevance can enhance student interest in their learning, something that is definitely observed in the data from this study. By encouraging and facilitating this kind of scientific research, Project STEMulate is also providing yet another reason why students might consider a STEM career in their future.

Discussion

The focus of the current study was to determine if participation in an industry-aligned technology-rich Problem-based Learning (PBL) model influenced the likelihood of students' selecting STEM careers. Prior research has indicated that the PBL environment can impact student's recognition and selection of STEM Careers (Christensen & Knezek, 2017; LaForce et al., 2017). This study is framed by culturally relevant research and Bandura's (1986, 2001) social cognitive theory, which suggests that students' behaviors are influenced by their learning environment. Results from the first research question indicated that the likelihood of selecting a career in STEM for the STEMulate group increased at the end (39% gain). In contrast, the likelihood of selecting a STEM career by the comparison group decreased by the end of the summer. These results imply that engagement in Project STEMulate positively exposed students to a variety of STEM career options, something that the comparison group was not exposed. The results also imply that students might have grasped the benefits associated with STEM careers as they explored to find a solution to their problem. In other words, they may not have been aware or exposed to such experiences. Additionally, the results indicated a higher likelihood for the female students in the STEMulate group to select a STEM career at the end of the camp, compared to the male students.

Results from the second research question showed that the level of STEM career interest among high school students was low at the beginning of the program, and it increased by the end of the summer: STEMulate group Time 1 ($M = 2.97$, $SD = .42$), Time 2 ($M = 3.58$, $SD = .75$), and Comparison group Time 1 ($M = 2.68$, $SD = .43$), and Time 2 ($M = 3.05$, $SD = .67$). Although the mean increased for both groups after the program, the paired-samples t-test was statistically significant for the career interest score of the STEMulate group only. These results align with previous research (Christensen & Knezek, 2017) stating that engagement in hands-on PBL activities will increase interest in a STEM career. As part of Project STEMulate, students had the support and guidance of a team of three teachers who facilitated their learning daily, they went on many field trips where they listened to STEM partners, and they had access to University of Hawai`i math and science instructors.

Results from the third research question displayed a high positive correlation between student science self-efficacy and their STEM interest. Students who were most comfortable and confident in their science experiences showed a higher interest in STEM careers. On various field trips, the STEM partners explored traditional indigenous ways the renewable energy problem has been approached and they connected students' cultural references to mainstream science skills and concepts. Both STEM partners and the program facilitators engaged students in critical reflection, facilitated students' cultural competence to learn about their own and others' cultures, and provided opportunities for students to critique discourses of power and find opportunities to pursue social justice. This concurs with Lemus et al. (2014) in infusing traditional knowledge and ways of knowing into science education.

Also, to be effective, culturally relevant education demands for student-centered instruction where teachers are acting as facilitators with high expectations of students and creating a learning environment within the context of culture (Ladson-Billings, 2014; Lemus et al., 2014; Zaffos, 2013). The PBL setting of this project created the right environment for students' learning and supported them in recognizing, acknowledging, and applying their own cultural identities, strengths, backgrounds, and knowledge. It also acknowledges various ways of knowing and cultural strengths that students and teachers bring by creating space for STEM connection through PBL. This clearly existed in students' final presentations.

Conclusion

Prior research has implied the rising demand for the STEM workforce and the need to prepare students for STEM careers (Christensen & Knezek, 2017; Vela et al., 2020). The overall results from the present study indicated how an industry-aligned technology-rich PBL program can improve student likelihood of selecting a STEM career. This could be the result of hands-on engaging experiences, exposure to many field trips and access to STEM professionals. These experiences provided students with opportunities to learn more about potential STEM career options along with the benefits of those careers. This study is in alignment with Blotnicky et al. (2018), and Vela et al. (2020) that creating opportunities for students to learn about STEM careers directly enhances their interest in those careers. A special contribution of this study is that hands-on STEM PBL science activities, such as those embedded in this study, are particularly effective in enhancing STEM career interests for high school students. The hands-on real-world activities were effective in promoting students self-reported intent and interest in pursuing a career in STEM.

References

American College Testing Service (ACTs) (2015). *The Condition of STEM 2015*. http://www.act.org/stemcondition/15/.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, 52, 1–26. doi: 10.1146/annurev.psych.52.1.1

Banks, J. A. (2008). Diversity, group identity, and citizenship education in a global age. *Educational Researcher*, 37(3), 129-139.

Barroso, L. R., Nite, S. B., Morgan, J. R., Bicer, A., Capraro, R. M., & Capraro, M. M. (2016). Using the engineering design process as the structure for project-based learning: An informal STEM activity on bridge-building. Proceedings from the *IEEE Integrated STEM Education Conference (ISEC*), Princeton, NJ, 249-256. doi:10.1109/ISECon.2016.7457542

Barrows, S. (1985). *How to design a problem-based curriculum for the preclinical years*. New York, NY: Springer Publication.

Baylor, E. (2016). *Closed doors: Black and Latino students are excluded from top public universities*. Center for American Progress.

Bicer, A., Beodeker, P., Capraro, R. M., & Capraro, M. M. (2015). The effects of STEM PBL on students' mathematical and scientific vocabulary knowledge. *International Journal of Contemporary Educational Research*, 2(2), 69-75.

Bicer, A., & Lee, Y. (2019). Effects of STEM PBL embedded informal learning on student interest in STEM majors and careers. *Journal of Mathematics Education*, 12(1), 5773.

Bicer, A., Lee, R., Capraro, R. M., Capraro, M. M., Barroso, L. R., Bevan, D., & Vela, K. N. (2018, October). Cracking the code: The effects of using Microcontrollers to code on students' interest in computer and electrical engineering. Proceedings of the 48th *Annual IEEE Frontiers in Education Conference (FIE).* IEEE, Piscataway, NJ.

Beier, M. E., & Rittmayer, A. D. (2009). Literature overview: Motivational factors in STEM: Interest and self-concept. In B. Bogue & E. Cady (Eds.). *Applying Research to Practice (ARP) Resources*. http://www.engr.psu.edu/AWE/ARPresources.aspx

Blotnicky, K. A., Franz-Odendaal, T., French, F., & Phillip, J. (2-18). A study of the correlation between STEM career knowledge, mathematics self- efficacy, career interests, and career activities on the likelihood of pursuing a STEM career among middle school students. *International Journal of STEM Education*, 5(22). https://doi.org/10.1186/s40594-018-0118-3

Boaler, J. (1998). Open and closed mathematics: Students' experiences and understanding. *Journal for Research in Mathematics Education*, 29(1), 41-69. DOI: https://doi.org/10.5951/jresematheduc.29.1.0041

Capraro, M. M., Capraro, R. M., Nite, S. B., Morgan, J., & Peterson, C. A. (2014). Does inclusion of the arts in STEM project-based learning increase motivation for learning for urban students in informal settings? Proceedings from *International Conference on Urban Education*. Montego Bay, Jamaica.

Carpi, A., & Lents, N. L. (2013). Research by undergraduates helps underfinanced colleges as well as students. *Chronicle of Higher Education*, 60(9), B30–B31.

Christensen, R., Knezek, G., & Tyler-Wood, T. (2015). Alignment of hands-on STEM engagement activities with positive STEM dispositions in secondary school students. *Journal of Science Education & Technology*, 24, 898–909.

Christensen, R. & Knezek, G. (2017). Relationship of middle school student STEM interest to career intent. *Journal of Education in Science, Environment and Health (JESEH)*, 3(1), 1- 13.

Cuevas, P., Lee, O., Hart, J., & Deaktor, R. (2005). Improving science inquiry with elementary students of diverse backgrounds. *Journal of Research in Science Teaching*, 42(3), 337-357. doi: 10.1002/tea.20053

Dahlquist, L. M., & Cutucache, C. E. (2013). Effectiveness of PBL in a large, undergraduate classroom setting. *Cider Online*. http://www.cider.vt.edu/ conference/proceedings/2014ConferenceProceedings.pdf.

Darling-Hammond, L., Barron, B., Pearson, P. D., Schoenfeld, A. H., Stage, E. K., Zimmerman, T. D., Cervetti, G. N., & Tilson, J. L. (2008). *Powerful learning: What we know about teaching for understanding*. San Francisco, CA: John Wiley & Sons, Inc.

DeSilver, D. (2018, Feb. 15). *U.S. students' academic achievement still lags that of their peers in many other countries.* Pew Research Centre. https://cpb-us-w2. wpmucdn.com/ blogs.cofc.edu/dist/0/348/files/2018/11/U.S.-academic-achievement-lags-that-of-many-other-countries-2iqc8mk.pdf

DeVellis, R. F. (1991). *Scale development*. Newbury Park: Sage Publications.

Dewey, J. (1933/1998). *How we think* (Rev. ed.). Boston, MA: Houghton Mifflin Company.

Dierking, L. D., Falk, J. H., & Rennie, L. (2003). Policy statement of the "informal science education" ad hoc committee. *Journal of Research in Science Teaching*, 40(2), 108111.

Dover, A. G. (2013). Teaching for social justice: From conceptual frameworks to classroom practices. Multicultural Perspectives, 15, 3–11. doi:10.1080/15210960.2013. 754285

Fayer, S. W., Lacey, A., & Watson, A. (2017, Jan.). *STEM Occupations: Past, present, and future*. U.S. Bureau of Labor Statistics.

Gay, G. (2010). Culturally responsive teaching: Theory, research, and practice (2^{nd} ed.). New York, NY: Teachers College Press.

Gay, G. (2013). Teaching to and through cultural diversity. *Journal of Teacher Education*, 57(3), 300-314. https://doi.org/10.1111/curi.12002

Gallagher, S. A. & Gallagher, J. J. (2013). Using problem-based learning to explore unseen academic potential. *Interdisciplinary Journal of Problem-based Learning*, 7(1), 111-131. doi: 10.7771/1541-5015.1322

Gerber, B., Marek, E., & Cavallo, A. (2001). Development of an informal learning opportunities assay. *International Journal of Science Education*, 23(6), 569-583.

Hansen, A. (2011). *How to choose the best college by organizing your priorities*. http://www.brighthub.com/education/college/articles/66095.aspx

Hayes, S. (2017, May). *Preparation matters most in STEM*. (ACT Research & Policy: Issue Brief), https://www.act.org/content/dam/act/unsecured/documents/R1647-preparation-matters-in-stem-2017-05.pdf.

Hmelo-Silver, C.E. (2004). Problem-based learning: What and how do students learn? *Education Psychological Review*, 16, 235–266.

Irvine, J. J., & Armento, B. J. (2001). *Culturally responsive teaching: Lesson planning for elementary and middle grades*. New York: McGraw Hill.

Junge, B., Quinones, C., Kakietek, J., Teodorescu, D., & Marsteller, P. (2010). Promoting undergraduate interest, preparedness, and professional pursuit in the sciences: An outcomes evaluation of the SURE program at Emory University. *CBE–Life Sciences Education*, 9, 119–132. https://doi.org/10.1187/cbe.09-08-0057

Kardash, C. M. (2000). Evaluation of undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors. *Journal of Educational Psychology*, 92(1), 191. https:// doi.org/10.1037/0022-0663.92.1.191.

Kier, M. W., Blanchard, M. R., Osborne, J. W., & Albert, J. L. (2013). The Development of the STEM Career Interest Survey (STEM-CIS). *Research Science Education*. Doi.10.1007/s11165-013-9389-3.

Kitchen, J. A., Sonnert, G., & Sadler, P. M. (2018). The impact of college-and university-run high school summer programs on students' end of high school STEM career aspirations. *Science Education*, 102(3), 529–547. https://doi.org/10.1002/sce.21332.

Ladson-Billings, G. (1994). *The dreamkeepers: Successful teachers of African American children*. San Francisco, CA: Jossey-Bass.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, 32, 465–491. doi:10.3102/00028312032003465.

Ladson-Billings, G. (2014). Culturally relevant pedagogy 2.0: a.k.a. the remix. *Harvard Educational Review*, 84, 74-84. Doi:10.17763/haer.84.1.p2rj131485484751.

LaForce, M., Noble, E., & Blackwell, C. K. (2017). Problem-based Learning (PBL) and Student Interest in STEM Careers: The Roles of Motivation and Ability Beliefs. *Education Sciences*, 7(92), 1-22.

Lemus, J. D., Seraphin, K. D., Coopersmith, A., & Correa, C. K. V. (2014). Infusing traditional knowledge and ways of knowing into science communication courses at the University of Hawai`i. *Journal of Geoscience Education*, 62, 5-10. http://manoa.Hawai`i.edu/crdg/wp-content/uploads/Lemus_etal_J_Geosciences_Edu_2014.pdf

Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology*, 47(1), 36-49.

Lynch, S., Kuipers, J., Pyke, C., & Szesze, M. (2005). Examining the effects of a highly rated science curriculum unit on diverse students: Results from a planning grant. *Journal of Research in Science Teaching*, 42, 921-946. doi: 10.1002/tea.20080

Maltese, A., & Tai, R. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education*, 95(5), 877–907.

Maltese, A. V., Melki, C. S., & Wiebke, H. (2014). The nature of experiences responsible for the generation and maintenance of interest in STEM. *Science Education*, 98(6), 937–962.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., & Tali, R. T. (2004). Inquiry-based science in the middle grades: Assessment of learning in urban systemic reform. *Journal of Research in Science Teaching*, 41(10), 1063–1080.

May, G. S., & Chubin, D. E. (2013). A Retrospective on undergraduate engineering success for underrepresented minority students. *The Research Journal for Engineering Education*. https://doi.org/10.1002/j.2168-9830.2003.tb00735.x

Mergendoller, J. R., Maxwell, N. L., & Bellisimo, Y. (2006). The effectiveness of problem-based instruction: A comparative study of instructional methods and student characteristics. *Interdisciplinary Journal of Problem-based Learning*, 1(2). doi: 10.7771/15415015.1026

Microsoft Corporation. (2011). *STEM perceptions: Student & parent study*. https://news.microsoft.com/download/archeived/presskits/citizenship/docs/STEMPerceptionsReport.pdf.

Mokter Hossain, M. D., & Robinson, M. G. (2012). How to Motivate US Students to Pursue STEM Careers. *US-China Education Review*, 4, 442-451.

Nariman, N., & Chrispeels, J. (2016). PBL in the era of reform standards: challenges and benefits perceived by teachers in one elementary school. *Interdisciplinary Journal of Problem-based Learning*, *10*(1).

National Academy of Sciences. (2011). *Expanding underrepresented minority participation: America's science and technology talent at the crossroads*. Washington, D.C., National Academies Press. https://www.nap.edu/read/12984/chapter/2

National Assessment of Educational Progress (NAEP) at Grades 4 and 8 (2017). *Reading. The Nation's Report Card*. https://nces.ed.gov/programs/coe/pdf/coe_cnb.pdf

Nieto, S. (1999). The light in their eyes: Creating multicultural learning opportunities. New York, NY: Teachers College.

Piaget, J. (1972). *The psychology of the child*. New York: Basic Books.

Savery, J. R. 2006. Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, 1(1).

Strayhorn, T.L. (2011). Bridging the pipeline: Increasing underrepresented students' preparation for college through a summer bridge program. *American Behavioral Scientist*, 55(2), 142–159.

Strobel, J., & van Barneveld, A. (2009). When is PBL More Effective? A Meta-synthesis of Meta-analyses Comparing PBL to Conventional Classrooms. *Interdisciplinary Journal of Problem-Based Learning*, 3(1), 44-58.

Tai, R., Liu, C., Maltese, A., & Fan, X. (2006). Planning early for careers in science. *Science*, 312, 1143–1144.

U.S. Department of Education. (2012). *The federal role in education*. http://www2.ed.gov/about/overview/fed/role.html?src=ln

Vela, K. N., Pedersen, R. M., & Baucum, M. N. (2020). Improving perceptions of STEM careers through informal learning environments. *Journal of Research in Innovative Teaching & Learning*, 13(1), 103-113.

Villalpando, O., & Solorzano, D. G. (2005). The role of culture in college preparation programs: A review of the research literature. In W. G. Tierney, Z. B. Corwin, & J. E. Colyar (Eds.), *Preparing for college: Nine elements of effective outreach* (pp. 13–28). Albany, NY: State University of New York Press.

Walker, A., & Leary, H. (2009). A Problem Based Learning Meta-Analysis: Differences Across Problem Types, Implementation Types, Disciplines, and Assessment Levels, *Interdisciplinary Journal of Problem-Based Learning,* 3(1), 3–24.

Zaffos, J. (2013). Power of place: Emerging science programs help tribal college students lead the way—at home. *Tribal College Journal of American Indian Higher Education*, 24(3), 6-12.