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# Impact of Lab Design and Students' Prior Engineering Interest on Outcomes from an Engineering Summer Camp (Evaluation)

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# Impact of Lab Design and Students' Prior Engineering Interest on Outcomes from an Engineering Summer Camp (Evaluation)

**Background and Motivation:** Outreach programs are an important tool for universities to recruit students and to help pre-college students see themselves as engineers. Outreach programs are also types of learning experiences that influences students' choice to pursue careers such as engineering according to Social Cognitive Career Theory. However, results from meta-analyses show that there are inconsistencies in how well outreach programs achieve their goals. Thus, there are questions about what aspects of outreach programs result in positive outcomes and what types of participants particularly benefit from participating.

**Program Details:** Engineering Possibilities in College (EPIC), is a one-week engineering summer program hosted at California Polytechnic State University (Cal Poly). Participants explore different engineering disciplines through 1) 2-4 multi-day hands-on labs taught by professors, 2) a design, test, build project, and 3) social events that let them bond with undergraduate engineering students and each other. Seven hundred and fifteen California students participated in 2025, ranging in ages from 12-17.

**Study Purpose, Framework, and Research Questions:** The study evaluates the impact of EPIC using the Social Cognitive Career Theory (SCCT) framework. SCCT predicts that career choices are influenced by person inputs, interests, external supports, and external barriers. This study builds on existing evaluation literature by investigating who is most impacted by attending EPIC and what aspects of lab design are most impactful. The resulting research questions consider the impact of attending EPIC for those who became interested in engineering at different stages of life, length of time in lab, and balance of lecture and hands-on activities.

**Methods:** Pre-program, post-program, and post-lab surveys evaluated the impact of lab design and students' prior exposure to engineering on EPIC outcomes. Outcomes assessed on the surveys include engineering interest, intent to apply to engineering, and how confident participants felt like they could be an engineer. Results were analyzed using Chi Square Tests for Independence and Mixed Repeated Measures Two Way ANOVA tests.

**Results:** After attending EPIC, when students first became interested in engineering showed a statistically significant relationship with intent to apply to engineering ($p = 0.008$) and whether they felt like they fit in more with others who like/do engineering ($p =0.020$). Both the length of the lab and balance of lecture vs activity showed a statistically significant relationship with increased interest in engineering and whether students considered becoming an engineer.

**Conclusions:** This study builds on a growing body of work that shows that context matters when designing effective outreach experiences. For example, there was a stronger association between attending EPIC and students who first became interested in engineering in middle school compared to other times in childhood. Experiencing more single-day labs also appears to have a stronger association with increased engineering interest compared to fewer multi-day labs. By evaluating how aspects of outreach camp structure and engineering lab design support or hinder program outcomes, outreach programs can make improvements that will better serve their local communities.

## Introduction and EPIC Background

The College of Engineering at California Polytechnic State University (Cal Poly) is committed to increasing the diversity of the engineering student body as seen in our college's strategic priorities [1]. One action that supports this goal is to expand pipeline activities in K-12 partner schools such as summer outreach programs. Outreach camps have been shown to be one of the most impactful forms of informal STEM learning outside of school for K-12 as shown in a 2025 meta-analysis by Xia et al. [2]. Some important outcomes from outreach programs include increasing students' interest in engineering [3], [4], confidence in their ability to do engineering [5], [6], and intention to apply to engineering programs [5], [7], [8].

EPIC is a one week summer outreach program for middle school students (rising 7$^{th}$ – 8$^{th}$ grades) and high school students (rising 9$^{th}$ – 12$^{th}$ grades). The goals of the program are to inspire a students with diverse backgrounds to pursue engineering and for those students to eventually apply to the College of Engineering at Cal Poly. Because students are required to select a specific major during application, EPIC serves as a way for students to make informed decisions when they apply to Cal Poly. One hundred and one students participated in the middle school track and six hundred and fourteen students participated in the high school track.

EPIC helps expose students to different engineering fields through hands-on labs and a week-long design, build, test project. The labs are designed and taught by engineering professors and industry professionals. The labs range in terms of engineering discipline, number of days the lab runs, balance between lecture and hands-on activities, and individual vs group work. Students attend 2-4 labs throughout the week. Table 1 shows the lab name, number of days the lab ran, and whether it was Lecture-focused, Activity-focused or Mixed. Labs were labeled as Lecture-Focused, Mixed, or Activity-Focused based on how the students discussed the balance of lecturing and hands-on activities on the open-ended post-lab survey question "Please Comment on any areas you feel could improve this lab in terms of understanding the engineering field and the enjoyment of the activity."

Students also get exposure to engineering disciplines through professional development such as lab tours, panels, and guest speakers. Outside of the labs, students also participate in a design, build, and test project. Last year, students worked in teams to design, build, and test a cardboard canoe. In addition to the labs and projects, EPIC also provides a social experience through bonding activities. Students meet and socialize with each other and counselors through fun campus activities. An example schedule showing the breakdown of activities during a typical day is shown in Figure 1.

| Residential Program Schedule | |
|---|---|
| 7:30-8:00am | Morning Gathering |
| 8:10-9:00am | Breakfast |
| 9:10-11:00am | Engineering Class |
| 11:10-12:00pm | Engineering Fields Presentations/Industry Guest Speakers |
| 12:10-1:00pm | Lunch Break |
| 1:10-3:00pm | Engineering Class |
| 3:10-5:00pm | Engineering Design Team Project |
| 5:10-5:30pm | Break |
| 5:30-6:30pm | Dinner |
| 6:30-8:30pm | Evening Activities |
| 8:30-9:00pm | Evening Gathering |
| 9:00-10:00pm | Free Time |
| 10:00-11:00pm | On Floor/In Room |
| 11:00 PM | Lights Out |

**Figure 1: Typical breakdown of activities per day for EPIC include attending Engineering Class, social activities in the evening, and working on an engineering design project.**

**Table 1: EPIC lab names, number of days ran, and the balance of lecture vs hands-on activities**

| Lab Name | Number of Days Ran | Lecture-Focused, Activity-Focused, or Mixed |
|---|---|---|
| Architecture Lab | 4 | Lecture Focused |
| Arduino | 2 | Mixed |
| Autonomous Driving Fundamentals with Mobile Robots | 4 | Mixed |
| Biomedical Lab | 1 | Mixed |
| Casting Lab | 1 | Activity Focused |
| Cranes | 4 | Lecture Focused |
| Cybersecurity | 2 | Mixed |
| Engine Lab | 4 | Mixed |
| Gliders and Composite Materials Testing | 4 | Mixed |
| Granite Bridge | 1 | Activity Focused |
| Industrial Engineering Lab | 1 | Activity Focused |
| Mechatronics Lab | 4 | Mixed |
| Robotics Lab | 2 | Activity Focused |
| Solar Energy Lab | 4 | Mixed |
| Supply Chain Lab | 4 | Mixed |
| Surfboard Lab | 4 | Mixed |
| Watts Up? Building a Smart Microgrid | 2 | Mixed |
| Wind Power Lab | 2 | Mixed |

This study is a continuation of ongoing research on the evaluation of the program and efforts to make data-driven decisions to improve the camp. The program started as an experience for high school students in 2007. Initial evaluations found that the camp effectively served those from underrepresented backgrounds, but many who attended were already interested in applying to engineering programs in college and attended the camp to distinguish between the different fields of engineering [9].

A subsequent study examined when students first became interested in engineering and how EPIC helped students differentiate between the different engineering fields, including what skills are relevant to engineering and what engineers in the different fields do [10]. The results of that study led to the expansion of EPIC to middle school students. The program currently serves 715 students ranging in rising grades 7 – 12 and from across the state of California.

## Literature Review

### Theoretical Framework: Social Cognitive Career Theory (SCCT)

The goal of EPIC is to encourage students to pursue engineering, particularly at Cal Poly. Our efforts to evaluate the program's effectiveness are based on the Social Cognitive Career Theory (SCCT) framework. The SCCT framework states that choosing and excelling in a career occurs over three stages. In the first stage, learning experiences and person inputs lead to self-efficacy and outcome expectations, which then help individuals develop an interest in a given career. Outreach camps are examples of learning experiences. In the second stage, self-efficacy, outcome expectations, interests, and goals combine to help individuals choose their career and take steps to prepare for that career. Career choice is influenced by individual factors including individual background experiences, demographics such as gender and ethnicity [11], [12], [13], [14], [15], self-efficacy [16], outcome expectations [16], and interests [16]. Additionally, the SCCT framework proposes that career choice is influenced by external supports and barriers encountered during the choice making process [14], [17], [18], [19]. In the third stage, SCCT examines the individual's performance in that career.

Outreach camps are one example of learning experiences proposed by the SCCT framework to help increase students' intent to apply to engineering programs. They do so by increasing students' interest in engineering [4], [20] and engineering self-efficacy[21]. This evaluation paper applies the SCCT framework to evaluate the impact of EPIC, an outreach camp at Cal Poly.

### Engineering Outreach Camps: Overall Structure and Evaluation Using the SCCT Framework

Engineering outreach programs range from single-day activities to multi-day residential camps. The former usually ranges from one hour to a whole day where participants do a deep dive into a single engineering discipline. The latter typically involves a combination of engineering labs/activities with professors and social/bonding activities with other participants and undergraduate student counselors [4], [22], [23], [24], [25]. In the residential camps, participants typically experience multiple shorter labs versus one longer lab so they can be exposed to a variety of engineering disciplines.

Regarding pedagogical techniques, hands-on laboratory experimentation is one of the most commonly used pedagogical techniques for the individual lab activities in STEM outreach followed by problem-based and inquiry-based learning according to a 2025 systematic literature review of science outreach programs [26]. The authors could not find a similar literature review specific to engineering outreach programs, but they suspect hands-on laboratory experiments would be the most common followed by engineering design projects similar to problem-based learning based on their prior experience with outreach programs at multiple institutions as a participant, instructor, and organizer.

Studies that evaluate the effectiveness of engineering outreach programs often do so through the lens of SCCT. The outcomes evaluated by these studies include factors within the SCCT framework. These include, but are not limited to, improved self-efficacy [21], engineering interest [4], [20], engineering identity [20], [27], [28], perceptions of what engineering is [29], [30], and intent to apply to engineering, especially at that institution [5], [7], [8]. However, there are disagreements about the impact outreach programs have on encouraging students to apply to the institutions hosting the outreach program. For example, a 2022 systematic literature review found no obvious correlation between institutions running outreach camps and increased enrollment of women [31]. Many institutions saw increased enrollment, but some saw decreased enrollment. This led the authors to wonder what makes some programs more successful than others and for whom are outreach programs most effective? Studies that investigate these questions are relatively few but are important for educators trying to make outreach camps the most impactful for different types of participants.

**Gaps in the Literature: Impact of Camp Structure and Person Inputs Beyond Demographics**

One area of outreach literature that is not as well explored is how and why parts of the camp's structure or which pedagogical techniques impact different outcomes. For example, many outreach camps incorporate design projects as part of the participant experience [4], [25]. However, how design is implemented differs across outreach programs and even across individual disciplines within the same outreach program. Some programs implement a week-long design project centered on one topic while others incorporate smaller, mini-design projects within individual labs while others do not cover engineering design at all [4]. One finding from that study is that the discipline without a design project decreased women's interest in engineering and desire to become an engineer. In contrast, the discipline that made the design project the central focus showed a statistically significant increase in women's interest in engineering and confidence in their ability to do engineering but no statistical difference in their desire to be an engineer.

This study builds on prior outreach program evaluations by assessing the relationship between how labs are structured and outcomes based on the SCCT framework such as increase in engineering interest and intent to apply to engineering programs, particularly at Cal Poly. The authors suspect that aspects of outreach camp or lab design play a role in developing career interest or choice by providing external supports or lowering external barriers. Informal discussions with camp counselors and EPIC director as well as reading comments from past EPIC participants indicated that participants could be impacted by two factors related to the design of the laboratory experiences.

First, how long participants spend in the lab. Counselors noticed more animated conversations among students who participated in the two- or four-day labs and students wishing they could have more time in the one-day labs. The authors also noticed that participants stated they wished there was more time on the post-lab surveys for the one-day labs. The authors' hypothesis is that students who spend more hands-on time with a topic will have more time to develop their interest in this area and thus increase their likelihood to apply to study engineering, particularly in the area they spend the most time exploring.

Second, what the balance between lecture (interactive or not) and hands-on activity is for the lab. Counselors noted that students talked about how they didn't feel like they did any engineering because there was too much lecture and not enough hands-on activity. In contrast, some students said they wished there was some lecture because they felt thrown in to doing an activity without knowing what was going on. The authors' hypothesis is that labs with a mixture of lecturing and hands-on activities will lead to higher interest in engineering and intent to apply to engineering, particularly at Cal Poly.

Another gap in the literature is examining the impact of outreach camps based on person input factors outside of demographics and parent influence. There are many studies that examine the impact of outreach camps on different genders [6], [8], [32], ethnicities [8], and age groups [3], [27], which aligns with what the SCCT framework predicts will impact students' career choices. What is less well-explored is the intersection of participant backgrounds with other components of the SCCT framework. This study builds on prior work by assessing the relationship between how attending EPIC impacts students based on how long they have been interested in engineering. The authors believe that how long participants have been interested in engineering is an important factor to study based on discussions with stakeholders and core components of the SCCT framework.

Regarding stakeholders, both camp counselors and EPIC's director noted that many students come to the program already planning to apply to engineering and many of them first became interested in engineering before middle school. They also noted that students who had more recently became interested in engineering showed a bigger shift in their excitement at the end of the week.

Regarding the SCCT framework, career choice is influenced by an individual's interests. Students who have been interested in engineering for longer (e.g., as long as they can remember) are more likely to have engaged more with learning experiences and other external supports to develop their interests. As a result, their engineering interests are possibly less sensitive to change during learning experiences such as outreach camps. For these individuals, EPIC may reinforce interests but not significantly change them. Conversely, individuals who have just recently become interested have had less time to engage with supports that would develop their engineering interest. For these individuals, EPIC may serve as a way to spark and solidify their engineering interest, which should lead to stronger commitments to career choices according to the SCCT framework.

## Research Questions

Based on the gaps in the literature, discussions with program stakeholders, and EPIC's goals at Cal Poly, we developed three research questions for the study:

***Research Question 1: What is the relationship between when participants became interested in engineering and how attending EPIC changes their interest in engineering, confidence in their ability to be an engineer, how well they think they fit in with others who do engineering, and their intent to apply to engineering?***

***Research Question 2: What is the relationship between the number of days participants spend on a specific lab and changes in their interest in engineering and intent to apply to engineering?***

***Research Question 3: What is the relationship between the balance of lecture and hands-on activity and changes in their interest in engineering and intent to apply to engineering?***

## Methods

### Study Design

This study follows a quasi-experimental time-series design without a control group. The intervention is participating in EPIC. Participants take a pre-program survey after consenting to participate in the study when registering for the camp. They then take the post-program survey on the last day of the camp. Some items on the pre- and post-program surveys are also present on the lab surveys, which are given after every lab the participants complete. The authors were not able to tie participants' pre- and post-program survey results to the post-lab surveys because participants did not put their names on the post-lab surveys. Thus, the authors were not able to achieve an interrupted time series design. This is a limitation that will be corrected in future studies.

### Overall Camp and Study Participant Demographics

Seven hundred and fifteen students participated in EPIC this past summer. The distribution of participant gender, ethnicity, and rising grade level of all camp participants are shown in Table 2. To protect the privacy of camp participants, any category with less than ten participants was not included in Table 2. Removing these individuals brings the total camp participants to 691.

Cal Poly's goal is to serve the population of the state of California. The male to female ratio of EPIC is (53% : 47%), which is higher than the state of California's ratio (49.9% : 50.1%) [33]. Asian, Multi-ethnic, and Hispanic or Latino individuals are representative or slightly overrepresented in EPIC compared to the state of California [33]. White individuals and Black individuals are underrepresented in EPIC compared to the state of California [33].

Participants for Research Question 1 of this study are those who completed all program-level surveys (demographics survey, pre-program survey, and post-program survey). This brings the total number of participants for Research Question 1 to N=216. Table 2 shows the breakdown of participants' gender, ethnicity, and grade level. Figure 2 shows the breakdown of when all participants first became interested in engineering while Figures 3-5 shows when participants first became interested in engineering broken down by gender (Figure 3), ethnicity (Figure 4), and grade level (Figure 5). To protect anonymity of participants, any category with less than 10 participants is removed from Table 2 and Figures 2-5. However, these individuals are still included in the analysis because demographic information is not a variable explored in Research Question 1 nor Research Question 2.

For Research Question 2, the program collected post-lab surveys from those who consented to the study, resulting in N = 917 responses. Because the post-lab surveys did not ask for the participants' names, I cannot group them by specific participant, nor do I know how many unique participants are in this dataset. I also cannot link their responses to the pre- and post-program survey responses. Participants attended 2-4 labs over the course of the week with each lab running for 1, 2, or 4 days, which is why the total number is higher than the total number of participants in the program.

**Table 2: Demographics of participants for Research Question 1 compared to all EPIC participants after removing categories with less than 10 individuals.**

| **Gender** | **Number of Participants who attended EPIC (% of total)** | **Number of Participants in Research Question 1 (% of total)** |
|---|---|---|
| Male | 365 (53%) | 110 (51%) |
| Female | 326 (47%) | 106 (49%) |
| **Total** | 691 | 216 |
| | | |
| **Ethnicity** | **Number of Participants who attended EPIC (% of total)** | **Number of Participants in Research Question 1 (% of total)** |
| Black/African American | 11 (2%) | (had less than 10 individuals) |
| Asian | 141 (20%) | 38 (18.7%) |
| White | 155 (22%) | 65 (32%) |
| Hispanic or Latino | 291 (42%) | 74 (36.5%) |
| Multi-ethnic | 65 (9%) | 26 (12.8%) |
| Prefer not to state | 28 (4%) | (had less than 10 individuals) |
| **Total** | 691 | 203 |
| | | |
| **Rising Grade Level** | **Number of Participants who attended EPIC (% of total)** | **Number of Participants in Research Question 1 (% of total)** |
| 7 | 26 (4%) | (had less than 10 individuals) |
| 8 | 69 (10%) | (had less than 10 individuals) |
| 9 | 76 (11%) | (had less than 10 individuals) |
| 10 | 73 (11%) | 22 (10.5%) |
| 11 | 153 (22%) | 60 (28.6%) |
| 12 | 294 (43%) | 128 (60.9%) |
| **Total** | 691 | 210 |

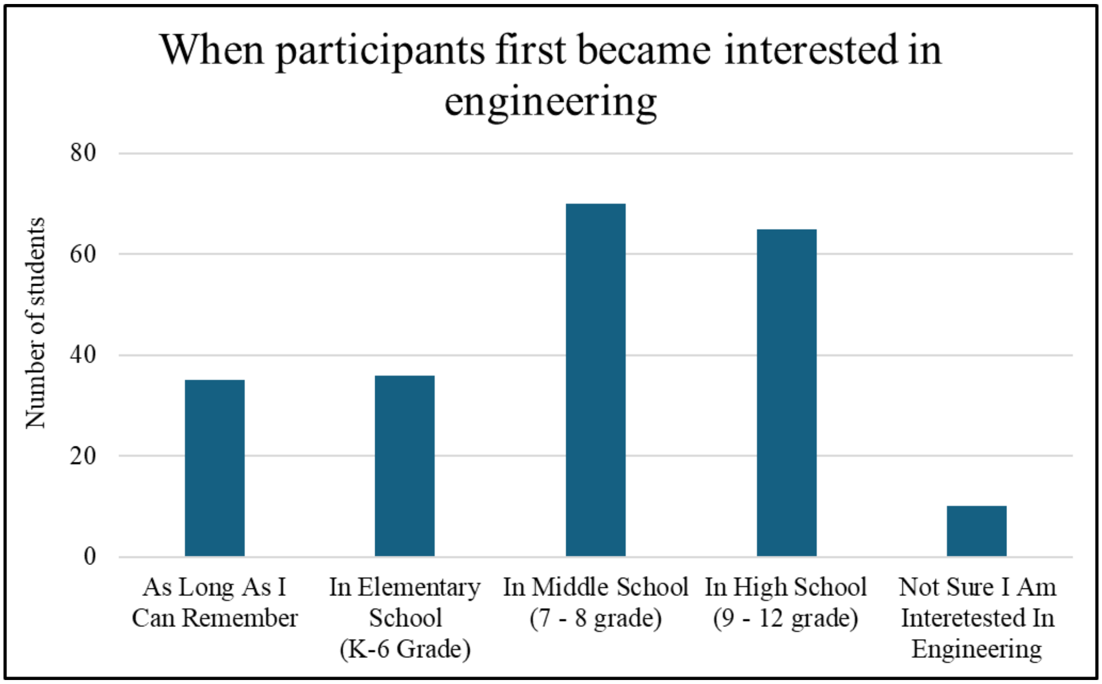


**Figure 2: Distribution of participants according to when they first became interested in engineering.**

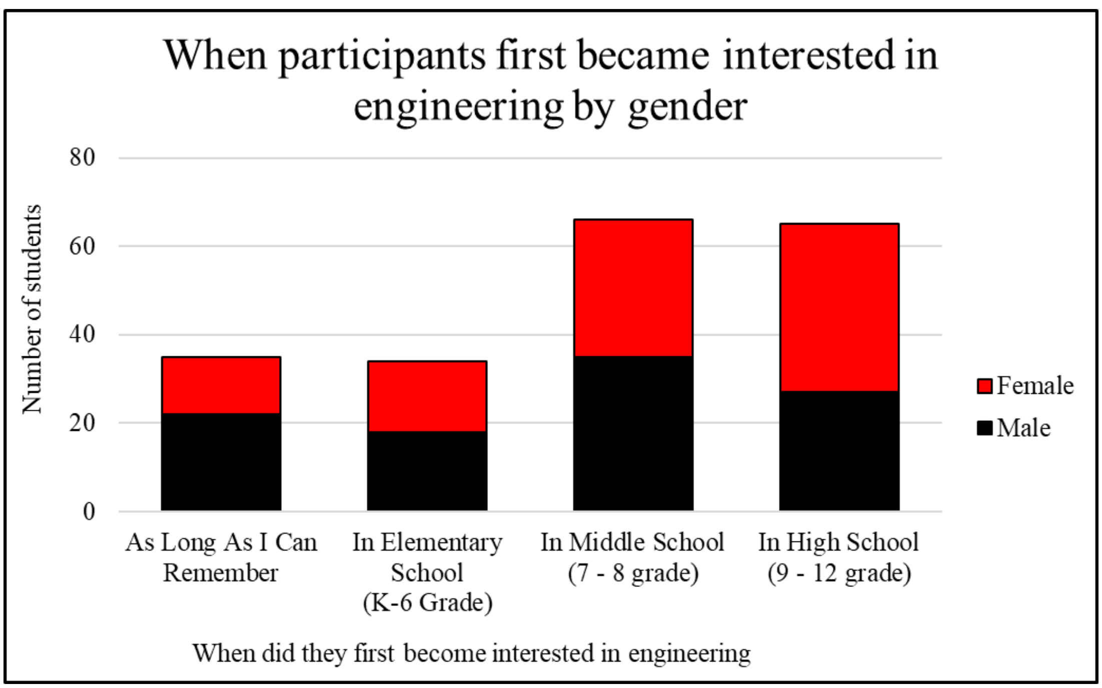


**Figure 3: Distribution of participants according to when they first became interested in engineering, broken down by gender.**

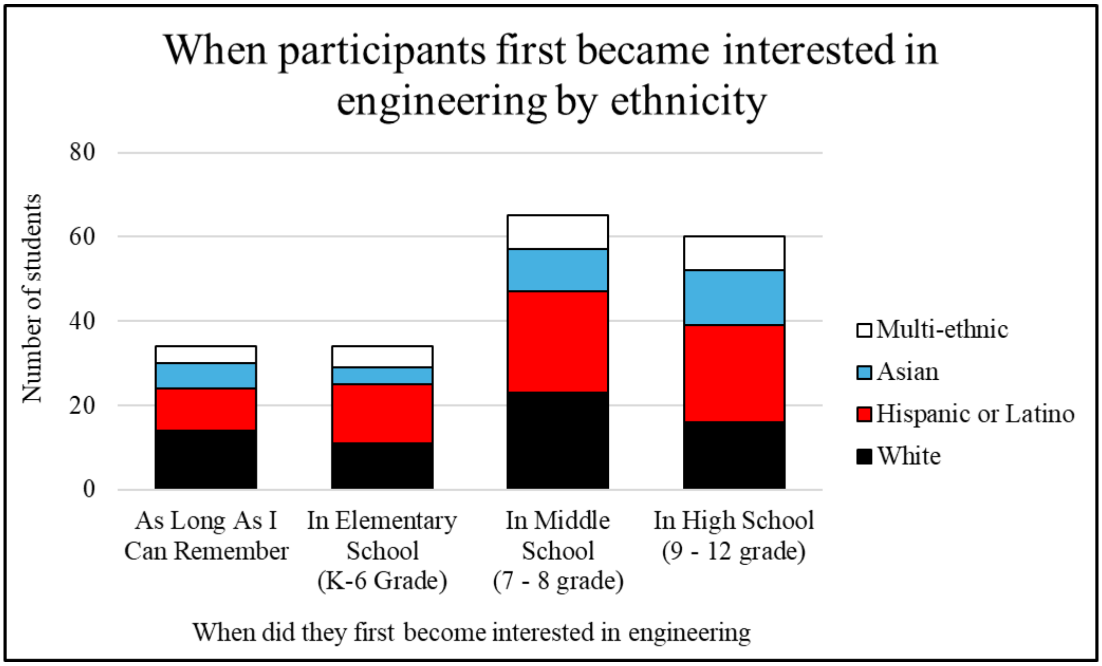


**Figure 4: Distribution of participants according to when they first became interested in engineering, broken down by ethnicity.**

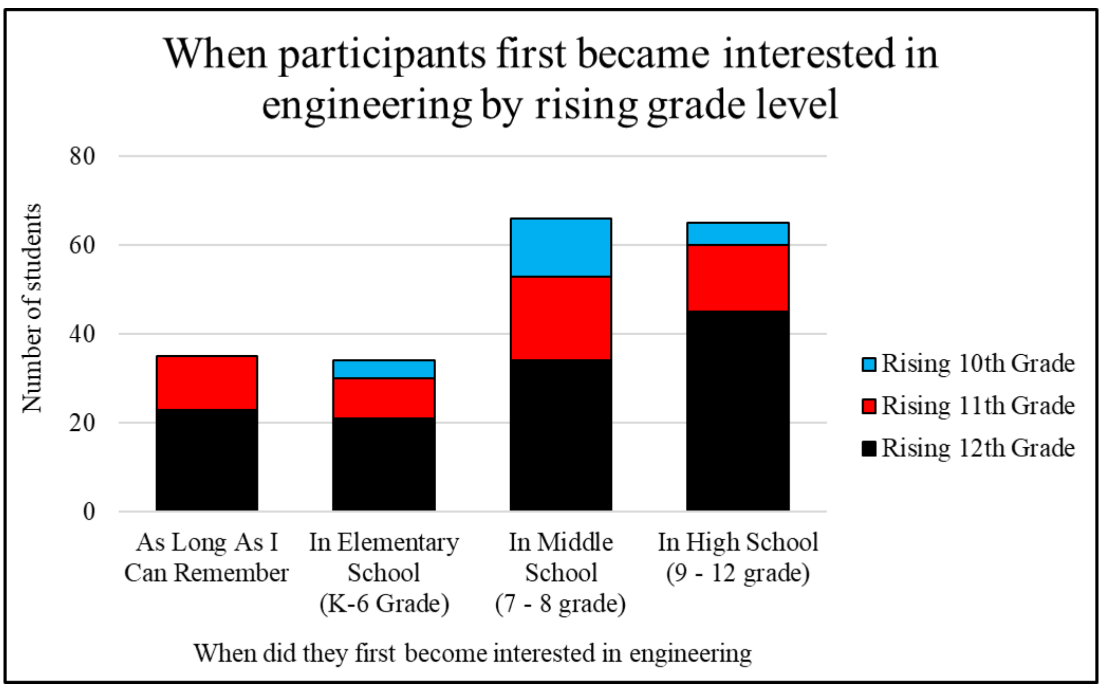


**Figure 5: Distribution of participants according to when they first became interested in engineering, broken down by rising grade level.**

## Data Collection

Two types of surveys were used to measure the impact of participating in EPIC. The first type of survey was a pre-EPIC and post-EPIC survey that measured a variety of program outcomes. The items analyzed by this evaluation paper include students' intent to apply for engineering programs, interest in engineering, confidence in their ability to be an engineer, and how well they feel like they fit in with others that like/do engineering. All questions analyzed in this study except the intent to apply for engineering programs were answered using a five-point Likert scale. The full pre- and post-program survey is provided in Appendix A.

The program survey was first administered when parents registered their child for EPIC and then again on the last day of EPIC. The survey was administered in English or Spanish depending on preference of the participant. Participant names were used to link pre-EPIC survey data to post-EPIC survey data.

The post-lab survey was given on the final day of each lab that students participated in. This survey included items on metrics such as engineering interest, learning, working in teams, and intent to apply to an engineering program either at Cal Poly or another university. There were also questions about whether students would apply to engineering, apply to engineering at Cal Poly, or apply to the major related to the lab. The post-lab survey is provided in Appendix B.

## Data Analysis

This study analyzed the two surveys using either Chi-Square Tests for Independence or Mixed Repeated Measures Analysis of Variable tests. In all analysis tests, we use a p-value of 0.05 to indicate statistical significance.

Items with categorical data such as the intent to apply to engineering questions were analyzed with Chi-Square Tests for Independence. If statistical significance was found, adjusted residuals and their associated p-values were calculated to determine which cells contributed the most to the observed statistically significant difference. While statistical significance is important, it does not give information about the size of the effect or its practical impact. Cramer's V measures how closely associated the two variables are with values between 0 and 1 with 0 being completely independent. The size of the effect depends on the degrees of freedom within the Chi-Square Test as shown in Cohen[34].

Some pre-post program survey items were answered using a Likert Scale that ranged from 1 meaning 1 "Highly Disagree" to 5 meaning "Highly Agree." These items were analyzed using a Mixed Repeated Measures Two Way Analysis of Variance (ANOVA). The within-subjects condition is attending EPIC, and the between-subjects condition is when participants first became interested in engineering. These tests produce three p-values. There is one for each within- and between-subjects variables, which are called the main effects. There is also one representing an interaction between the main effects. Interaction effects will help us determine whether EPIC is particularly beneficial to different groups of participants.

## Limitations

There are a few limitations to the current study. First, the authors could not link participants' pre-program and post-program survey responses to their post-lab survey responses. This limits our ability to analyze the impact of lab design on students with specific pre-program experiences that would have been captured on the pre-program survey. Additionally, this limits our ability to explore how the camp impacts those with multiple underrepresented identities.

Second, the study's participants are mostly rising high school students. Findings from this data used to make changes to EPIC will thus be based mostly on high school students' experiences. The program is meant to serve both middle and high school students, so missing the middle school student data may not serve all the goals of the program. The authors suspect that the middle school students are underrepresented due to hesitancy among parents to have data collected when their child is particularly young.

Third, there is potentially a ceiling effect present in our survey data (responses before the program are already above a 4.0 on a 5-point scale). This is likely because participants tend to self-select into programs such as outreach camps based on already being interested in engineering. Ceiling effects can make detecting differences in group means harder to detect.

Finally, responses for a couple survey items might be too similar. For example, the item "Did you think the lab activity was too long?" has responses "Yes," "Just Right," and "No." "Just Right" and "No" could be too similar to result in accurate understanding of students' perceptions.

## Results

### Outcomes on Pre-Post Program Surveys

#### Intent to apply to engineering

The goal of EPIC is to encourage students to apply to engineering, ideally at Cal Poly. The goal of this study is to understand who particularly benefits from attending this program. In particular, does the program benefit those who are first developing their engineering interest or those who have a more established interest in engineering? A Chi Square Test of Independence was performed to assess the relationship between when participants first became interested in engineering and whether the program increased their intent to apply to engineering. There was a significant relationship between these two variables, $\chi^2$ (3, 206) = 11.89, p = 0.008 with a Cramer's V of 0.24. This is a small-to-medium effect size based on the degrees of freedom.

Adjusted residuals and associated p-values were calculated to determine which cells contributed most to the observed difference between the groups (see Table 3). Participants who first became interested in High School show no statistically significant relationship to whether the camp increased their intent to apply to engineering. Participants who became interested in engineering in elementary school or earlier show a strong, statistically significant negative relationship with whether the camp increased their intent to apply to engineering. Participants who became interested in engineering in middle school show a strong, statistically significant positive relationship with whether the camp increased their intent to apply to engineering.

**Table 3: Adjusted residuals and associated p-values for participants' intent to apply to engineering as a result of attending EPIC based on when they first became interested in engineering.**

| | Adjusted residuals | | p values | |
|---|---|---|---|---|
| | Yes | No | Yes | No |
| As Long as I Can Remember | -2.07 | 2.07 | .038 | .038 |
| In Elementary School (K-6 Grade) | -2.13 | 2.13 | .033 | .033 |
| In Middle School (7-8 Grade) | 2.46 | -2.46 | .014 | .014 |
| In High School (9-12 Grade) | 0.91 | -0.91 | .364 | .364 |

**Interest in engineering**

The Social Cognitive Career Theory framework states that people are more likely to choose careers that they have high interests in. This study evaluated the impact of the program on increasing students' engineering interests using a Mixed Repeated Measures ANOVA. This test assesses the effect of when participants first became interested in engineering and attending EPIC on increasing participants' interest in engineering. There was not a significant interaction between when participants became interested in engineering and attending EPIC, $F(3,202) = 1.75$, $p = 0.16$, $\eta_p^2 = 0.03$. There was also no significant main effect between the pre- and post-program values across all groups $F(1,202) = 2.03$, $p = 0.16$, $\eta_p^2 = 0.01$. However, there was a significant main effect based on when participants first became interested in engineering $F(3,202) = 6.25$, $p < 0.001$, $\eta_p^2 = 0.08$. Figure 6 shows how the average score on the engineering interest survey item varied between groups before and after attending EPIC.

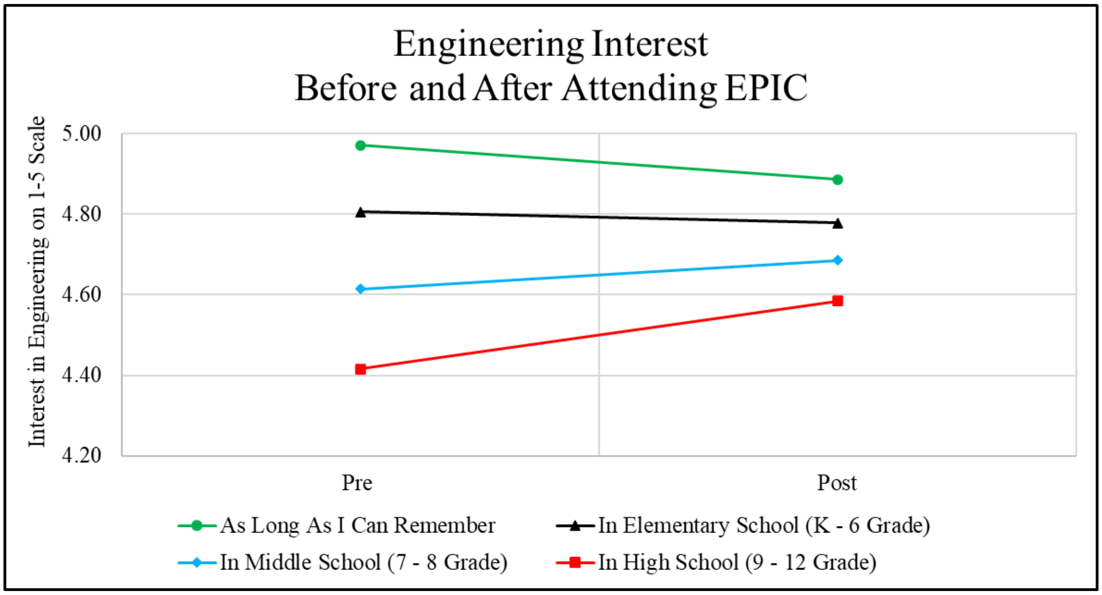


**Figure 6: Average score on participants' engineering interest pre- and post-program based on when they first became interested in engineering.**

**Self-efficacy**

In addition to interests, the Social Cognitive Career Theory framework states that people are more likely to choose careers in which they have high self-efficacy. Self-efficacy was probed on the surveys through two questions: 1) I am confident in my ability to be an engineer and 2) I fit in well with others who do/like engineering. The former probes for self-efficacy while the latter probes the social persuasion component of self-efficacy through sense of belonging. Mixed Repeated Measures ANOVA tests were used to assess the effect of when students first became interested in engineering on both outcomes.

Regarding the confidence item, there was not a significant interaction effect between when participants became interested in engineering and attending EPIC, F(3,202) =0.53, p =0.66, $\eta_p^2 = 0.01$. However, there was a significant main effect between the pre- and post-program values across all groups F(1,202) =9.81, p =0.002, $\eta_p^2 = 0.05$. There was also a significant main effect based on when participants first became interested in engineering F(3,202) =2.73, p = 0.04, $\eta_p^2 = 0.04$. Figure 7 shows how the average score on the confidence in being an engineer survey item varied between groups before and after attending EPIC.

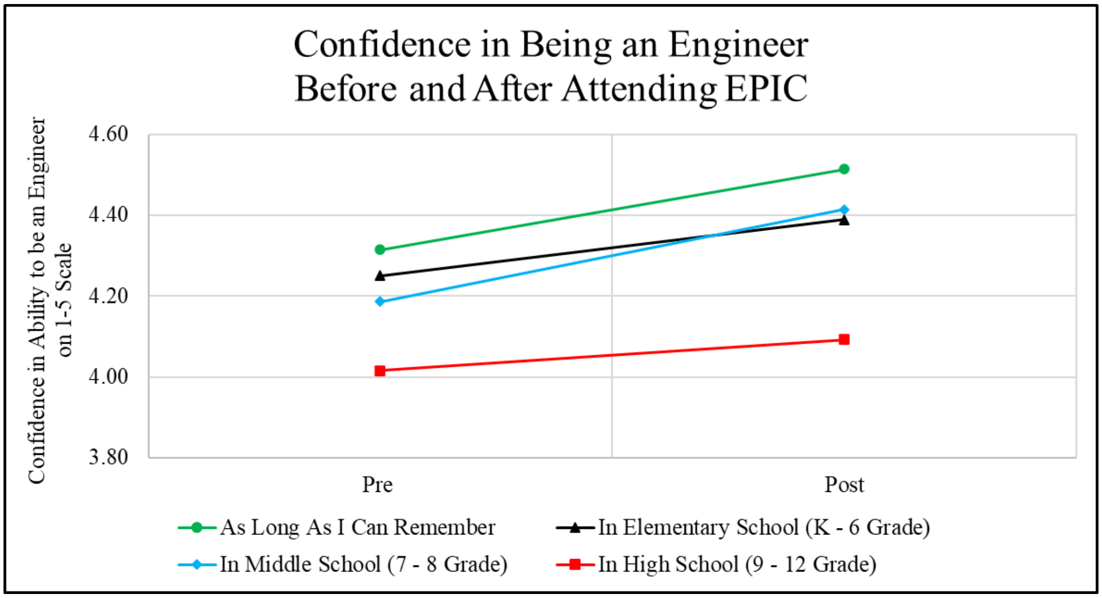


**Figure 7: Average score on participants' confidence in their ability to be an engineer pre- and post-program based on when they first became interested in engineering.**

Regarding the fitting in with others item, there was a significant interaction effect between when participants became interested in engineering and attending EPIC, F(3,202) =3.19, p =0.02, $\eta_p^2 = 0.04$. There was also a significant main effect between the pre- and post-program values across all groups F(1,202) =9.81, p < 0.001, $\eta_p^2 = 0.16$. However, there was not a significant main effect based on when participants first became interested in engineering F(3,202) =0.25, p = 0.86, $\eta_p^2 = 0.003$. Figure 8 shows how the average score on the fitting in with others survey item varied across groups before and after attending EPIC.

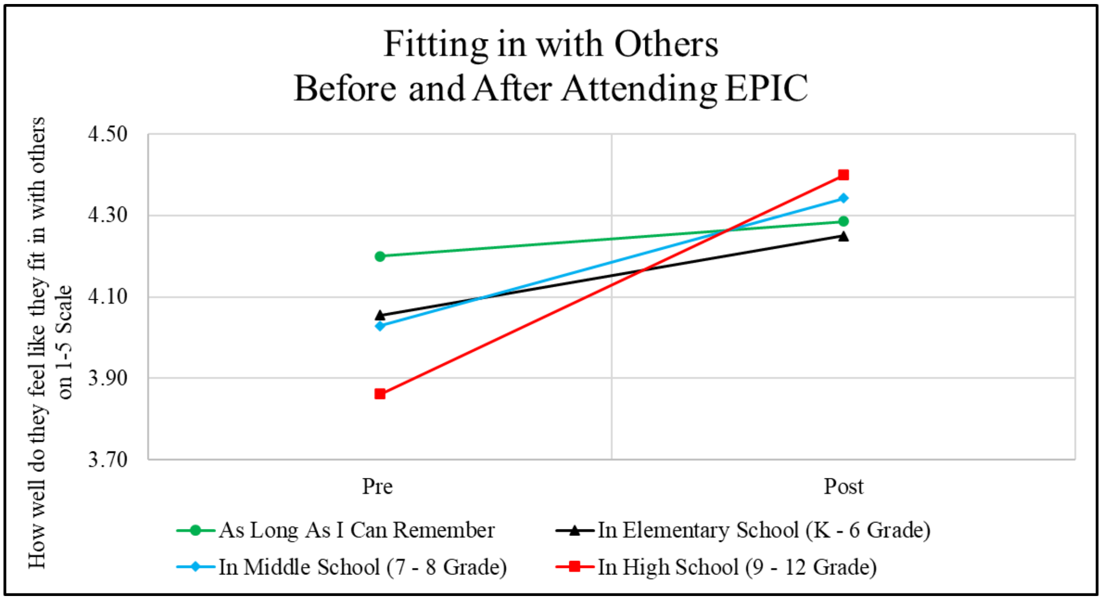


**Figure 8: Average score on how well participants feel like they fit in with others who like/do engineering based on when they first became interested in engineering before and after attending EPIC.**

## Outcomes on Post-Lab Surveys

### Length of time participants spend on a given lab

This study assesses the relationship between EPIC outcomes and two aspects of lab design. First, the number of days participants spent on a given lab. Labs were either characterized as short exposure (1 day), medium exposure (2 days), or long exposure (4 days). Chi-Square Tests of Independence were performed to assess the relationship between length of the lab and outcomes such as engineering interest, desire to become an engineer, intent to apply to engineering at Cal Poly, and intent to apply to the engineering major related to the lab whether at Cal Poly or another university.

Table 4 summarizes the results from the Chi-Square Tests of Independence. There was a significant relationship between the length of the lab and increase in engineering interest, desire to become an engineer, and intent to apply to the engineering major related to the lab whether at Cal Poly or another university. There was no significant relationship between the length of the lab and intent to apply to engineering at Cal Poly. Cramer’s V for all outcomes ranged between 0.09 and 0.12, which are small effect sizes for the given degrees of freedom.

**Table 4: Results from the Chi-Square Tests of Independence when assessing the relationship between the length of the lab and EPIC outcomes.**

| Outcome | Relationship to length of lab ($\chi^2$) | p value | Cramer's V |
|---|---|---|---|
| Increase in engineering interest | $\chi^2$ (4 , 917) = 17.06 | .001 | 0.10 |
| Desire to become an engineer | $\chi^2$ (8 , 917) = 25.81 | .001 | 0.12 |
| Intent to apply to engineering at Cal Poly | $\chi^2$ (8 , 917) = 15.16 | .056 | 0.09 |
| Intent to apply to the engineering major related to the lab whether at Cal Poly or another university | $\chi^2$ (8 , 917) = 17.03 | .029 | 0.10 |

**Increased engineering interest**

Table 5 shows the adjusted residuals and associated p-values for each cell. Short exposure showed a strong, statistically significant positive relationship to increased engineering interest while long exposure showed a strong, statistically significant negative relationship to increased engineering interest. Medium exposure resulted in no statistically significant relationship with engineering interest.

**Table 5: Adjusted residuals and associated p-values for whether participants' interest in engineering increased based on the number of days spent on a lab.**

| | Adjusted residuals | | | p values | | |
|---|---|---|---|---|---|---|
| | Yes | Maybe | No | Yes | Maybe | No |
| Short exposure (One-day lab) | 2.78 | -2.22 | -1.11 | .005 | .026 | .265 |
| Medium exposure (Two-day lab) | 1.90 | -1.57 | -0.69 | .057 | .116 | .490 |
| Long exposure (Four-day lab) | -4.04 | 3.28 | 1.56 | <.001 | .001 | .120 |

**Increased desire to become an engineer**

Table 6 shows the adjusted residuals and associated p-values for each cell. Short exposure showed a strong, statistically significant positive relationship to increased desire to become an engineer while long exposure showed a strong, statistically significant positive relationship to not being sure if the lab increased their desire to become an engineer.

**Intent to apply to engineering major associated with the lab**

Table 7 shows the adjusted residuals and associated p-values for each cell. Short exposure showed a strong, statistically significant positive relationship to wanting to do something else while medium exposure showed a strong, statistically significant positive relationship to intent to apply to the engineering major associated with the lab because that is why they came to EPIC.

**Table 6: Adjusted residuals and associated p-values for whether participants' desire to become an engineer increased based on the number of days spent on a lab.**

| | Adjusted Residuals | | | | | p values | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No, I want to do something else | No, this lab decreased my interest | Still not sure | Yes, especially after this lab | Yes, that is why I came to progra m name | No, I want to do something else | No, this lab decreased my interest | Still not sure | Yes, especially after this lab | Yes, that is why I came to program name |
| Short exposure (one-day lab) | -0.26 | -0.51 | -1.67 | 3.21 | -0.09 | .794 | .611 | .094 | .001 | .928 |
| Medium exposure (two-day lab) | -0.24 | -0.88 | -2.40 | -1.71 | 3.30 | .811 | .378 | .016 | .087 | .001 |
| Long exposure (four-day lab) | 0.43 | 1.22 | 3.56 | -1.16 | -2.89 | .664 | .223 | <.001 | .246 | .004 |

**Table 7: Adjusted residuals and associated p-values for whether participants' intent to apply to the engineering major associated with the lab changed based on the number of days spent on a lab.**

| | Adjusted Residuals | | | | | p values | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No, I want to do something else | No, this lab decreased my interest | Still not sure | Yes, especially after this lab | Yes, that is why I came to progra m name | No, I want to do something else | No, this lab decreased my interest | Still not sure | Yes, especially after this lab | Yes, that is why I came to program name |
| Short exposure (one-day lab) | 2.03 | -1.00 | -0.88 | 1.74 | -0.97 | .042 | .316 | .382 | .083 | .064 |
| Medium exposure (two-day lab) | -2.10 | -0.68 | -0.28 | -0.37 | 2.81 | .036 | .495 | .773 | .709 | .005 |
| Long exposure (four-day lab) | 0.18 | 1.45 | 0.99 | -1.12 | -0.97 | .857 | .146 | .321 | .263 | .330 |

**The balance of lecture vs activity in a given lab**

The second relationship assessed by this study is the balance of lecture vs activity in a given lab and EPIC outcomes. Chi-Square Tests of Independence were performed to assess the relationship between the balance of lecture and activity and outcomes such as engineering interest, desire to become an engineer, intent to apply to engineering at Cal Poly, and intent to apply to the engineering major related to the lab whether at Cal Poly or another university. Table 8 summarizes the results from the Chi-Square Tests of Independence. The only significant relationships were between the balance of lecture vs activity and participants' increase in engineering interest and desire to become an engineer. Cramer's V for all outcomes ranged between 0.07 and 0.11, which are small effect sizes based on the degrees of freedom.

**Table 8: Results from the Chi-Square Tests of Independence when assessing the relationship between the balance of lecture and activity and EPIC outcomes**

| Outcome | Relationship to balance of lecture and activity in lab ($\chi^2$) | p value | Cramer's V |
|---|---|---|---|
| Increase in engineering interest | $\chi^2 (4, 917) = 18.81$ | .001 | 0.10 |
| Desire to become an engineer | $\chi^2 (8, 917) = 22.91$ | .003 | 0.11 |
| Intent to apply to engineering at Cal Poly | $\chi^2 (8, 917) = 11.67$ | .167 | 0.08 |
| Intent to apply to the engineering major related to the lab whether at Cal Poly or another university | $\chi^2 (8, 917) = 8.73$ | .366 | 0.07 |

**Interest in Engineering**

Table 9 shows the adjusted residuals and associated p-values for each cell. Lecture focused labs show no statistically significant relationships with increased interest in engineering. Activity focused labs showed a strong, statistically significant positive relationship with increased engineering interest and a negative relationship with an uncertain increase in engineering interest. Conversely, labs with a mix of lecture and activity showed a strong, statistically significant negative relationship with increased engineering interest and positive relationship with an uncertain increase in engineering interest.

**Table 9: Adjusted residuals and associated p-values for whether participants interest in engineering increased based on the balance of lecture vs activity.**

| | Adjusted Residuals | | | p values | | |
|---|---|---|---|---|---|---|
| | Yes | Maybe | No | Yes | Maybe | No |
| Lecture Focused | 1.04 | -1.27 | 0.17 | .301 | .203 | .866 |
| Mixed | -3.87 | 3.39 | 1.16 | <.001 | .001 | .247 |
| Activity Focused | 3.82 | -2.99 | -1.61 | <.001 | .003 | .107 |

**Considering becoming an engineer**

Table 10 shows the adjusted residuals and associated p-values for each cell. Lecture focused and Activity focused labs showed a strong, statistically significant negative relationship with students being unsure about whether they are considering becoming an engineer. Labs with a mixture of lecture and activity showed a strong, statistically significant positive relationship with students being unsure about whether they are considering becoming an engineer and students indicating the lab decreased their interest in becoming an engineer.

## Discussion

### Research Question 1: What is the relationship between when participants became interested in engineering and how attending EPIC changes their interest in engineering, confidence in their ability to be an engineer, how well they think they fit in with others who do engineering, and their intent to apply to engineering?

One of EPIC's goals is to encourage students to apply to engineering programs, ideally at Cal Poly. Data from this study show that students who first became interested in engineering before middle school did not statistically significantly increase their intent to apply to an engineering program. Those who first became interested in engineering during middle school did show a statistically significant increase in intent to apply to engineering as a result of attending the camp. Students who became interested in engineering in high school did not show a statistically significant change.

Potential reasons for the relationship between when participants first became interested and intent to apply to engineering could be explained using the Social Cognitive Career Theory (SCCT) framework. In the first stage of SCCT, individuals begin their journey to choosing a career by first developing their interest in that career. Learning experiences such as outreach camps have been shown to increase participants' interest in engineering. However, this study's data did not show a statistically significant increase in engineering interest across all groups or for any particular group after attending EPIC. Before this study, the authors suspected that those who have been interested in engineering for longer have a more robust interest in engineering and wouldn't be influenced as much by attending learning experiences. This idea is not supported by the data. However, there is evidence that the longer someone has been interested in engineering, the higher their interest in engineering. This does support the idea that those interested in engineering for longer have a more well-developed engineering interest.

SCCT also proposes that choosing a career results from changes in self-efficacy. Participating in EPIC increased students' confidence in their ability to be an engineer regardless of when they first became interested in engineering. Additionally, participating in EPIC disproportionately benefited those who first became interested in engineering in high school through helping them feel like they fit in with others who do/like engineering. This survey item is based on the Social Persuasion sub-scale of self-efficacy. EPIC has a mixture of social and professional development activities in addition to engineering labs. These events create a variety of opportunities to interact with others who like/do engineering. It is possible that this combination of activities is what created the differential benefit in self-efficacy that could have led to the increased intent to apply to engineering.

**Table 10: Adjusted residuals and associated p-values for participants desire to become an engineer based on the balance of lecture versus activity.**

| | Adjusted residuals | | | | | p values | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No, I want to do something else | No, this lab decreased my interest | Still not sure | Yes, especially after this lab | Yes, that is why I came to program name | No, I want to do something else | No, this lab decreased my interest | Still not sure | Yes, especially after this lab | Yes, that is why I came to program name |
| Lecture Focused | -0.15 | -1.56 | -2.08 | 0.11 | 2.16 | .880 | .119 | .038 | .911 | .031 |
| Mixed | -0.01 | 2.51 | 3.86 | -0.59 | -3.58 | .992 | .012 | <.001 | .556 | <.001 |
| Activity Focused | 0.16 | -1.60 | -2.78 | 0.63 | 2.35 | .872 | .109 | .005 | .531 | .019 |

**Research Question 2: What is the relationship between the number of days participants spend on a specific lab and changes in their interest in engineering and intent to apply to engineering?**

Before the study, the authors suspected that EPIC would produce better outcomes if participants were able to spend more time exploring an engineering topic. This was not supported by the data. The one-day labs had more participants say the lab increased their interest compared to what was expected. Additionally, the one-day labs also had more participants show desire to become an engineer, although not necessarily the type of engineering associated with the lab they attended. This finding is consistent with SCCT, which predicts that individuals will choose a career that they have a high interest in.

Conversely, fewer participants in the four-day labs said the lab increased their interest and more participants in the four-day labs said the lab maybe increased their engineering interest. The two-day labs appeared to be a mix of benefits. There was no statistically significant difference in how the lab increased engineering interest, but there were more participants than expected who indicated they wanted to become an engineer and intended to apply to the engineering major associated with the lab that they attended.

One possible explanation for the better outcomes from the shorter labs is that participants are not feeling engaged when the labs get longer than one day. The post-lab survey also asked participants whether they felt the lab was too long. Seventeen percent of participants in the one-day labs indicated it was too long (37 out of 218) versus 27% of participants in the two- and four-day labs (43 out of 161 and 146 out of 538 respectively). A Chi-Square Test for Independence on this question did show a statistically significant relationship between the amount of time in lab and whether students felt the lab was too long, $\chi^2$ (4, 917) = 24.79, $p < .001$ with a Cramer's V of 0.11. This is a small effect size based on the degrees of freedom. Adjusted residuals indicate that there is a strong, statistically significant negative relationship between having one day of lab and feeling like the lab was too long. There is also a strong, statistically significant positive relationship between having lab for four days and feeling like it was too long. The two-day labs do not have a statistically significant relationship with participants feeling like the lab was too long. This sentiment was echoed in the open-ended question "please Comment on any areas you feel could improve this lab in terms of understanding the engineering field and the enjoyment of the activity." Example quotes include "The lab was very long, and I lost concentration" and "make it a little shorter."

Another possible explanation is that participants might benefit more from focusing on exploring a variety of fields, even if at a superficial level, rather than diving deeper into one field of study. This could mean having a track that is only one day labs versus the current structure where students participate in 2-4 labs of different lengths. Focusing on one day labs could allow exposure to lesser-known engineering disciplines or interdisciplinary fields. This sentiment was echoed in the open-ended comment section represented by the quote "It would be cool if the labs were distributed so everyone would be able to attend to (sic) for each major"

**Research Question 3: What is the relationship between the balance of lecture and hands-on activity and changes in their interest in engineering and intent to apply to engineering?**

Before the study, the authors thought that labs that were more focused on activities than lecture would create better outcomes. The data show mixed support for this idea. Activity-focused labs did have a stronger association with increased interest in engineering and whether participants were considering becoming an engineer. Lecture-focused labs did not have a strong association with increased engineering interest, but they did have an association with desire to become an engineer. Labs with a mix of lecture and activity showed a strong association with not considering becoming an engineer specifically due to participating in that lab or being unsure if they want to consider becoming an engineer. The balance of lecture and activity did not have a statistically significant association with participants' intent to apply to engineering at Cal Poly.

There could be a couple of potential explanations for these observations. First, activity-focused labs provide opportunities for students to master engineering content, which could help improve students' self-efficacy through the mastery experiences component. The SCCT framework proposes that an increased self-efficacy leads to developing interests and a higher likelihood of choosing that particular career. Activity-focused labs showed associations with both engineering interest and consideration in becoming an engineer. Conversely, lecture-focused labs do not have as many opportunities to engage self-efficacy through mastery experiences. These labs did not show an association with higher engineering interest, but they did show an association with considering becoming an engineer.

Second, the authors propose that the pedagogical techniques used in lab (i.e., lecture vs activity) could directly influence career choice by serving as external supports or barriers experienced during choice making rather than influencing career choice indirectly through engineering interest or self-efficacy.

Third, it is possible some labs were miscategorized. Whether a lab was designated as lecture focused, activity focused, or mixed was based on the lab description, conversations with counselors, and reading open-ended comments from the participants' post-lab surveys. Perhaps the data would paint a clearer picture if the labs were designated based on direct observations of student and instructor behavior. This will be incorporated as a source of data in future evaluation studies.

Finally, there were more labs and number of responses for labs that had a mix of lecture and activity (12 labs, n = 604) compared to labs that were activity-focused (4 labs, n = 160) or lecture-focused (2 labs, n = 153). The labs also covered a wide variety of topics. Thus, there is nuance that needs to be explored before solid claims can be made.

## Conclusions

This evaluation study applied the Social Cognitive Career Theory (SCCT) framework to analyze the impact that EPIC had on pre-college students in the state of California. EPIC positively impacted participants in some outcomes within the SCCT framework but not all. There is evidence that EPIC impacts students differently depending on when they first became interested in engineering. Participants who first became interested in engineering in or after middle school seem to be particularly impacted by attending EPIC. Participants who first became interested in middle school had a stronger association with intending to apply to engineering. While participants who became interested in high school did not have a stronger association with applying, attending EPIC did help these individuals feel like they fit in more than participants who became interested at different stages of childhood.

Outreach programs are an important tool for universities to recruit students and to help pre-college students see themselves as engineers. EPIC has grown over its nearly twenty year run and has continuously improved based on collecting and analyzing data from evaluation studies like this one. This study's main recommendation for EPIC is to have an option for participants to engage in more single-day labs rather than doing a deep dive into a couple engineering disciplines. The option to explore breadth over depth could keep the experience fun, help students discover what they can be good at (i.e., mastery experiences component of self-efficacy), or help students determine what they are interested in (engineering interest).

This study contributes to a growing body of work that shows context matters when designing effective pre-college learning experiences in engineering. For example, participants who have become interested in engineering more recently could particularly benefit from outreach camps that incorporate social and professional development activities alongside engineering labs. These activities potentially improve outcomes for these participants by helping them feel like they fit in with others (i.e., social persuasion component of self-efficacy). With that said, it is important to note that recommendations based on this study are not meant to apply to all outreach programs. Context matters. By evaluating how aspects of outreach camp structure and engineering lab design support or hinder program outcomes, outreach programs can make improvements that will better serve their local communities.

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**Appendix A: Pre- and Post-Program Survey Instrument**

Name

I first became interested in engineering

- o as long as I can remember
- o in elementary school (k-6 grade)
- o in middle school (7-8 grade)
- o in high school (9-12 grade)
- o not sure I am interested in engineering

[Multiple responses allowed – Check all that apply]
The following people have encouraged me to study engineering

- o my parents
- o a relative (e.g., sibling, cousin)
- o a school counselor
- o teacher(s)
- o other [fill in text box]
- o no one really

Please choose the statement that best fits you.

- o I plan to study engineering in college.
- o I'm considering engineering but am also considering other majors for college.
- o I'm not sure what I want to study.
- o I don't plan to major in engineering.
- o I don’t plan to go to college.

[**Likert scale for degree of agreement**: 1= Highly Disagree, 5= Highly Agree] (for each question)

1. __ I have a high interest in engineering.
2. __ I feel that engineering and the creative arts are exclusive of one another.
3. __ I fit in well with others that like/do engineering.
4. __ I like open-ended projects that don’t have any obvious set answers.
5. __ I like working in teams on projects.
6. __ I am confident in my ability to be an engineer.
7. __ I think engineers play a large role in the global societal and environmental challenges that we face today.

[rank – allow only one number to be used once]
Rank the following phrases that you think best describes what engineers do on a scale of 1-6: (1= best describes, 6= least describes)

1. __ analyzes data
2. __ applies math and science
3. __ comes up with creative solutions
4. __ designs, builds, and tests
5. __ gives presentations
6. __ helps society

[rank importance of]
Rank the following traits in the order of importance that you think are important to be a successful engineer: (1= most important, 10= least important)
__ good problem solver
__ creative
__ team player
__ works well with non-engineers
__ draws well
__ good in math and science
__ writes neatly
__ speaks well in public
__ builds stuff
__ good with computers

[Check box – multiple possible]
Check which engineering disciplines you are familiar enough with such that you could describe them to another person.

[list with check boxes: Aerospace Engineering , Architectural Engineering, Biomedical Engineering, Bioresource & Agricultural Engineering, Civil Engineering, Computer Engineering, Computer Science, Electrical Engineering, Environmental Engineering, Industrial Engineering, Manufacturing Engineering, Materials Engineering, Mechanical Engineering, Software Engineering]

**Appendix B: Post-Lab Survey Instrument**

**EPIC Lab Survey 2025**

| | |
|---|---|
| **Lab Attended:** ______________________ | **Circle One:** Morning / Afternoon |
| **Track Color:** ________________________ | **High School Graduation Year:** |
| | **Gender:** Female Male |
| | **Ethnicity:** Hispanic White Asian Black Other |

| **Please circle one** | | | |
|---|---|---|---|
| Did you have fun in this laboratory activity? | Yes | Sort of | No |
| Would you like to keep working on this lab activity? | Yes | Maybe | No |
| Did you learn about engineering in this lab activity? | Yes | I am not sure | No |
| Did this lab activity increase your interest in engineering? | Yes | Maybe | No |
| Do you think you got a feel for what engineers do? | Yes | No sure | No |
| Did you think the lab activity was too long? | Yes | Just right | No |
| Did you activity participate in the lab? | Yes | Sometimes | No |
| Did you enjoy working on teams? | Yes | Sort of | No |
| Do you have more questions about this activity? | Yes | Maybe | No |

| **Please mark the best response** | **Yes, that is why I came to EPIC** | **Yes, especially after this lab** | **Still not sure** | **No, this lab decreased my interest** | **No, I want to do something else** |
|---|---|---|---|---|---|
| Are you considering becoming an engineer? | | | | | |
| Do you think you might apply to Cal Poly, engineering? | | | | | |
| Do you think you might apply to this major (either at Cal Poly or another school)? | | | | | |

| COMMENTS |
|---|
| In the space below, please comment on any areas you feel could improve this lab in terms of understanding the engineering field and the enjoyment of the activity. |
| What part of the lab activity would you keep and which part should change for next time? |
| Which part of the lab helped you learn about engineering and which part didn't? |