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Effect of STEM PBL Embedded Informal Learning on Student Interest in STEM Majors and Careers

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The purpose of the present study was to investigate the effects of a two-week long STEM summer camp on high school students' interest in pursuing mathematics, science, and engineering majors and careers. The results of the present study indicated that students' interest in mathematics and science majors and careers statistically significantly increased from pre- to post-survey after they received the STEM PBL summer camp intervention. However, the differences from pre- to post-survey in students' interest in engineering majors and careers were not statistically significant. Therefore, the findings suggest that participation in a STEM summer camp has the potential to increase students' interest in certain STEM majors and careers, particularly those in the fields of mathematics and science.

Keywords: STEM fields, STEM summer camp, informal learning

Scholars have conducted extensive research that has revealed positive results in terms of academic achievement for students participating in after school science, technology, engineering, and mathematics (STEM) activities and programs (Bicer, Boedeker, Capraro, & Capraro, 2015; Bicer, et al., 2018; Vela, Bicer, Capraro, Barroso, & Caldwell, 2018). In recent years, researchers have examined the academic performance outcomes of elementary and secondary school students who engaged in various types of informal STEM learning and have found that these students experienced improvement in their academic achievement after participating in informal STEM activities (Kurz, Yoder, & Ling, 2015; Sadler, Sonnert, Hazari, & Tai, 2012; Wang, 2013). The informal STEM learning embedded within STEM summer camps in particular has been found to improve students' academic achievement (Davis & Hardin, 2013; Mohr-Schroeder et al., 2014). However, there have been few detailed investigations conducted to examine the effects of participating in STEM summer camps on students' interest in pursuing STEM careers and college majors. Therefore, we aimed to investigate how high school students' interest in pursuing science, mathematics, and engineering college majors and careers changed after participating in a residential STEM summer camp for two weeks. Interest in academic and career pathways in technology was excluded from analysis because technology was integrated into every course in the present study as a tool rather than as an overarching goal.

Theoretical Framework

In the United States (U.S.), the number of students enrolling in STEM majors is decreasing, which has resulted in a nation-wide shortage of skilled students, teachers, and professionals in STEM fields (National Research Council, 2011). Without a systematic national strategy to remediate this shortage, the number of scientists and engineers entering the U.S. workforce in the future will be inadequate to meet the demand for professionals in STEM careers (National Science Board, 2010). Many students in the U.S. lack general STEM knowledge required to both successfully pursue STEM majors and be active citizens in a technology driven world in the 21st century (Olson & Labvov, 2014; Torlakson, 2014). Thus, identifying and implementing effective educational interventions that enhance elementary and secondary (K-12) STEM education may be a way to increase the number of students interested in STEM majors and careers. All students should have the opportunity to experience formal and informal STEM activities that prepare them for post-secondary success.

Factors Affecting Students' Choice of College Major

Making a decision regarding what academic and career pathway to pursue after secondary school is an important choice for students because it affects the rest of their social and professional lives (Borchert, 2002). Research has revealed that various factors play important roles when students are making decisions about college major selection, and scholars have suggested that each factor needs to be considered simultaneously (Kuechler, Mcleod, & Simkin, 2009) so that students select a post-secondary academic and/or career pathway in which they can be more productive and pleased in their professional lives. Several possible influences on students' choice of college major have been identified: (a) students' personality traits, (b) their genuine interest in a particular academic and/or career pathway, (c) their preconceptions regarding anticipated difficulty of particular pathways, 3) the influence of others, and (d) a host of ancillary factors (Kuechler et al., 2009). These factors can be organized into three main categories: economic, social, and psychological factors (Kimweli & Richards, 1999; Kuechler, et al., 2009). Economic factors have been found to be primarily career driven and include many sub-factors such as job security, job salary, signing bonuses, opportunities for advancement, job availability upon graduation, and initial compensation levels (Kuechler et al., 2009). Social factors have been described as the influences from students' social network of friends and family whose beliefs, attitudes, and experiences influence the students' career-related decisions (Kimweli & Richards, 1999; Zhang, 2007). Relatives who were found to influence students' college major selection included their family members, friends, and teachers. Psychological factors have been found to be mostly related to personal characteristics and include several sub-factors such as personal skills, self-image, and personal interests (Kuechler et al., 2009; Noël, Michaels, & Levas, 2003; Sabot & Wakeman-Linn, 1991).

In addition to the three main factors, "scholars suggest that a host of ancillary factors have the potential to influence the choice of college major" (Kuechler et al., 2009, p. 466). Researchers have found that the following variables are ancillary factors: degree programs that offer career-related classes, student access to informational resources regarding degree programs, students' precollege coursework, student perceptions regarding the future quality of life related to particular academic and career pathways, and the lack of gender bias in a selected college major (Kimweli & Richards, 1999). Ancillary factors have received a growing amount of attention in the field of education as educators and researchers aim to identify the factors influencing the decline in the number of students pursuing a STEM-related degree (National Research Council [NRC], 2011).

Given the rising concern related to the shortage of individuals pursuing STEM-related pathways, scholars from various fields have conducted studies to determine what factors might increase students' motivation and interest toward STEM-related majors (Canton & De Jong, 2005). It is critical to examine factors that influence students' interest in and motivation toward STEM-related pathways because motivation and interest are significant predictors of students' selection of college major and career. Early interest in a specific field or career was found to be one of the strongest predictors of students' selection of particular college majors (Beier, 2008; Calkins & Welki, 2006). Furthermore, research findings have indicated that increasing students' personal interest in STEM is crucial to inspire them to pursue a career in STEM-related fields (Mohr-Schroeder et al., 2014). Scholars developed the social cognitive career theory (SCCT) to explain why and how individuals develop academic and career interests, pursue certain majors aligned with their developed interests, and persevere in their educational and occupation goals (Lent, Brown, & Hackett, 1994; Soldner, Rowan-Kenyon, Inkelas, Garvey, & Robbins, 2012). According to the SCCT, students' career development is influenced by environmental factors (e.g. the quality of the formal or informal educational experiences an individual has been exposed to) (Lent, Brown, & Hackett, 2000). In other words, students are more likely to develop interest in STEM-related majors if they have had the opportunity to engage in stimulating STEM-related learning environments. In the present study, researchers applied the SSCT theoretical framework to investigate how students' interest in STEM-related academic and career pathways changed after they participated in a STEM summer camp that had a stimulating informal learning environment.

STEM Interest

Scholars from various disciplines have emphasized that the status of the U.S. as a global economic power and scientific leader is largely contingent on the number of U.S. students who pursue and complete a STEM-related degree (National Academy of Engineering, and Institute of Medicine, 2007; National Academy of Sciences, 2005). However, there has been a gradual decrease in the graduation rate of students in STEM-related majors throughout the nation (National Science Foundation [NSF], 2010). In response to these findings, there has been a call for educational researchers to conduct formal and informal educational research and interventions designed to foster students' interest in pursuing STEM-related pathways (NRC, 2011).

Research has indicated what factors influence students' interest in STEM majors (Burkam & Lee, 2003; Maltese & Tain, 2011; Sahin, 2013). The factors influencing students' interest in pursuing a STEM-related degree were found to be their school and classroom experiences as well as their academic and social desires (Maltese & Tai, 2011). For instance, it was found that that the greater the number of advanced mathematics courses students took during high school, the more likely they were to express interest in pursuing STEM-related majors in college (Burkam & Lee, 2003). In another previous study, the relationship between students' academic success and their selection of a STEM-related major was investigated; this study revealed that the higher the students' academic achievement, the more likely they were to indicate interest in pursuing STEM-related careers (Sahin, 2013). When students developed an interest in one of the STEM-related subjects during grades K-12, their interest increased the likelihood that they would pursue STEM career pathways in college (Buxton, 2001).

To increase students' interest toward STEM-related subjects, it is critical to provide them with engaging and positive STEM experiences before and during high school because at that juncture in their education, most students are either just beginning to or have yet to consider what career pathway to follow (Hansen, 2011). One recent survey showed that 78% of college students decided in high school that they would pursue STEM-related majors and careers, whereas only 21% of them indicated that they had made this decision prior to high school (Microsoft Corporation, 2011). Because students' high school years are more determinant on their decision to pursue STEM-related majors when compared to their elementary and middle school years, investigating what factors increase students' interest in STEM-related majors during high school is vitally important. Scholars have proposed many research-based suggestions for increasing students' interest in STEM-related subjects during high school years.

For instance, one researcher listed the following five recommendations for fostering high school students' interest in STEM subjects (Beier, 2008). First, science and mathematics classrooms need to be well-organized because classroom environment and students' STEM interest are positively correlated. Second, students should be provided opportunities to develop their self-concepts in the STEM domain. Third, students should collaborate in engaging with hands-on STEM problems that incorporate real-life scenarios so that they understand STEM fields' utility and value (Capraro, Capraro, & Morgan, 2013). Fourth, students should be divided into groups based on their STEM proficiency level to be more responsive to their academic needs in STEM disciplines. Fifth, students should attend informal STEM learning activities so that they can see that STEM subjects have various applications in their daily life. Implementing these recommendations with the intent to improve students' interest in STEM is critical given the recent significant drop in STEM career interest among male high school students and the persistently low STEM career interest among female high school students (Ernst & Young Global Limited, 2018).

Informal Education

Informal education is defined as "the sum of activities that comprise the time individuals are not in the formal classroom in the presence of a teacher" (Gerber, Marek, & Cavallo, 2001, p. 570). Under the category of informal education, informal science learning is defined as "the science learning that occurs outside the traditional, formal schooling realm" (Dierking, Falk, & Rennie, 2003, p. 108). This form of learning can be stimulated through activities such as visiting a science or mathematics museum, participating in science fairs, going on educational field trips, or by simply engaging in activities that allow one to learn new science and mathematics knowledge related to personal areas of interest (Dierking & Falk, 1997; Dierking & Falk, 2003).

Informal learning environments have received increased attention as alternatives to traditional learning in promoting students' learning in science (Robelen, 2011) and mathematics (Grabinger & Dunlop, 1995). Research has indicated that there are several benefits to informal learning in STEM-related subjects, such as increasing students' STEM interest, providing students with meaningful STEM learning, and demonstrating the utility of STEM fields to students (NRC, 2011). In another study, it was found that participating in science fairs increased students' STEM interest, which made them more likely to follow a STEM-related career pathway (Sahin, 2013). Researchers have also presented evidence supporting the positive effects of participation in informal learning environments such as science fairs on students' motivation and engagement toward STEM-related subjects (Sawyer, 2006). Another emerging informal STEM learning type is the STEM summer camp. Scholars have noted its importance in increasing students' interest in STEM majors (Bicer et al., 2015; Bicer et al., 2018; Vela et al., 2018).

All STEM summer camps can be consider a form of informal education because they take place outside of the school day and the traditional learning environment. Results from research studies revealed that STEM summer camps, used as a form of informal education, statistically significantly improved middle and high school students' mathematics and science vocabulary knowledge (Bicer et al., 2015), increased their self-efficacy in the creative processes involved with the arts in STEM (Capraro, Capraro, Nite, Morgan, & Peterson, 2014), improved students' satisfaction, teamwork, and communication skills (Bicer et al., 2015), and developed students' self-identity (Barroso et al., 2016) and scientific reasoning (Gerber, Cavallo, & Marek, 2001).

The scope of previous studies regarding informal STEM camps allowed for the examination of the effects of engagement in informal STEM summer camps on critical areas of students' affective and cognitive development. That said, the aim of the present study was to identify and address any effects a STEM summer camp may have on students' interest in college majors and careers within science-, engineering-, and mathematics-related fields. We predicted overall positive effects for participating in STEM summer camps on high school students' interest in post-secondary academic and career pathways in STEM. This prediction is supported by the SCCT, in which it is theorized that individuals choose a certain major if they have been exposed to stimulating environments associated with that particular area of study or subject matter (Lent et al., 1994). Because STEM summer camps frequently contain stimulating informal STEM teaching and learning environments, students' interest in pursuing STEM academic and career pathways may increase after receiving the informal STEM intervention.

Research Questions

1. Can participating in a STEM summer camp significantly increase high school students' interest in pursuing mathematics, science, and engineering-related majors and careers?
2. Is there any statistically significant difference between female and male students in terms of their interest in pursuing college majors and careers in STEM before and after they attended the STEM summer camp?

Method

A STEM summer camp was held in the southern part of Texas during the summer of 2017. During the two-week residential camp, students spent each day engaged in a variety of STEM classes and activities. Students participated in STEM classes on a daily basis that included, but were not limited to, Bridge Building, Trebuchet, Cryptography, Data-analysis, Coding, Musical Instrument Construction, UAV (drones), 3D Printing, Multimedia Marketing, Microcontroller, and Cosmetic Chemistry. To measure any changes in their interest in pursuing college majors and careers in STEM, students were administered the same survey, which took approximately 30 minutes to complete, both before and after the intervention. The survey questions were derived from the *Student Attitude Towards STEM survey* developed by Mahoney (2010). The focus of the present study was on the section of the survey that includes three items related to students' interest in mathematics, science, and engineering college majors and careers.

Participants

The current study was conducted with 86 high school students at a two-week residential STEM summer camp. The camp consisted of students who were entering grades 9 through 12. The students were from several different U.S. states as well as countries around the world, such as Italy (2), Honduras (1), Guatemala (1), and Canada (2). Unfortunately, not all students who applied to the camp could be accepted due to logistic limitations, so the STEM camp program coordinators only accepted students who registered before the enrollment limit was reached. Students were accepted on a first come, first served basis regardless of their demographic and academic backgrounds; however, a diverse student body was served in terms of gender (44 males and 42 females) and ethnicity. The ethnic/racial backgrounds of participants were Hispanic (26.2%), White (50%), Asian (6.9%), African American (4.6%), and Native American (2.3%), and the remainder of the students provided no specific ethnicity/racial identity. Before the camp started, informed consent was gathered from all of the students and their parents.

Instruments

Pre- and post-surveys were administered to the participants through Qualtrics. Participants took the pre-survey before the camp started and took the post-survey after the camp was finished. The survey questions were adopted from the *Student Attitude Towards STEM Survey* developed by Mahoney (2010), which consisted of 96 Likert-scaled items. The reported Cronbach's alpha score for each STEM discipline in the survey was $\geq .95$ for the items used in the present study. Students were instructed to respond to the items by indicating their level of agreement or identification with item statements, ranging from (4= "most like them", 3= "more like them", 2= "somewhat like them", and 1= "least like them"). The items of this survey were used to measured participants' interest in pursuing science, mathematics, and engineering majors and careers.

Specifically, the researchers in the present study used six of the 96 total survey items. The items "I am interested in a career in science", "I am interested in a career in engineering", and "I am interested in a career in mathematics" were used to determine if students' interest toward STEM careers increased after engaging in the informal STEM learning opportunities during the camp. To determine if there was a change in students' interest in pursuing science, engineering, and mathematics college majors, the variables "I would like to continue my education in science", "I would like to continue my education in engineering", and "I would like to continue my education in mathematics" were used. A software package, SPSS 24, was used for statistical analysis. To determine pre-to-post differences on survey items, a paired-sample *t*-test was applied and Hedge's *g* effect sizes were also reported. A variable referred to as "Students' interest in STEM careers" was calculated by adding the scores of students' career interests in mathematics, science, and engineering together. We also examined how students' interest in STEM careers changed before and after participating in the STEM summer camp in terms of gender.

Intervention

During the two-week STEM summer camp, students spent each day engaged in a variety of STEM classes and activities for a total of 90 hours. On the first day of the camp, students filled out preference sheets through which they were able to indicate and then take their course preferences from among the available STEM project-based learning (PBL) classes. All students participated in either the Bridge Building or the Trebuchet classes. In both the Bridge Building and Trebuchet classes, students were able to participate in STEM PBL activities that required every group to design and build either a bridge or a trebuchet. Within the other STEM PBL-integrated classes offered at the camp, students also had the opportunity to engage in projects related to 3D printing and design, app creation, microcontroller design, cosmetic chemistry, conducting data-analysis, or cryptography. Each of these activities was taught by implementing the fundamental components of STEM PBL instruction.

STEM PBL has been defined as "a well-defined outcome with an ill-defined task" (Capraro & Slough, 2008, p. 2). A well-defined outcome in this context is one that involves students achieving the specified learning objectives and acquiring and developing skills that adhere to state and national educational standards (Yetkiner & Capraro, 2013). To support students' attainment of the intended outcome, the ill-defined tasks are designed to be complex, flexible, and unstructured, which requires students to consider and apply multiple approaches to identify one of multiple viable solutions (Capraro & Slough, 2008; Finkle & Torp, 1995). By utilizing an ill-defined task to achieve a well-defined outcome, students in the STEM camp actively engaged with real-world STEM-related problems to produce creative solutions through collaborative and cooperative group work in a student-centered environment (Bicer, Capraro, & Capraro, 2013).

Three professors who are specialists in the integration of innovative STEM PBL instruction within mathematics and science classrooms trained all camp instructors about how to implement STEM PBL instructional practices. Two of the professors were from the university's education department and one was from the engineering department. After the training, every camp instructor was able to identify the differences between traditional STEM classroom instruction and innovative STEM PBL teaching and learning practices. One newly trained instructor articulated a key tenant of STEM PBL instruction after receiving training, stating, “My role as an instructor in STEM PBL classrooms is to be a facilitator rather than a disseminator of knowledge”.

Results

Descriptive statistics were calculated to determine if students’ interest in pursuing mathematics, science, and engineering majors and careers changed after receiving STEM summer camp intervention. These calculations were performed to understand the center and the spread for each variable. Conducting descriptive analyses revealed that our data were normally distributed, the variance between the pre-and post-survey was not statistically significantly different, and the sample size was adequate. Furthermore, the results of the descriptive statistics indicated that students’ interest in pursuing college majors and careers in mathematics, engineering, and science increased from pre- to post-survey. Specifically, the mean score of students’ post-survey responses was higher than that of their pre-survey responses for interest in mathematics, science, and engineering majors and careers (see Table 1). In addition, standard deviations were relatively unchanged from pre- to post-survey responses in mathematics, science, and engineering majors and careers (see Table 1).

Table 1

Mean and Standard Deviation of Students’ Interest in Mathematics, Science, and Engineering Majors & Careers from Pre- to Post-Survey (N =86)

Students’ Interest in	Mathematics Major	Science Major	Engineering Major
Pre-survey	*M* = 3.14 (*SD* = 0.75)	*M* =3.03 (*SD* = 0.82)	*M* = 3.28 (*SD* = 0.77)
Post-survey	*M* = 3.84 (*SD* = 0.81)	*M* = 3.40 (*SD* = 0.74)	*M* = 3.32 (*SD* = 0.83)
Students’ Interest in	Mathematics Career	Science Career	Engineering Career
Pre-survey	*M= 3.18 (SD = 0.78)*	*M = 3. 10 (SD = 0. 85)*	M = 3.27 (*SD* = 0.75)
Post-survey	*M= 3.88 (SD = 0.86)*	*M =3.48 (SD = 0.81)*	*M* = 3.34 (*SD* = 0.85)

Researchers also used a paired sample *t*-test to examine changes in students’ interest in mathematics, science, and engineering majors and careers. The results of the present study showed that students’ interest in mathematics and science majors statistically significantly increased from pre- to post-survey after receiving STEM summer camp intervention: mathematics (t = 5.88, df = 85, p < .05) and science (t = 3.11, df = 85, p < .05). However, students' pre- and post-survey responses indicated that they experienced no statistically significant increase in their interest toward pursuing an engineering degree (t = .74, df = 85, p > .05). Similar results were found in terms of the participants' interest in science, mathematics, and engineering careers. The students' pre- and post-survey scores revealed a statistically significant increase in students' career interest in mathematics- and science-related professions from pre- to post-survey, (t = 5.99, df = 85, p < .05) and (t = 3.01, df = 85, p < .05), respectively. However, students' pre- and post-survey scores for career interest in engineering professions indicated no statistically significant difference (t = .57, df = 85, p > .05) after they received the two-week long STEM intervention. These results suggested that engaging in the STEM summer camp had a positive effect on student's attitudes toward certain STEM-related careers and college majors, specifically those in mathematics and science.

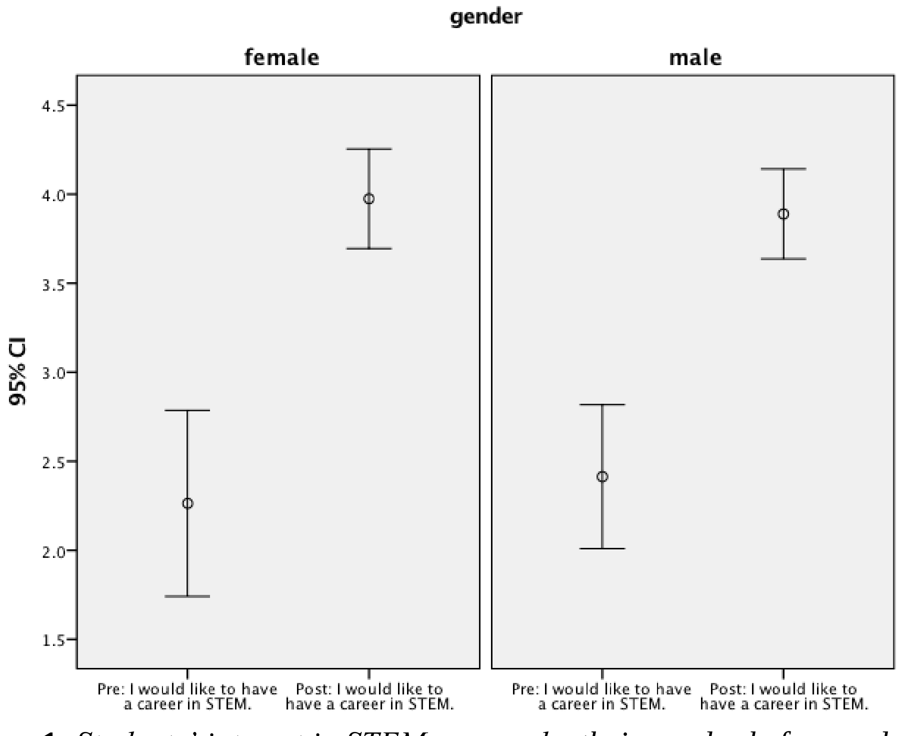

Figure 1. *Students' interest in STEM careers by their gender before and after they received the intervention.*

The Hedge's g effect sizes of students' interests in mathematics-, science-, and engineering-related majors from pre- to post-survey were 0.89, 0.47, and 0.04, respectively. In addition, the Hedge's g effect sizes of students' interest in mathematics-, science-, and engineering-related careers from pre-to post-survey were 0.85, 0.46, and 0.08, respectively. Results also revealed that there was no statistically significant difference ($p < .05$) between female and male students' STEM career interests either before or after they attended the STEM summer camp (see Figure 1). As was expected, there were strong correlations between the mean scores of students' interest in STEM majors and their interest in STEM careers.

Discussion

The effects of the STEM summer camp on students' interest in science- and mathematics-related college majors and careers were positive, while the effects of the intervention on students' engineering-related college major and career interest indicated no significant change from pre- to post-survey. The positive effect sizes for interest in mathematics and science majors and careers might be due to the fact that the entire camp was taught as a STEM PBL, which was student-centered and included innovative instruction. This finding can be supported by the findings in previous research (Han, Capraro, & Capraro, 2015; Han, Rosli, Capraro, & Capraro, 2014; Lou, Liu, Shih, & Tseng, 2011; Lou, Shih, Diez, & Tseng, 2011; Robinson, Dailey, Hughes, & Cotabish, 2014) in which STEM PBL activities were found to increase students' academic achievement and interest in science and mathematics.

In the present study, the effect sizes for students' interest in a mathematics and science college major and career were higher than the effect sizes representing their interest in engineering college majors and careers. There are several possible explanations for these findings. One explanation might be the activities that students engaged in during the STEM camp. The students took classes in coding, data-analysis, drones, rocketry, robotics, 3D printing, print marketing, bridge making, and cryptography, among others. Although these classes have an application within bioscience, physics, and engineering disciplines and all directly involve mathematics and science, not all include the engineering design process or its applications (e.g. cryptography and data-analysis). In addition, it is possible that the students were able to relate the concepts learned in the activities directly to their mathematics and science courses at school because every student takes some sort of mathematics and science courses. However, not all students take upper-level bioscience or engineering courses. Additionally, mathematics educators with an enthusiasm for mathematics and mathematics-related classes such as cryptography and data-analysis taught the majority of the STEM summer camp courses, which could have unknowingly biased the results in favor of mathematics-related college majors and careers compared to college majors and careers in science and engineering. Perhaps for future activities, being explicit about the engineering design process and the role of engineering within mathematics- and science-focused PBL activities could increase the positive effects of participating in STEM summer camps on students' interest in engineering-related majors and careers.

Several scholars have suggested strategies for improving the way in which engineering activities and content are taught to clearly present the application of engineering processes and concepts within STEM activities and instruction. For example, one scholar recommended having interdisciplinary meetings amongst groups of teachers to collaborate on engineering design activities in order to make explicit connections between different disciplines and engineering tasks (Hefty, 2015). In addition, another researcher argued for the use of engineering-related pedagogy to demonstrate the explicit connection of engineering to various STEM content areas and asserted that "with sustained, job-embedded professional development, engineering design pedagogy can help foster integrative approaches to STEM education" (Donna, 2012, p. 7). During the STEM summer camp, students actively engaged with interdisciplinary projects by designing and building their own products. For example, students in the 3D printing course were able to work with the 3D printers along with the SketchUp software to design and print their cipher wheel for the Cryptography class. Along with the interdisciplinary and hands-on component, each course was situated in a real-world context to make students' mathematics and science learning meaningful. For example, when students built their bridges by following the engineering design process, they were required to follow certain criteria. The criteria included constraints such as, students should build a bridge that is wide enough for a toy car to drive through with ramps or students should build a bridge that allows the toy car easy access to the bridge from both sides. These restrictions or criteria enable students to be prepared for the challenges they may face in their daily lives. Connecting students' learning with their daily lives through PBL is one of the most vital components of STEM PBL that makes students' learning meaningful rather than a process of rote memorization. Moreover, it is through the STEM PBL process that students are encouraged to ask questions and to seek innovative approaches for solving complex problems of the 21st century.

This STEM summer camp consisted of only two weeks of STEM-centered activities as an intervention, which we view as a limitation. Further research should be conducted to determine if a longer intervention period at a STEM summer camp has a greater effect on high school students' interest in engineering majors and careers. In addition, the number of students who attended the STEM summer camp was limited in the present study. Approximately one thousand students show interest in and apply for a spot in the STEM summer camp; however, only about 60 applicants receive a spot for each camp session. Lastly, the study was limited in terms of sample type: students were self-selected into the STEM summer camp. Self-selection of the STEM summer camp might be already indicative of early career interest in STEM-related fields. In addition, we applied a convenient sampling rather than a random sampling. A randomly selected sample would have been an ideal sample for this intervention, and hence, the results of this intervention might not be applicable to the greater population due to the lack of random sampling.

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