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A Summer Bridge Program Tech Challenge for Improving Self-Efficacy of Diverse Incoming Engineering First-Year and Transfer Students

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Abstract

This Complete Evidence-Based Practice Paper evaluates a summer bridge program for academically talented, diverse, and low-income engineering first-year and transfer students entering the University of California, Irvine. Summer bridge programs can play an important role in a student's transition to a 4-year university. These programs may give students opportunities to build community, connect with institutional resources, practice their knowledge and skills in critical areas, and generally excite and engage them in the next step in their education. Students in the program worked in teams to complete a "Tech Challenge" consisting of an interdisciplinary team project to design and build a remotely-controlled robotic vehicle to complete a competition course. This tech challenge was meant to build team-working relationships and hands-on engineering skills to give these students confidence entering their engineering studies at the 4-year university. Students completed surveys at the beginning and the end of the program in which they evaluated the program, their own knowledge and skills, and psychological safety in their team project. We present implementation details of the tech challenge and results from analyzing these surveys, comparing responses from the pre- and post-surveys as well as differences between the first-year and transfer students. Students reported feeling more confident and prepared for engineering studies in general, and more proficient at teamwork and important hands-on engineering skills specifically, after participating in the program.

Introduction

Summer bridge programs can play an important role in a student's transition to a four-year university, either as a first-year student or a transfer student. Summer bridge programs are a common mechanism to help incoming students get acquainted with resources, peers, and faculty and staff before starting at a new institution. These programs often include opportunities for students to build community, explore institutional resources, become more proficient in certain skills or areas critical for their success, and generally prepare and welcome students at their new institution. Summer bridge programs are often in residence programs so that students get to know their living and learning environments before the academic year begins. The goals of these programs include promoting students' self-awareness, academic success and retention, motivation, and access for students who are academically talented but may face additional barriers related to accessing resources, materials, courses, and programs for preparing students for postsecondary education. In recognition of the need for, and effectiveness of, summer bridge programs, they are prevalent throughout postsecondary institutions, and their effectiveness and challenges have been studied [1].

Summer bridge programs can motivate students while preparing them for their future studies. Research has been done to study how a summer bridge program impacts students' motivation-related perceptions, and how those perceptions vary across different groups of students [2]. A two-week residential summer bridge program for Science, Technology, Engineering, and Mathematics (STEM) community college transfer students entering a 4-year university was effective at increasing students' confidence and motivation to pursue STEM undergraduate degrees [3]. Summer bridge programs have been shown to improve students' confidence and sense of belonging, particularly for first-generation and underrepresented students [4, 5]. They can also help close gaps in academic preparation and improve retention rates [6, 7]. For example, a two week summer program was designed to address mathematics deficiencies for pre-college students and positively impacted students' academic performance and persistence rates [8]. There are several examples of summer bridge programs for first-year students aimed to raise the initial math preparation and course placement of engineering students to improve their persistence in engineering (see, e.g., [9–11]). Other examples include a summer bridge program developed for first-year students that was effective for improving student retention at Historically Black Colleges and Universities (HBCUs) [12], a summer bridge program designed to increase students' retention, completion, and graduation at a two-year Hispanic serving community college [13], and a residential, six-week, summer program where students enrolled in coursework and improved their core competencies prior to beginning at the university that positively impacted retention and graduation rates of underrepresented engineering students [14].

In general, summer bridge programs can be one part of a variety of important and effective co-curricular supports for improving undergraduate STEM students' success [15–19]. An example that integrates multiple forms of co-curricular support is a STEM "Boot Camp" program that includes a two-week summer program that integrates peer and faculty mentoring, mock lectures, student projects, and faculty office hours. This Boot Camp showed improved course pass rates and retention rates for underrepresented students in the program as compared to those not in the program [20]. Another example integrates online and in-person aspects including self-paced online learning modules, synchronous online tutorials, and in-person workshops [21]. These different forms of support can help students succeed beyond just improving grades and retention. Providing authentic experiences in small group work in summer bridge programs allows students to build social networks with peers from different academic and cultural backgrounds and can give them confidence in their abilities to learn [3]. Moreover, integrating peer mentors who are further along at the university into the program provides role models and examples for incoming students to see themselves succeed. An in-depth look at the experience of six diverse participants in a five-week summer bridge program for first-year students found that the program helped students gain self-awareness and improve skills, confirm their decision to study engineering (or not), form relationships with peers and faculty, and empower them through helping them realize that their success is influenced by how hard they work [22]. In addition, summer bridge programs affect engineering students' expectations for their undergraduate experience and are an important opportunity to provide a supportive environment where students can learn from mistakes and failure and take those lessons into their future studies [23].

In this study, we present an in residence summer bridge program for both incoming engineering first-year and transfer students meant to build community, promote student academic and social support resources, and improve students' confidence before beginning their studies at a 4-year university. We especially focus on a team-based "tech challenge" and investigate its impact on students' self-efficacy, with the aim of answering the following research question:

> Does a "tech challenge" team project in a summer bridge program impact students' self-efficacy in their engineering abilities and hands-on skills?

Program Description

The summer bridge program we evaluate was a one week in residence program for academically talented low-income engineering first-year and transfer students at the University of California, Irvine. The program included campus tours, presentations about academic and social support and resources, presentations from student organizations, a faculty panel, and a small group "Tech Challenge" project. Ultimately, the summer bridge program aimed to foster student motivation, social and academic support, and self-efficacy that will help these students persist and excel in their engineering major. In this work we specifically focus on the Tech Challenge, which had the goals of enabling networking and community building among peers, introducing students to hands-on engineering resources available on campus, and giving students a jumpstart on knowledge and skills they will use in their courses.

In the Tech Challenge, students worked in 15 teams of 4 or 5 to complete an interdisciplinary project to design and build a remotely controlled robotic vehicle to complete a competition course. As much as possible, teams were formed to be diverse groups of half first-year and half transfer students. One engineering faculty and 7 current undergraduate engineering students advised and mentored the students on the project. The peer mentors were great resources and role models for students in the program, not only for how to succeed in the Tech Challenge, but also for learning more about life as a student at the university.

Each team was provided a small chassis kit with two metal plates, spacers, fasteners, 4-omnidirectional wheels, and 4 motors. Teams also received an Arduino Uno microcontroller, a motor driver, a rechargeable battery pack, a Bluetooth module, and a breadboard and jumper cables. Besides using these components, the teams were required to 3D print at least one component and laser cut at least one component. These requirements served to familiarize students with different manufacturing techniques and enabled their creativity to customize and personalize their designs. Teams could 3D print in different colors of plastic and could laser cut thin plywood sheets. Many teams 3D printed and laser cut the body for their vehicle. Additional supplies that were available included electrical tape, double-sided tape, wood glue, velcro straps, wire cutters, safety goggles, and paint markers.

In this interdisciplinary project, students needed to wire their circuits, including soldering electrical connections, assemble the chassis and wheels, program the microcontroller, and configure a smartphone application to communicate with their vehicle via Bluetooth. Additional optional challenges included adding sensors to enable autonomous operation with feedback control, such as adding an ultrasonic sensor and programming an algorithm to detect and avoid obstacles. This was an ambitious project for teams of 4 to complete in one week, given only about 12 hours of total time to work on the project, which was split into multiple sessions scheduled around the summer bridge program's other activities. Even so, more than 80% of the teams successfully completed the main challenge, and at least one team also accomplished the additional optional challenge. Those who did not complete the challenge ran into hardware problems on the final day before the competition, but they were still able to manufacture, assemble, wire, and code aspects of the project. This was a low stakes and supportive environment where students were encouraged to be ambitious and to not be afraid to fail. Awards were given to the top three teams who completed the competition course the fastest and the teams that demonstrated the most creativity, best algorithm, and best cable management for their circuits.

Data Collection and Research Methods

In this section, we describe the data collection and assessment methods. To evaluate the program, students completed a pre-survey on the first day of the program (Monday) and a post-survey on the final day of the program (Friday) that included quantitative and qualitative responses. The demographics of the 62 students who participated in the program in summer 2024 are given in Table 1. Of those 62 students, 60 students responded to the pre-survey, and 59 students responded to the post-survey.

Table 1: Demographics of the 62 students in the program

Demographic	**Percentage (%)**
First-generation college-going	90
First-year	60
Transfer	40
Gender	**Percentage (%)**
Female	42
Male	56
Non-binary	2
Race/ethnicity	**Percentage (%)**
Hispanic / Latino/a	55
Southeast Asian	16
White	13
East Asian	5
Black or African American	2
Middle Eastern/North African	2
South Asian	6

Survey Questions

Here we present a subset of the survey questions that students answered in pre- and post-surveys. These are the questions analyzed in this paper. The questions related to psychological safety were developed inspired by existing scales (see, e.g., [24] and [25]). Given the context of the tech challenge as a collaborative activity, we solely focus on whether the team members felt they had a voice. For the psychological safety scale, we calculated a Cronbach's α of 0.80, which shows internal consistency among this group of questions and gives confidence in the scale's reliability. The survey questions and Likert-scale responses are given in Table 2.

Table 2: Survey Questions

	Time of assessment	Likert response scale
Attitudes towards engineering		
How confident are you that you will do well in your engineering studies at the university?	Pre + Post	*1=Not confident at all* to *5=Very confident*
How confident are you that you will enjoy your engineering studies at the university?	Pre + Post	*1=Not confident at all* to *5=Very confident*
How confident are you that you will be able to make friends once you start your engineering studies at the university?	Pre + Post	*1=Not confident at all* to *5=Very confident*
How well prepared do you feel for your engineering studies at the university?	Pre + Post	*1=Not prepared at all* to *5=Very prepared*
Technical proficiency		
How proficient do you feel in the following skills?		
Circuits & Wiring Electronic Components	Pre + Post	*1=Beginner* to *5=Expert*
Working with Motors	Pre + Post	*1=Beginner* to *5=Expert*
Arduino	Pre + Post	*1=Beginner* to *5=Expert*
Laser Cutting	Pre + Post	*1=Beginner* to *5=Expert*
3D Printing	Pre + Post	*1=Beginner* to *5=Expert*
3D Modeling programs	Pre + Post	*1=Beginner* to *5=Expert*
Working in teams on a technical design challenge	Pre + Post	*1=Beginner* to *5=Expert*
Coding and Programming	Pre + Post	*1=Beginner* to *5=Expert*
Attitude towards tech challenge		
How much did you enjoy the tech challenge project you worked on all week?	Post	*1=Did not enjoy at all* to *5=Enjoyed it a lot*
How well did you work with your team?	Post	*1=Did not work well together at all* to *5=Worked together very well*
Psychological safety (Cronbach's $\alpha = .80$)		
I felt comfortable talking to the project advisor(s) about my questions or issues.	Post	*1=Not true at all* to *5=Very true*
I felt comfortable talking about my work and asking questions during our time working on the project.	Post	*1=Not valued at all* to *5=Very valued*
My unique skills and ideas were valued and utilized by my team members.	Post	*1=Not comfortable at all* to *5=Very comfortable*
I feel that everyone's opinion and suggestions were considered on my team.	Post	*1=Not comfortable at all* to *5=Very comfortable*

Analysis

We computed descriptive statistics of the responses to all of these questions and performed pairwise comparisons using t-tests to evaluate the differences between pre- and post-survey responses and between responses from first-year and transfer students. The mean (M), standard deviation (SD), t-value, and p-value for significant results are given.

Results and Discussion

In this section, we present results from analysis of the survey responses to answer our research question:

> Does a "tech challenge" team project in a summer bridge program impact students' self-efficacy in their engineering abilities and hands-on skills?

Attitudes towards engineering

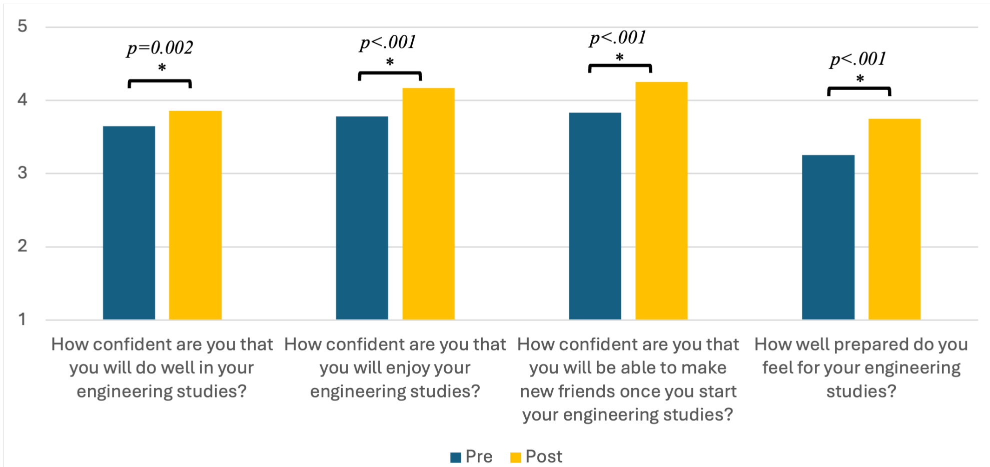
Comparing the data from the pre- and post-surveys, students reported statistically significant improvement in their attitudes towards their engineering studies. This is shown in Figure 1. At the beginning of the program, students' attitudes towards engineering studies on average were at moderate levels, but their attitudes towards engineering statistically significantly improved by the end of the program. Students reported that they felt more confident that they will do well in their studies, will enjoy their studies, will be able to make new friends and felt more prepared for their studies by the end of the program.

The results are broken down by responses from first-year students and transfer students in Figures 1b and 1c, respectively. Both groups reported statistically significantly more positive attitudes at the end of the summer transition program compared to the beginning (just like the total sample). At the beginning of the summer transition program, transfer students compared to first-year students were statistically significantly more confident that they would do well in their studies (Item: How confident are you that you will do well in your engineering studies at the university?; First-Year: M = 3.51, SD = 0.70; Transfer: M = 3.84, SD = 0.69; $t(58) = -1.787$, $p = .04$) and felt better prepared (Item: How well prepared do you feel for your engineering studies at the university?; First-Year: M = 3.06, SD = 0.94; Transfer: M = 3.52, SD =0.92; $t(58) = -1.901$, $p = .03$). At the end of the summer transition program, only one statistically significant difference remained: Transfer students compared to first-year students were still statistically significantly more confident that they would do well in their studies (Item: How confident are you that you will do well in your engineering studies at the university?; First-Year: M = 3.7, SD = 0.73; Transfer: M = 4.08, SD = 0.74; $t(57) = -1.971$, $p = .03$)

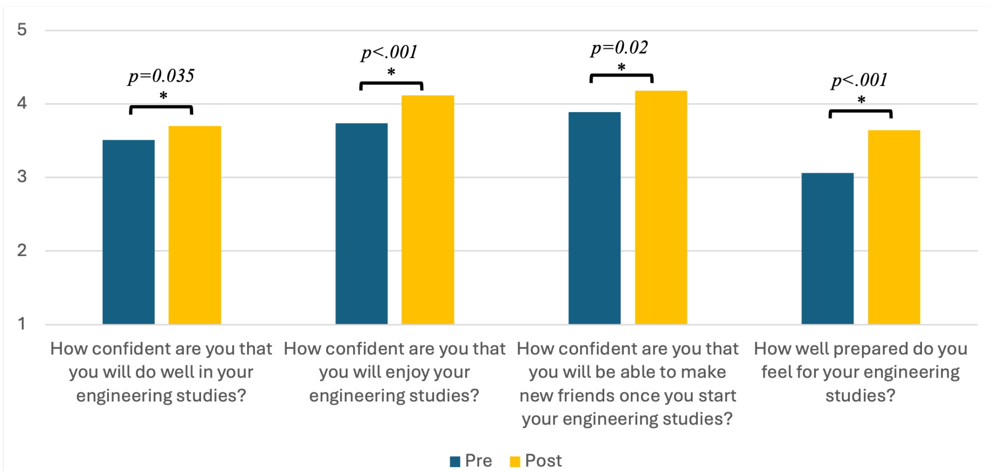
Technical proficiency

The tech challenge project was the most extensive group activity that took place across the whole week of the summer bridge program and involved hands-on experience related to multiple engineering disciplines. At the beginning of the week, students' rated their own proficiency in teamwork and hands-on skills as fairly low, close to "beginner". Students felt least proficient in their Arduino and laser cutting skills and most confident in their ability to work in teams on a technical design challenge. At the end of the week, students' responses indicated that they felt statistically significantly more proficient in all technical skills with the exception of their coding and programming skills. This is shown in Figure 2. Students' self-efficacy was higher at the end of the program in all areas, including working on teams on a technical challenge, 3D modeling, manufacturing, and working with electronics and microcontrollers.

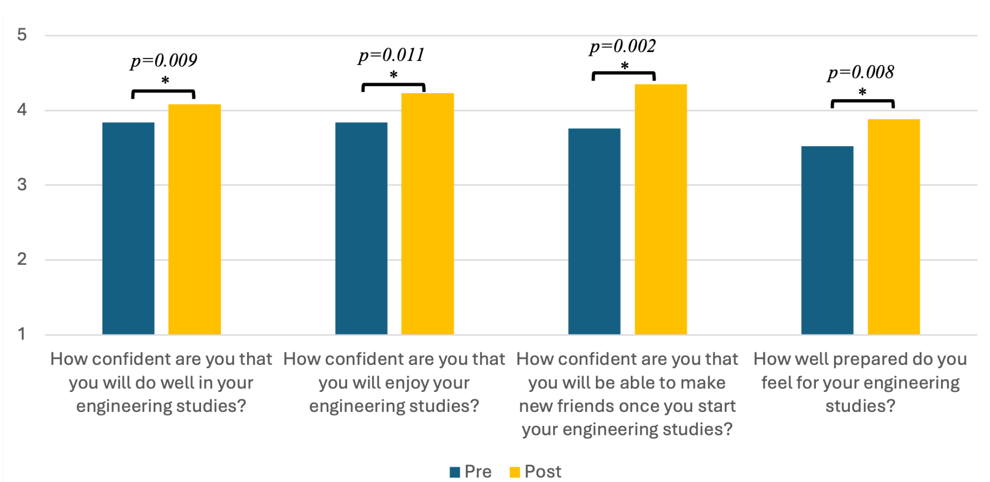
The results are broken down by responses from first-year students and transfer students in Figures 2b and 2c, respectively. Both groups reported statistically significantly higher levels of



(a) Total sample

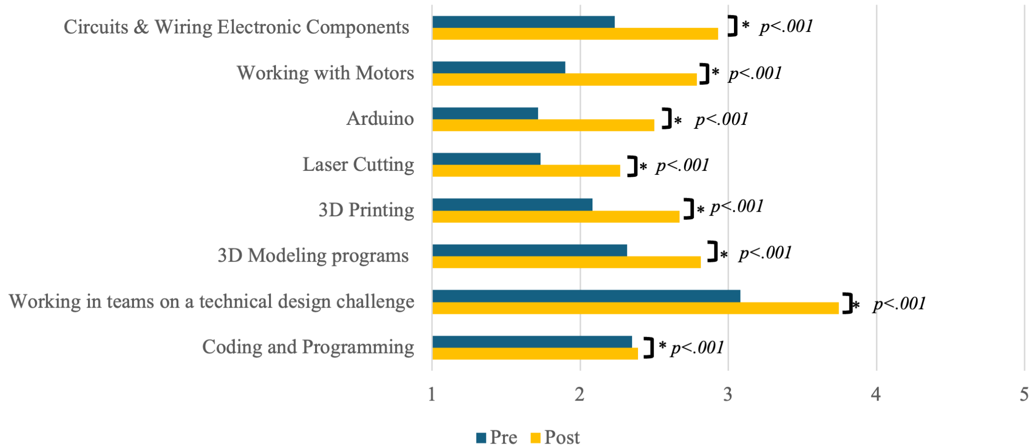


(b) First-year students

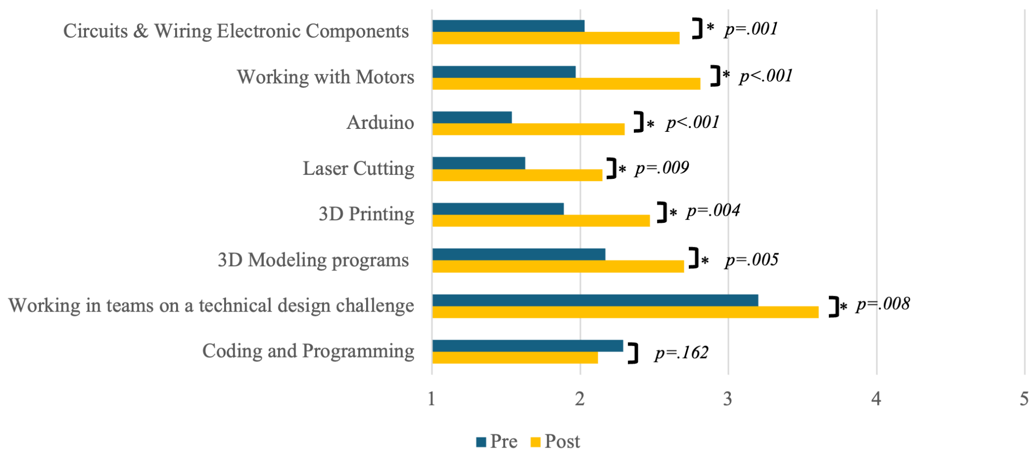


(c) Transfer students

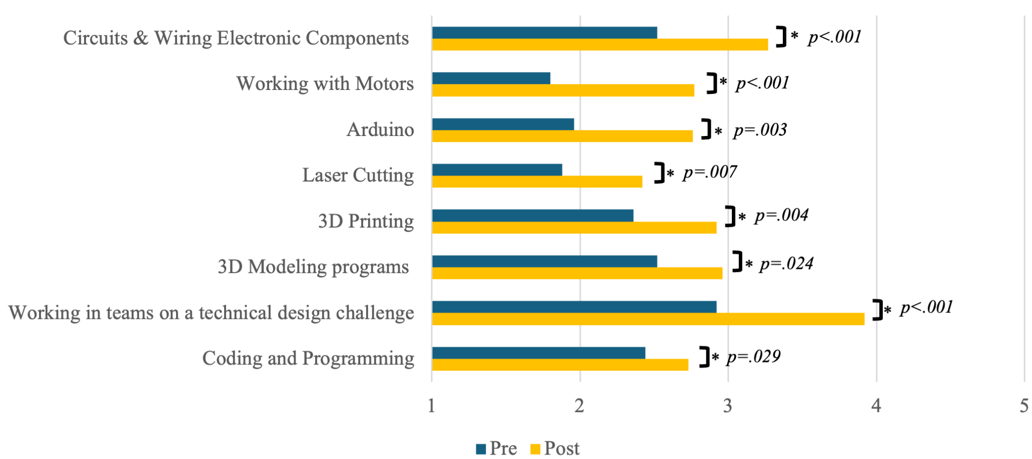
Figure 1: Mean responses for questions related to attitudes towards engineering studies and p-values from t-tests comparing responses from pre- and post-surveys. $*$ denotes statistical significance.



(a) Total sample



(b) First-year students



(c) Transfer students

Figure 2: Mean responses for questions related to technical proficiency and p-values from t-tests comparing responses from pre- and post-surveys. $*$ denotes statistical significance.

proficiency in skills at the end of the summer transition program compared to the beginning (just like the total sample) with one exception: First-year students reported descriptively lower, but not statistically significant lower levels of proficiency in coding and programming at the end of the summer transition program. At the beginning of the summer transition program, there were no statistically significantly different levels of technical proficiencies reported by transfer students compared to first-year students. At the end of the summer transition program, statistically significant differences emerged: Transfer students compared to first-year students reported statistically significantly higher mean levels of proficiency in coding and programming (First-Year: M = 2.12, SD = 1.11; Transfer: M = 2.73, SD = 0.96; $t(57) = -2.218$, $p = .015$) and in Circuits & Wiring Electronic Components (First-Year: M = 2.67, SD = 1.34; Transfer: M = 3.27, SD = 1.34; $t(57) = -1.714$, $p = .046$). These differences may be related to the differences in prior experience that transfer students have as compared to first-year students, and they may also be related to how the teams chose to distribute the technical work among their members.

Overall assessment and psychological safety

In their overall assessment at the end of the week, students reported a high level of enjoyment of the Tech Challenge and that they worked well with their team on average, as shown in Figure 3. No statistically significant differences between transfer and first-year students were found.

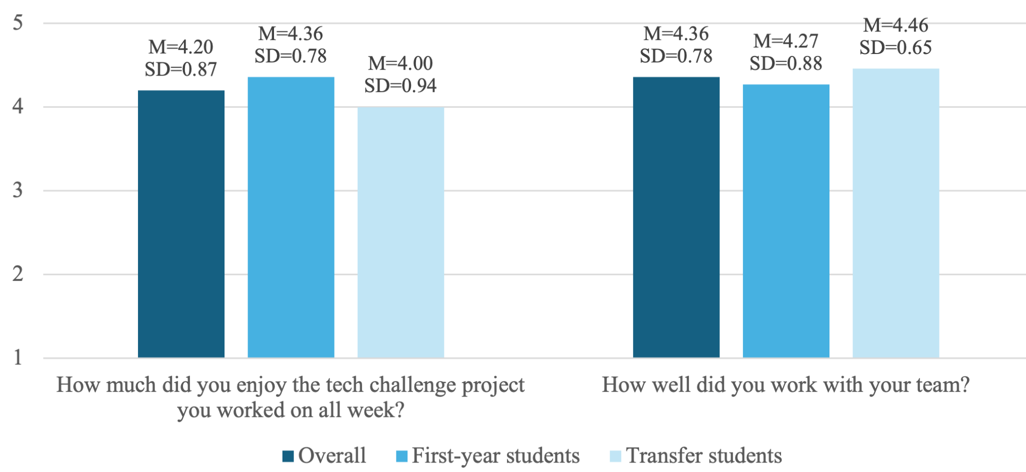


Figure 3: Mean (M) responses to questions evaluating attitude towards tech challenge for the total sample and for first-year and transfer students. Standard deviation (SD) is also reported.

Importantly, students also reported high levels of psychological safety during the Tech Challenge project. They reported that they felt comfortable talking to the engineering faculty advisor, the peer mentors, and their teammates. They also felt their skills and opinions were valued by their team. These are shown as a single scale in Figure 4. Psychological safety is important for students to feel more comfortable being ambitious, seeking help, learning, and failing. These are critical for engineering students in their studies and their future careers. Again, no statistically significant differences between transfer and first-year students were found.

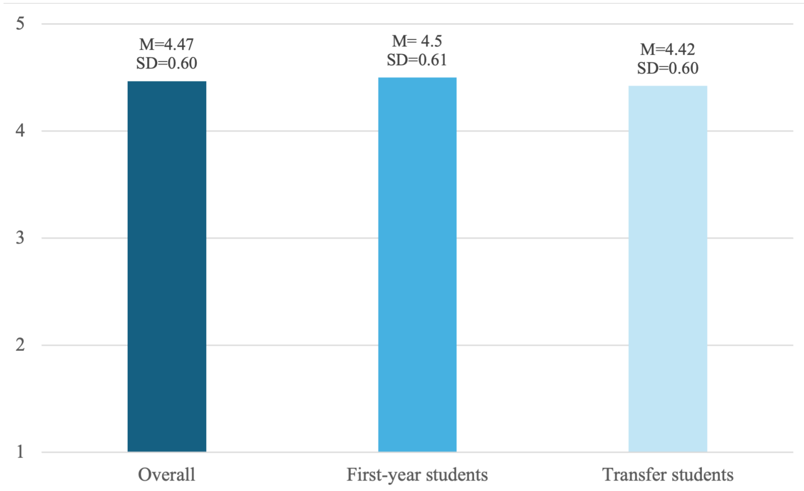


Figure 4: Mean (M) responses to psychological safety scale for the total sample and for first-year and transfer students. Standard deviation (SD) is also reported.

Conclusion

We presented an engineering summer bridge program for diverse incoming engineering first-year and transfer students meant to foster students' success at the beginning of their studies at a 4-year university through building community, promoting academic and social support resources, and motivating students with hands-on experiences. Within this program, students worked on an interdisciplinary "Tech Challenge" team project, and we evaluated this project's impact on students' confidence in engineering abilities and hands-on skills through analysis of pre- and post-surveys. The results show that the summer bridge program and Tech Challenge improved students' self-efficacy in their engineering abilities and hands-on skills. Moreover, students enjoyed the Tech Challenge and felt psychologically safe working with their teams and mentors. As future work, we plan to gather additional data from students who did not participate in the bridge program and data later in their engineering studies to further understand the bridge program's impact. We plan to continue offering similar summer bridge programs in the future to support students' success in transitioning into an engineering program at a 4-year university and hope that this example can be adapted for other institutions looking to offer similar opportunities.

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