Evaluation of Summer Camp Recruitment Methods and Campers' Perceptions of Engineering (Evaluation, Diversity)

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Program leaders put a tremendous amount of thought into how they recruit students for engineering summer camps. Recruitment methods can include information sessions, established partnerships with school districts, and teacher or school counselor nominations of students. This study seeks to assess if the methods used to recruit students broaden participation or have any impact on students' perceptions of engineering. Two identical week-long summer camps were hosted by the University of Texas at Austin (UT Austin) in the summer of 2022. Camps were entirely free for all campers. A specific goal of the camp was to promote engineering as a career pathway for students from groups that have been historically excluded from STEM majors. Campers were rising 8th and 9th grade students in two cities near UT Austin; this age was intentionally identified as students who have sufficient STEM backgrounds to engage in meaningful engineering design challenges, and who are also at a critical inflection point with respect to decisions that put them on a trajectory to study engineering in college. Summer camp topics ranged from additive manufacturing to the chemical properties of water proofing, and students did activities such as constructing a prosthetic limb from recovered materials or designing an electronic dance game pad.

In one camp session, students primarily found out about the camp by being nominated by counselors at their schools, with an intentional focus on recruiting students who might not otherwise be exposed to engineering. In the other camp session, parents signed up campers after hearing about the camp via information sent through the schools. All students who applied were accepted to the camps. Identical pre- and post-camp surveys asked campers questions about their knowledge of what engineers do, their interest in math and science, and what factors are important to them when choosing a career. Survey analysis showed that there were statistically significant differences in answers to questions between the groups in the pre-camp surveys, but post-camp surveys show that these differences disappeared after participating in the summer camp. Students whose parents directly enrolled them in the camp had higher pre-camp interest in science and technology; thus, counselor nominations may be a method to recruit students who might not have been interested in engineering had they not attended the camp. Additionally, prior to participating, campers recruited via counselor nominations had a narrower view of what engineers do than the parent-enrolled campers, but after camp the two groups had similar perceptions of what engineers do. The results of this study confirm literature findings regarding the importance of exposing young learners to engineering as a profession and broaden their views of opportunities in this field. The recruitment methods used for these camps show that nomination-based recruitment methods have the potential for greater impact on changing students' engineering trajectories.

Introduction

Many universities offer K-12 engineering outreach programs such as summer camps [1], afterschool clubs [2], in-class activities [3], printed brochures [4], and single-day on-campus visits [5] as ways to increase students' awareness of and interest in engineering. While many of

these are short-term programs, longer-term outreach programs have been recommended, as students with sustained engineering exposure report greater long-term interest in engineering than students who participated in a week-long outreach program without additional engineering exposure [6]. Participating in outreach programs widens students' perceptions of what engineers do and increase students' perceptions that engineers work on things relevant to them [7-9]. Many students have narrow perceptions of what engineers do. For example, when asked to draw an engineer, middle school students most commonly depict people making or fixing things, working with their hands, operating machines or vehicles, designing or inventing products, or experimenting [10]. However, engineering encompasses much more than these activities. Students with narrow views of engineering who are not interested in those activities, or those who think engineers work on things not relevant to them, may be less likely to be interested in engineering. By extension, students may also be less likely to sign up on their own for extracurricular engineering activities such as clubs or summer camps. Early exposure to science and math is linked with students' interest in engineering careers [11]. Though the survey used in this evaluation has been used in research studies and evaluations of other K-12 outreach projects [12], those researchers have not focused on the survey's questions about the personal factors students consider when choosing a career field. In addition to early exposure, other studies have found that students' STEM career interests are influenced by their parents, teachers, classes, and STEM identities [11, 13]. Additionally, stereotypes of computer scientists have been found to play a role in students' career interests in that field [14].

While engineering outreach programs are often offered widely to students, many programs in the United States exist to increase diversity in students from historically excluded groups such as gender and racial/ethnic minorities. Women engineers with a bachelor's degree or higher represent only 19% of the total engineering workforce, and Hispanic/Latino and Black/African American engineers represent only 10% and 5%, respectively [15]. Centers funded by the National Science Foundation (e.g., Materials Research Science and Engineering Centers [MRSECs] and Engineering Research Centers [ERCs]) are required to do outreach focused on broadening participation. As such, they have many outreach efforts for K-12 students from historically excluded groups [16, 17]. There is growing evidence that these diversity-specific outreach events have increased the number of students from historically excluded backgrounds seeking bachelor's degrees in engineering. One summer-long research program for high school students that was 56% women and 60% underrepresented minority students had a high rate of participants studying engineering (62%) or non-engineering STEM disciplines (36%) in college after graduation [17]. Another outreach program has been credited with increasing the number of women engineering students [18].

Engineering outreach summer camps employ a variety of recruitment methods to reach students, including presentations in selected K-12 schools, distributing flyers to school counselors and teachers to give directly to students, websites, e-mail distribution lists, and establishing partnerships with specific schools or school districts [1, 19]. While there has been significant work done to evaluate the impact of outreach programs on students' interest in engineering [6]; engineering knowledge, skills, and abilities [20], and eventual enrollment in engineering degree programs [17, 18], it is more difficult to find studies of how recruitment methods impact student outcomes and the types of students who these programs reach. In this

paper, we look at the effects of recruiting methods on the ability to reach out to more students with little or no engineering exposure. We seek to answer the following evaluation questions:

1. What could the impact be of two different summer camp recruitment methods on broadening participation and reaching campers from historically excluded backgrounds in engineering?
2. What is the role, if any, of the summer camp in changing campers' perception of engineering as a profession?

Lastly, since our data analysis showed interesting statistically significant changes regarding important factors influencing campers' consideration related to career choices, we added a short section presenting our findings.

Longhorn Engineering Summer Camp

The Longhorn Engineering Summer Camp (LESC) is a free, five-day day camp that engages rising 8th and 9th graders in interactive learning experiences that promote the wide impact of engineering. 8th and 9th graders were chosen because students these ages have sufficient STEM background to engage in meaningful engineering design challenges. Additionally, these students are reaching a critical point in their education where they need to choose math and science classes that will make them eligible to apply for undergraduate engineering programs. As such, parents were provided with information about math classes needed prior to entering an engineering program for college: Algebra 1 by 8th grade and Calculus during 12th grade. In the future, we are adding a short information session to the camp's agenda to give students the information directly so that they feel empowered to speak with their teachers and guidance counselors themselves about course choices.

Each day, camp attendees learned a few engineering fundamentals through an engaging presentation by the University of Texas at Austin (UT Austin) faculty and students, then saw these concepts come to life through guided hands-on activities. In collaboration with the UT Austin Youth Engagement Center, we were able to increase the participation of students who identify with groups that have been historically excluded from engineering. Two camps were run (one in Houston and one in Austin) in collaboration with Project Explore in Houston independent school district (ISD), and Advancement via Individual Determination (AVID) in Austin ISD and Pflugerville ISD.

Campers in the Houston and Austin camps applied and were admitted to the summer camp in very different ways. In Houston, we worked closely with Project Explore, which provides college and career readiness programs at selected middle schools. Counselors from Project Explore were encouraged to nominate students they identified as those who may benefit the most from added exposure to engineering (e.g., students from groups historically excluded from engineering, those who will be first generation college students, or those who do not have access to robust engineering courses in their schools). Nominated students should also be on a trajectory towards Algebra in the 8th grade. Additionally, six students who found the camp through a website called STEMSTARTS and applied on their own. Through connections the program coordinator has with schools, information was sent out to schools, and teachers sent the

information home. From there, parents chose to apply. For both camps, we did not turn away anyone who applied. Of those who applied, not all showed up for actual camp. In contrast, Austin campers strictly applied on their own. So that readers can easily distinguish between these camps, we will call Houston the Nomination Camp and Austin the Self-Selection Camp.

Over the five-day camp, campers were introduced to a new type of engineering daily, although the structure of each day stayed the same. Each day, campers had a one-hour lecture from a faculty member or alum from UT Austin's Cockrell School of Engineering. Our fifteen counselors had smaller breakout groups to teach campers more about the topic of the day. Campers did one activity in the morning and then a second, competition-based activity in the afternoon. Campers were introduced to a wide range of engineering topics, as middle-school students often do not exactly know what engineers do. Providing variety helped introduce them to different types of engineering to explore and consider, and each day highlighted a different discipline of engineering by introducing the topic via a lecture and following it up with a hands-on activity. The types of engineering and activities highlighted were aerospace, biomedical, civil, electrical, and mechanical engineering. In many activities, we used every day household items. For aerospace engineering, campers created bottle rockets and tested what ratios of vinegar to baking soda resulted in flight. For biomedical engineering, campers created prosthetic legs using a plunger, sponges, and tape. After building them, campers presented their prostheses and voted on whose were most functional and best-looking. For civil engineering, students created roofs out of tape, cardboard, aluminum foil, straws, foam, and waterproof fabric and tested them to ensure that they did not leak when water was poured on them. For electrical engineering, campers created circuits using LED lights, copper tape, and masking tape and created circuit art and a Dance Dance Revolution pad. Finally, for mechanical engineering, students designed boats and used 3D printers to create them. Boats were tested using pennies as weights, and the winner of the activity was the camper whose boat held the most pennies. Although parents did not attend the camp, they were kept well-informed of all that we did through the Remind app with regular messages through the day. In the evening, they received a daily report of all the activities and objectives. Finally, at the end of camp, parents received a link to download any pictures of their campers.

Methods

Participants

The Nomination Camp had a total of 31 participants and the Self-Selection Camp had a total of 34 participants. The number and percentages of campers by gender and racial/ ethnic identities for each camp are shown in Tables 1 and 2, and highest parent education levels are shown in Table 3. The survey response rates are shown in Table 4.

Table 1. Gender demographics

	Nomination Camp	**Self-Selection Camp**
Boys (%)	18 (58%)	24 (71%)
Girls (%)	13 (42%)	10 (29%)

Table 2. Racial/ ethnic demographics

	Nomination Camp	Self-Selection Camp
Asian/ Asian American	8 (26%)	9 (26%)
Black/ African American	13 (42%)	4 (12%)
Hispanic/ Latino/a/x	10 (32%)	7 (21%)
White	0 (0%)	10 (29%)
Pacific Islander	0 (0%)	1 (3%)
Other	0 (0%)	1 (3%)
Multiracial	0 (0%)	1 (3%)
Prefer Not To Say	0 (0%)	1 (3%)

Table 3. Highest education level held by either parent

	Nomination Camp	Self-Selection Camp
Some / No High School Diploma	5 (16%)	3 (9%)
High School Diploma or GED	6 (19%)	3 (9%)
Associate's Degree or other 2-year degree	1 (3%)	1 (3%)
Bachelor's Degree or other 4-year degree	10 (32%)	13 (38%)
Graduate Degree	6 (19%)	5 (15%)
I don't know/ Other	3 (10%)	6 (18%)
No response	0 (0%)	3 (9)

Data Collection

Campers in both cities filled out the same survey in Qualtrics at the beginning (on Day 1) and end (on Day 5) of the week-long summer camp in 2022. The survey instruments were the Engineering Versions of the Core High School Pre-Participation and Post-Participation Surveys [21], which included items about campers' perceptions of what engineers do, interest in becoming an engineer, factors important to them in their careers, and interest in STEM topics. The questions were consistent between the pre- and post-camp surveys. Question responses were on three- or four-point Likert scales, depending on the question. Completing the surveys was voluntary. Response rates for the pre-camp survey were 90% for the Nomination Camp and 91% for the Self-Selection Camp. Response rates for the post-camp survey were 74% for Nomination Camp and 97% for Self-Selection Camp. An IRB for the de-identified data allows for publication.

Survey items were related to three topics: perceptions of engineering, importance of factors for future jobs, science or technology activities in school, and importance of factors for future jobs. Responses to survey items were converted to numerical values for statistical analysis.

Data Analysis

This evaluation utilized quantitative data analysis [22]. Respondents were asked to rate levels of agreement or importance for a variety of items on three-point Likert scale

(3=Agree/Very Important, 2=I don't know/Somewhat Important, 1= Disagree/Not Important) or four-point Likert scale (4=Strongly Agree, 3=Somewhat Agree, 2=Somewhat Disagree, 1= Strongly Disagree). After converting campers' answers to numerical scores, t-tests were calculated comparing the pre-camp and post-camp responses between the Nomination Camp and Self-Selection Camp (i.e., Nomination Camp pre-camp vs. Self-Selection Camp pre-camp, Nomination Camp post-camp vs. Self-Selection Camp post-camp). P-value was determined for each item and statistical significance is reported.

Limitations

Campers were assigned camper identification numbers so that they could anonymously complete the surveys. However, it was apparent that campers did not remember or use their ID numbers appropriately: many surveys were submitted with ID numbers that had not been assigned to any camper. As such, we treated all camper ID numbers as invalid and are unable to complete paired t-tests looking at individual camper's changes in the pre- and post-camp surveys. Additionally, the post-camp surveys did not include any demographic questions since our intention was to match campers' ID numbers with the demographic information provided by both parents and campers. Because we are not able to reliably use the camper ID numbers on the completed surveys, we are not able to complete any analysis to compare the changes in responses between campers from different demographic groups.

Positionality

The first author was solely involved in the data analysis and evaluation. The second author coordinated, planned, and oversaw the summer camps. The third author was the engineering content expert for the camps, helped run the camps, and had the ideas for the camps and this paper's evaluation of the camps' recruitment methods. The fourth author supported the first author in writing and editing this paper.

Results

All pre-camp and post-camp survey items were compared between Camps #1 and #2 to see if there were any items with statistically significant differences. In the comparison of pre-surveys between the Nomination Camp and Self-Selection Camp, six items showed a statistically significant difference change:

1. Engineers mainly work on machines and computers. (p = .012)
2. Engineers mainly work on things that have nothing to do with me. (p = .012)
3. More time should be spent on hands-on projects in science or technology activities in school. (p = .000)
4. I would like to (or already do) belong to a science or technology activities club. (p = .009)
5. How important is it to you to do work that allows you to make lots of money? (p = .017)
6. How important is it to you to do work that allows you to have time with family? (p = .004)

However, after completing the camp, there were no statistically significant differences between the Nomination Camp and Self-Selection Camp. Figure 1 shows the histograms and significance levels of the responses to each of these six survey items.

Survey items about campers' perceptions of engineering included items #1 and #2. For these survey items, campers from the Nomination Camp, the nomination and direct application camp, reported higher perceptions of engineers working mainly on machines and computers and engineers working on things unrelated to the camper. However, after completing the camp, there were no statistically significant differences between the two groups, and both groups reported higher disagreement on both statements. Survey items related to science and technology activities in campers' schools included items #3 and #4. Campers from the Self-Selection Camp initially reported higher agreement with item #3, but campers from both camps reported strong agreement at the end of the camps. Campers from the Nomination Camp initially reported higher disagreement with item #4, but campers from both campers reported high interest in science or technology clubs after the camps. Survey items related to what campers perceived as important factors for their future jobs were items #5 and #6. Pre-camp, compared to campers from the Self-Selection Camp, campers from the Nomination Camp reported it was significantly more important to have jobs that allowed them to make a lot of money and spend time with their families. There was no statistical significance between the two groups on the post-camp survey.

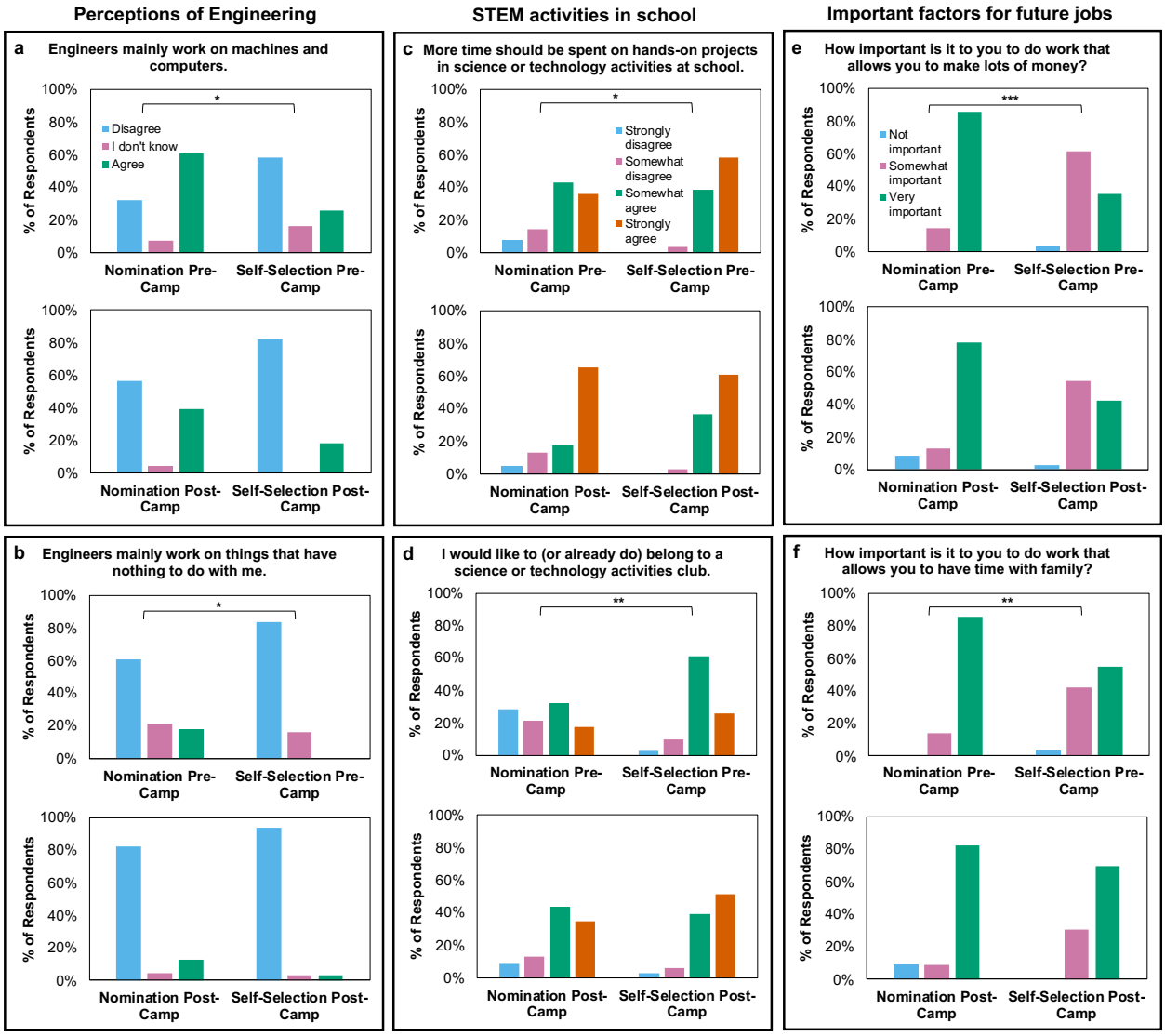

Figure 1. Histograms of responses to select survey questions (*$p < .05$, **$p < .01$, ***$p < .001$ when comparing the Nomination Camp and Self-Selection Camp at the same point in time)

Discussion

The results from pre-camp survey items about perceptions of engineering show that campers who were recruited primarily through their parents directly signing them up (Self-Selection Camp) had much broader ideas of what engineering encompassed. This result could be explained by the possibility that parents who encourage their children to join engineering camps could have knowledge of engineering and their children, thanks to their familial exposure, and may have developed a perception of engineering that more closely aligns with the profession. In contrast, campers from the Nomination Camp had more narrow definitions of engineering, thinking that it mainly pertained to working on machines and computers. The post-camp results for both camps show that the majority of campers later believed that engineers did not work mainly on machines and computers. One implication from these pre-camp findings is why some

students might not be interested in signing up for an engineering summer camp: if a student does not enjoy machines or computers, they might think they will not enjoy an engineering summer camp and, by extensions, schooling or a career in engineering. However, as engineering jobs encompass much more than this narrow definition, students might actually enjoy engineering. Similarly, more campers from the Nomination Camp thought that engineers worked on things that were not related to them before completing the camp. More broadly, we assume that campers who sign up on their own for engineering summer camps or engineering extracurricular activities already have an initial level of interest in engineering, while others might be dissuaded from signing up by misperceptions of engineering jobs and lack of relatability.

The results from the questions regarding science and technology activities in school yield similar implications. Students from the Self-Selection Camp who all signed up directly reported significantly higher levels of interest pre-camp in school or club activities related to science and technology than those from the mixed nomination-application group. Therefore, we posit that a recruitment model that utilizes school counselor model is one way to reach students who might not be interested in engineering is a way to provide access to and increase participation in engineering. As the post-camp survey results show, campers reported similarly high levels of interest in science or technology camps after completing them with no difference between campers' recruitment methods.

Conclusion

Comparing two camps with identical content using different recruitment methods is a novel contribution to the K-12 engineering outreach space, as literature related to outcomes in recruitment methods is sparse. We have shown that school counselor nomination results in the participation of students previously less interested in, and with less knowledge of, engineering. At the end of identical camp content, survey results showed no statistically significant differences between campers recruited by school counselor nomination and voluntary self-sign up. These results suggest that the summer camp was successful in expanding students' knowledge and perception of the job of an engineer and the fields that engineering encompasses. Additionally, since the summer camp seems to have filled the gap in students' perceptions between the two groups, it appears evident that the nomination recruiting method was able to reach students who may have otherwise been not interested in engineering. Engineering outreach practitioners can use the results of this evaluation to inform their choice of recruitment method.

Additional consideration for future camps:

Survey items "How important is it to you to do work that allows you to make lots of money?" and "How important is it to you to do work that allows you to have time with family?" showed statistically significant differences in the comparisons of the pre-camp survey and post camp survey of the two groups.

We offer possible explanations to the differences in important factors for future jobs that are unrelated to recruitment methods, how we will address them in subsequent camps, and how others can do the same. Pre-camp, campers in the Nomination Camp reported significantly higher levels of the importance of a high-paying job. The majority of campers did not know their

household income. Thus, we instead use highest parent education level as a proxy for socioeconomic status, since higher levels of education are often correlated with higher incomes. As shown in Table 3, more campers in the Nomination Camp reported that their parents had below a bachelor's degree compared to campers in the Self-Selection Camp (n = 12, 39% vs. n = 7, 21%). By 8th and 9th grade, many students are aware of the advantages that a high-income job would enable them to have. Engineering careers have significant earning potential [23], but students might not be aware. To increase awareness of the economic advantages of an engineering degree and career, we plan to add salary ranges to our presentation that provides an overview of engineering disciplines and career types.

Additionally, campers in the nomination camp reported it was significantly more important that their work would allow them to have time with family. The Nomination Camp had more Hispanic/ Latino/a/x campers (n = 10, 32% vs. n = 7, 21%) and Black/ African American campers (n = 13, 42% vs. n = 4, 12%) than the Self-Selection Camp. While we are not able to disaggregate responses by race/ethnicity (as discussed in Limitations), the racial/ethnic demographics of the Nomination Camp offer one possible explanation for why that session's campers more highly valued a job that allows them to spend time with their families. Familialism can be defined as "a sense of loyalty, identification, solidarity, and attachment to both nuclear and extended family" [24, p. 252]. Hispanic/Latino and Black/African American people report high values of familialism [25-27]. Hispanic and Black non-Hispanics people have more frequent contact than White people with members of both their nuclear family unit as well as their extended family [24]. Hispanic [26] and Black [28] families include "fictive kin": people who are not blood relatives but can be just as important as blood relatives. Of particular relevance to this evaluation of a summer camp for 8th and 9th graders, a study comparing familialism between Black and White middle school boys found that Black boys reported significantly higher familialism than White boys in the 8th grade [26]. To address campers' concerns about careers that allow them to spend time with their families, we plan to add how engineering jobs can have a good work-life balance to our engineering careers overview.

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