2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
Paper ID #38994

Why Should You Join? Exploring the Role of Engineering Clubs on the Undergraduate Engineering Experience

Ms. Katherine Drinkwater, Duke University

Katie Drinkwater is a recent graduate of Duke University with a Bachelor's in Mechanical Engineering. She is excited to begin working towards her Ph.D. in Engineering Education at Virginia Tech in the Fall. Her interest in Engineering Education began through a project where she helped to design a makerspace inside a shipping container. Since then, she has explored design and engineering education through independent projects and extracurricular leadership in SWE, FSAE, and Duke Engineers for International Development.

Dr. Karis Boyd-Sinkler, Duke University

Karis Boyd-Sinkler, PhD is the Director of Diversity, Equity, & Inclusion and Adjunct Assistant Professor at Duke University's Pratt School of Engineering. She plays a key role in providing strategies to strengthen Pratt's efforts to create and sustain an equitable environment for all members of the Pratt Community including students, staff, faculty, and alumni. She has over 7 years of experience leading multiple mentoring, outreach, and professional development programs focused on the recruitment and retention of engineering students at all levels, especially students from Black and Hispanic/Latino populations. Dr. Boyd-Sinkler has a B.S. in Engineering Science from the University of Virginia and a M.Eng in Industrial and Systems Engineering and a Ph.D. in Engineering Education from Virginia Tech.

Dr. Rebecca Simmons, Duke University

Rebecca Simmons is an Associate Professor of the Practice in the Department of Mechanical Engineering and Materials Science at Duke University. She arrived as a freshman to Duke in 1996 and has never left; she completed both her B.S.E and Ph.D. in Mechanical Engineering and Material Sciences. She teaches a variety of design courses and is passionate about helping her students build creative confidence, think outside of the box, and design their life with personal metrics of success. She hosts a podcast called This Engineering Life, the undergraduate series.

WIP: Why should you join? Exploring the Impact of Engineering Extracurriculars on the Undergraduate Engineering Experience

1. INTRODUCTION

An engineering courseload is a big commitment, yet undergraduate engineering students find time to engage in many activities outside of required coursework. Research, clubs, jobs, sports, extracurriculars, social activities, and leisure time all constitute attractive ways for an engineering undergraduate to spend “residual time”. The time available to spend on these activities, however, is limited to as little as 1.9 hours per day for full-load students (over 15 credit hours), with an average of 19 hours per week across all engineering students [1]. 66% of senior engineering students spend some of that weekly time in a co-curricular activity [2]. A subset of these activities are student-run clubs, and an even smaller subset of clubs focus on engineering.

Thus, the purpose of this study is to gain a preliminary understanding of the landscape of engineering club participation at Duke University (Durham, NC). This understanding includes what clubs students participate in, what they hope to gain, and a cursory inquiry into the skills and attitudes gained from engineering club participation. In short, the goal is to understand why students *do* join engineering clubs, why they *should* join, and any differences between the two. The research questions that guided this study were:

> RQ1: How do undergraduate engineering students perceive the amount of time spent engaging in engineering clubs?
>
> RQ2: Why are undergraduate engineering students motivated to join engineering clubs?
>
> RQ3: What are the perceived benefits of engineering club participation?

Students are motivated to join engineering clubs to find community with peers [3], apply knowledge to real-world settings [4], prepare for their careers [5], develop new skills [6], [7], and pursue personal interests [8]. Design clubs (both competition and impact-focused teams) provide additional opportunities to practice the design process [9], manufacture parts, integrate designs, and access special technologies/tools. These outcomes stem from engineering clubs, but could also originate from many other extracurriculars. Engineering students are drawn to extracurriculars of all types [8]. Little research has focused on outcomes of engineering clubs and differences in student outcomes for specific categories of engineering clubs. This study seeks to build on current work on extracurricular participation by focusing on engineering design clubs and student perceptions of these activities.

2. METHODS

This study used a single online survey to collect data from current engineering undergraduates at Duke University, a large, four-year, largely residential and research-intensive institution in the Southeast United States. Given the exploratory nature of the study, a novel survey tool was created that focused on: residual time, club participation, design skills before and after club participation, design self-efficacy, and demographic information, see Appendix A. This research study was approved by the IRB at Duke University (protocol #2023-0178).

1) *Survey Design*

For the purpose of transparency, we defined *engineering clubs* as a subset of clubs whose membership is primarily engineers, the subject matter is technical, and/or they are a pre-professional organization for engineers. The engineering school at Duke University gives clubs this designation. We divide engineering clubs into three categories: competition design teams, impact-focused design groups, and pre-professional and affinity groups. Competition design teams design and build a device (racecar, drone, robot, rocket, etc.) to compete in an intercollegiate competition. Whereas impact-focused design groups work on social issues like accessibility, global development, and sustainability. Clubs in this category will design and build devices, but without the goal of competing. Some teams that work with global communities may travel to complete projects internationally. Lastly, pre-professional and affinity groups connect students to a particular industry or major (e.g. ASME, ASCE, BMES) for professional development and networking. Affinity groups support an (often underrepresented) subset of the engineering population (e.g. SWE, NSBE, SHPE). Preprofessional and affinity groups are grouped together because they do not typically involve hands-on design work.

The survey is divided into five sections. The questions were largely multiple choice, but four open-response questions were included to allow respondents to expand on their answers. The five survey sections were as follows:

1. **Residual Time:** Residual time focused on the amount of time, in hours, students spent doing various curricular and non-curricular activities each week. This section did not separate different types of extracurriculars, but rather aggregated activities into broad categories (sleep, jobs/work study, classes/labs/homework, research, extracurriculars, mental/physical wellness, social activities, and digital leisure).
2. **Club Participation:** Club participation broke the extracurricular category into many different types of activities. Students indicated the number of active and passive extracurriculars they were involved in, and the time involved in membership. This included both engineering and non-engineering extracurriculars. This section also

included an open response question that asked students how their participation in a design club has impacted their experience as a student at Duke University.

3. **Design Skill Competencies**: To explore how participation in engineering design clubs could affect design skill development, students were asked to rate their mastery of six design skill competencies: 1) communication, teamwork & leadership; 2) ideation; 3) low fidelity prototyping; 4) manufacturing, CAD/CAM; 5) programming, electronics; and 6) professional development based on their involvement in up to 29 engineering clubs at Duke University. The rating scale provided was the NIH Proficiency Scale [10]. Students rated their competencies before joining engineering clubs and current competency. To expand, students were asked a free-response question on how extracurriculars have helped them build skills. In this section students were also asked where they learned design skills. The respondents could choose from 5 options: All Classes, Mostly Classes, Neutral, Mostly Extracurriculars, and All Extracurriculars. After answering these questions, respondents could answer an open-response question asking, "How has your involvement in clubs changed how you engage in classes?"
4. **Design self-efficacy:** The design self-efficacy was an adaptation of the New General Self-Efficacy Assessment [11]. The only modifications made were to specify that the tasks, goals, and challenges in question were in relation to engineering design. The response format was a five-point Likert scale. After the assessment statements, respondents had the opportunity to explain how participation in clubs affected their answers to the assessment statements.
5. **Demographic information:** The demographic information collected in the survey was gender, race/ethnicity, major(s), graduation year, and minor(s). The authors selected these demographics to identify possible correlations between these variables and student engagement in engineering clubs and any concomitant increases or decreases in skill development and self-efficacy.

A complete list of survey questions can be found in Appendix A.

2) Data Collection

Survey participants were recruited through email and listservs. The survey was distributed by faculty members to undergraduates in all engineering majors and class years. In soliciting survey responses, the Directors of Undergraduate Study were contacted to help with dissemination. Professors in Mechanical Engineering and Biomedical Engineering responded to the request by sending the survey link to their students. Additionally, the survey was sent to an email list of all leaders of all engineering extracurriculars for distribution to their members. The survey was also included in weekly newsletters of the Engineering Student Government and Dean of Diversity, Equity, Inclusion, and Community.

Survey Participants: Ninety-three students consented to participate in the study and began the survey. Of those students, 48 participants completed all survey questions but only 45 of these 48 students completed the demographic information concerning gender and only 43 of these 48 students completed the demographic information concerning race and ethnicity. An additional 21 participants partially completed the survey. The remaining 24 respondents that began the survey were removed from the data set because they did not complete the first section of the survey.

3) Data Analysis

All the survey data was exported to a database and analyzed by the first author. Responses that did not complete the Club Participation section were removed from the data set. Any response that completed Club Participation and at least one other section of the survey was included in the analysis. Survey responses were separated into types of engineering club participation based on responses in the Club Participation section. Many of the other survey sections were analyzed using responses from Club Participation (see section below).

Residual Time: The residual time section was analyzed quantitatively by assigning numerical values to each time block in the response options (i.e. 0-4 hrs.=1, 5-9hrs.=2, etc.). The median response for each category was calculated and translated back into a time category (i.e. the median value for the Classes, Labs, & Homework category was 6, which translates to 25-29hrs.)

Club Participation: Respondents chose all the extracurricular activity categories in which they currently participate. These were tallied, graphed, and qualitatively analyzed for themes. Respondents also selected from a list all the engineering clubs to which they have been an active member for more than one semester. The authors categorized this list of clubs based on personal knowledge of the organizations into the three club categories: Competition Design Team, Impact-Focused, or Professional/Affinity. Each club only received one designation. Responses were then sorted into one of 8 groups based on indicated participation in one or multiple engineering club categories (None; Competition; Impact; Professional/Affinity; Competition & Impact; Competition & Professional/Affinity; Impact & Professional/Affinity; Competition, Impact, & Professional/Affinity).

Design Skill Competencies: Respondents rated their skills according to the NIH Proficiency Scale [10]. The categorical scale was translated into a numerical one such that those with no experience in that design skill were rated "0", those with Basic competency were rated "1", and those of the highest competency level (Expert) received a "5" rating. The numerical values were statistically analyzed by comparing the mean value for the entire sample and the mean for respondents that participate in design clubs (either Competition or Impact Focused). The part of this section that asked respondents where (classes or extracurriculars) they had learned design skills was separated by class year to analyze skill development over the course of college.

Self-Efficacy: Analysis of the New General Self-Efficacy Assessment [11] requires translating the Likert Scale response statements into numerical values from 1 (Strongly Disagree) to 5 (Strongly Agree). The average of all 8 statements was taken as the total self-efficacy score. The responses were separated by type of engineering club participation. Averages and standard deviations were also analyzed for each statement in the assessment.

Demographics: Demographic information was used as context for the analysis of other sections of the survey. It was not analyzed separately. Gender, class year, and major were demographics used in analysis. Racial analysis was not performed because of the low number of minority responses (Table 1b). It was determined by the authors that a few responses could not represent the larger racial/ethnic population at Duke University and also posed a threat to confidentiality.

3. RESULTS

The results presented include all the information (partial and complete) that was collected. We chose to include partial survey responses in the analysis within each section to maximize sample size. For all analysis that compared two or more sections of the survey, the response had to be complete in both sections to be included. Tables 1a and 1b show the distribution of participants by gender, major, class year (1a), and race (1b).

Table 1a: Participant Survey Demographics by Class Year

	Biomedical Engineering		**Civil Engineering**		**Electrical & Computer Engineering**		**Mechanical Engineering**			**Total**
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Other**	
Class Year										
2023	2	2	-	-	-	-	7	9	-	**20**
2024	-	1	-	3	1	1	3	-	1	**10**
2025	-	1	-	3	-	-	2	3	-	**9**
2026	-	1	-	-	1	-	2	1	-	**5**
Other	-	-	-	-	-	-	1	-	-	**1**
Total	**2**	**5**	**0**	**6**	**2**	**1**	**15**	**13**	**1**	**45**

Table 1b: Participant Demographics by Race/Ethnicity

	Biomedical Engineering		Civil Engineering		Electrical & Computer Engineering		Mechanical Engineering			Total
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Other**	
Race/Ethnicity										
White/Caucasian	1	1	-	3	1	-	11	6	-	**23**
Black/African American	-	-	-	-	-	-	-	1	-	**1**
Asian/Asian American	1	2	-	-	-	1	4	2	1	**11**
Middle Eastern/North African	-	1	-	-	-	-	-	-	-	**1**
Multiracial	-	-	-	1	-	-	3	-	-	**4**
Other	-	-	-	1	1	-	-	-	-	**2**
Latino/a/x	1	-	-	-	-	-	-	-	-	**1**
Total	**3**	**5**	**0**	**5**	**2**	**1**	**18**	**9**	**1**	**43**

Residual Time

Of the activity categories assessed, extracurriculars, research, mental/physical wellness, social activities, and digital leisure can be considered components of a student's residual time [1]. Participants responded to residual time questions in discrete, 5-hour increments. Table 2 summarizes the median response for all time questions. Summing the median responses, engineering students at Duke University spend 25 to 29 hours a week on classes, labs, and homework and have between 10 and 30 hours of residual time per week.

Table 2: Summary of Residual Time Assessment

Activity	Median Time Spent Weekly
Classes, Labs, Homework	25-29 hrs.
Job/Work Study	0-4 hrs.
Extracurriculars	5-9 hrs.
Research	0-4 hrs.
Mental/Physical Wellness	0-4 hrs.
Social Activities	5-9 hrs.
Digital Leisure	5-9 hrs.

To assess whether different types of extracurriculars demanded different time commitments, the weekly time spent doing extracurricular activities was broken down by type of engineering club (Table 3).

Table 3: Time Spent in Extracurriculars by Club Type

Engineering Extracurricular Participation	Median Time Spent in Extracurriculars
None	5-9 hrs.
Competition	10-14 hrs.
Impact Focused	0-4 hrs.
Professional/Affinity	0-4 hrs.
Comp. and Impact	5-9 hrs.
Comp. and Prof./Affinity	5-9 hrs.
Impact and Prof./Affinity	5-9 hrs.
Comp., Impact, & Prof./Affinity	0-4 hrs.

Participation in Engineering Extracurriculars

Sixty-three participants completed the extracurricular involvement section of the survey. Of these students, 62 indicated participation in at least one extracurricular category, and one response selected no extracurriculars. Figure 1 shows the distribution of participation in the listed categories of extracurriculars.

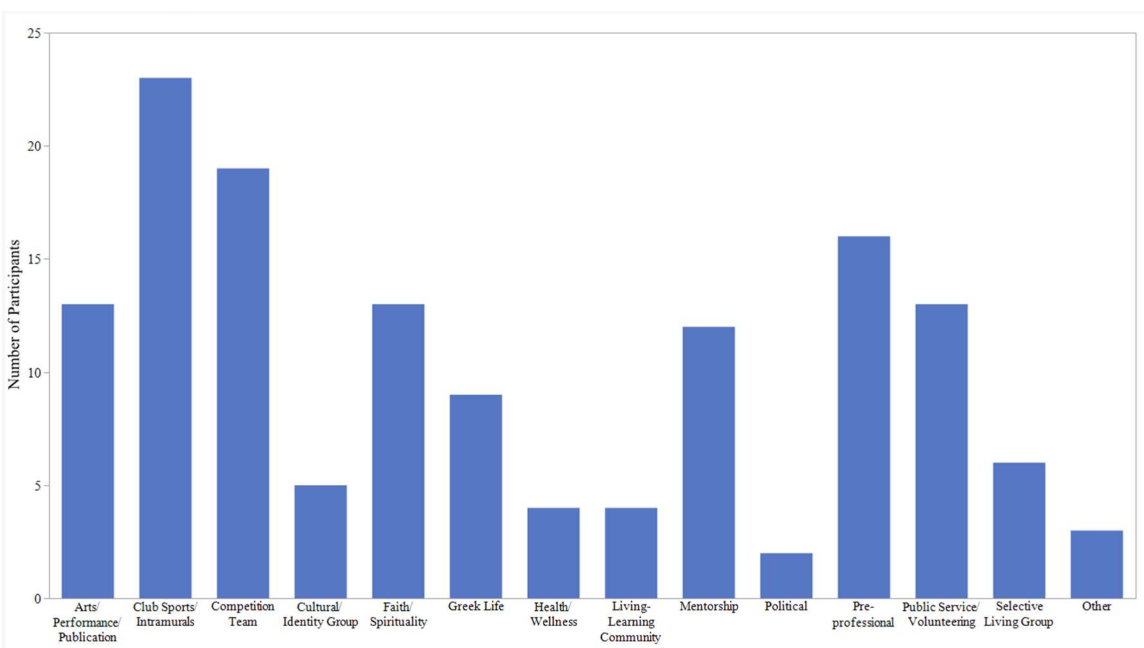

Figure 1: Distribution of General Extracurricular Participation

82.5% of participants indicated membership to at least one engineering club. Of the 52 participants that are active in engineering clubs, 50% are active in one category, 46% are active in two, and only 3.8% are active in all three categories. Professional/affinity groups are the most popular category (55.8% of engineering club participants), followed by competition teams (53.8%) and impact-focused teams (44.2%). Table 4 presents the distribution of participation in engineering clubs.

Table 4: Engineering Club Participation by Category

Engineering Club Category	n	% of total
Competition Design Teams	14	22.2
Impact-Focused Teams	5	7.9
Professional/Affinity Groups	7	11.1
Competition & Impact	4	6.3
Competition & Professional/Affinity	8	12.7
Impact & Professional/Affinity	12	19.0
Competition, Impact, & Professional/Affinity	2	3.2
None	11	17.5

Figure 2 presents engineering extracurricular participation separated by gender. There was one survey response by a non-binary student, which was not included in the gender analysis to preserve confidentiality. It is apparent that male students were 13% more likely to report membership on a competition team, while impact and professional/affinity were more popular among female students (17.5% more likely to join impact-focused than male peers). For impact groups, 44% of female students participate, while only 26% of male students participate.

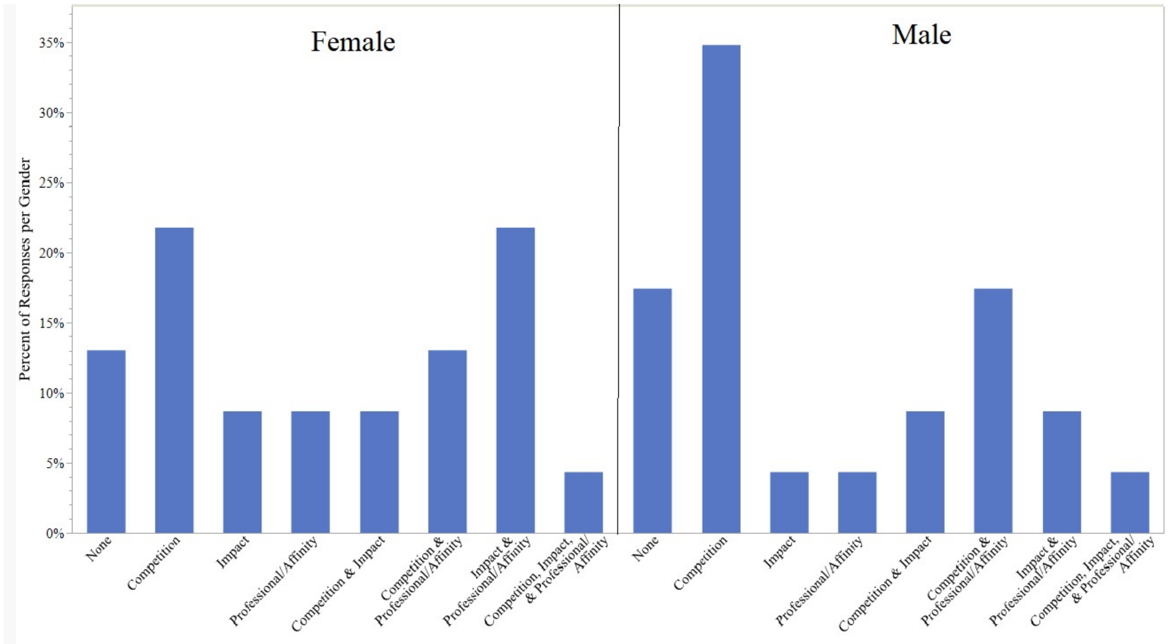

Figure 2: Engineering Club Participation by Gender

Students that are active in design clubs were asked to select motivations for joining engineering design clubs from a provided list. Every student that answered selected multiple motivations, with an average of 8.05 motivations per response. There were 14 motivations to choose from, so the average participant selected more than half of the available options. Figure 3 presents the 14 motivations and shows the frequency each potential motivation was selected as a percent of total selections.

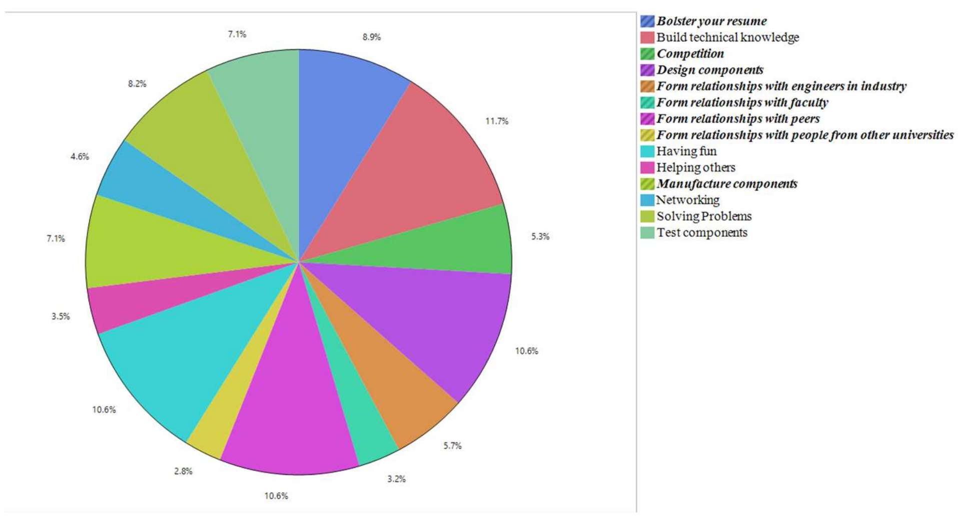

Figure 3: Motivations to Join Engineering Design Extracurriculars

Design Skill Competencies

Participants indicated a perceived improvement in all design skill groups since joining engineering extracurriculars. Table 3 summarizes the average Proficiency Scale scores for all participants that completed this portion (n=44). Skill development occurs in a variety of places and cannot be attributed entirely to classes or clubs. To compare skill competencies for engineering design club members to the entire sample, the Proficiency Scale averages are also listed in Table 5. Students in design clubs had lower initial competencies than average, perhaps leading them to pursue extracurricular design. Current skill competencies only vary by hundredths of a point between design club members and the average in all skill groups except Communication, Teamwork, & Leadership. Design club members did indicate slightly higher competence in Ideation, Manufacturing; CAD/CAM, and Programming/Electronics.

Table 5: Design Skill Competency Comparison

Skill Group	**Before joining extracurriculars**		**Current Skill Level**	
	Entire Sample	Design Clubs	Entire Sample	Design Clubs
Communication, Teamwork, & Leadership	3.11	3.06	4.0	4.39
Ideation	2.45	2.75	3.72	3.78
Low-Fidelity Prototyping	2.02	1.92	3.42	3.42
Manufacturing; CAD/CAM	1.66	1.61	3.3	3.42
Programming; Electronics	1.35	1.19	2.5	2.54
Professional Development	1.57	1.44	3.16	3.17

To further explore the effect of curricular and extracurricular learning environments on the development of design skills, survey participants were asked where they developed more general engineering skills. Figure 4 shows responses by graduation year. The variation in responses increases with older students. Freshman and sophomores trend toward classes while upperclassmen are more likely to credit extracurriculars with skill development.

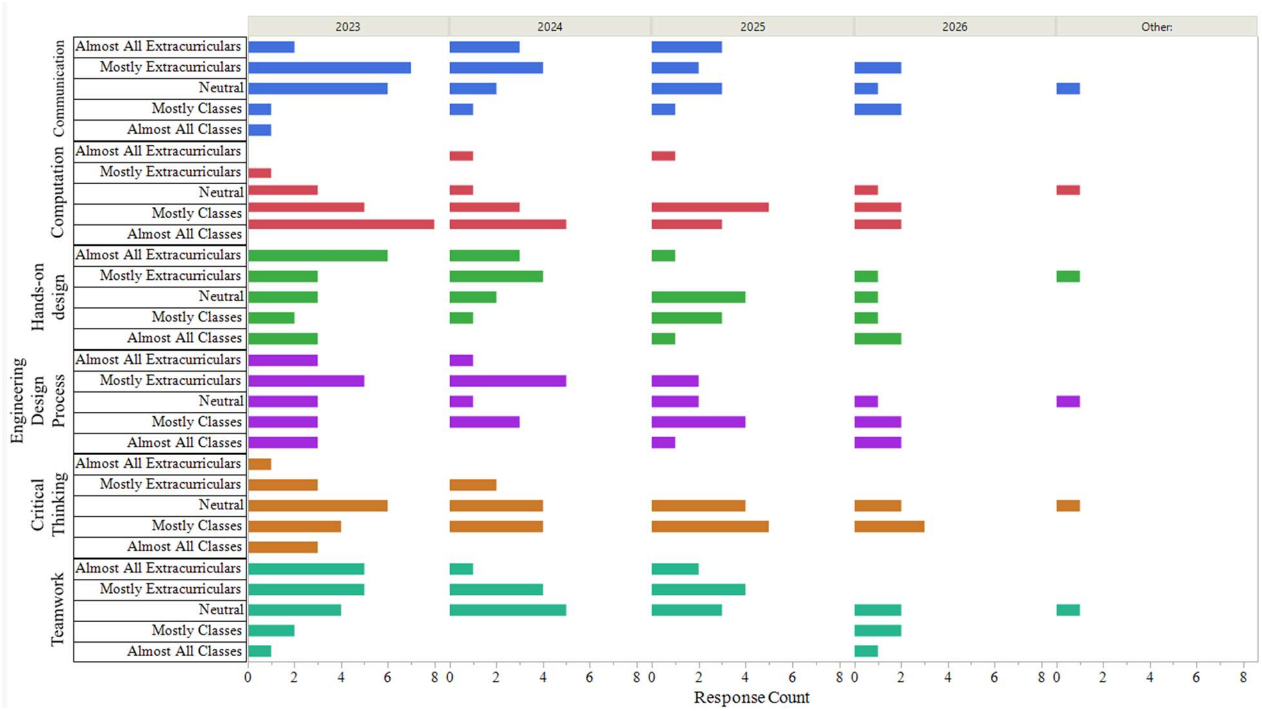

Figure 4: Skill Development and Learning Environments by Graduation Year

An attractive facet of extracurriculars is the freedom to pursue topics of interest. Study participants were invited to write in additional details about how participation in engineering clubs has affected their personal skill development. The responses were qualitatively coded with the selection choices from the motivation question at the beginning of the survey (Figure 3; Question 1 of Competition Design Team Specific Questions in Appendix A). The most common theme in the open responses was to connect with industry by building technical knowledge and bolstering a resume. Getting to know peers was also a very commonly perceived benefit of club participation, often through peer mentorship. Several responses attributed much of their development to mentorship from students and the opportunity to mentor. An additional theme that emerged was the opportunity for failure. Students felt more comfortable failing in a club environment and were more willing to take on challenging projects.

In another open-response question, participants were asked how club participation had impacted their engagement in courses. Responses to this question were diverse, and not all positive. Several students noted that clubs take a significant amount of time, and classwork/grades can suffer as a result. Another prominent theme in responses was the ability to make connections between class concepts and club work. Many responses specifically highlighted a moment when they were able to connect a club experience and First Principles. Class concepts also seemed easier to learn because of these connections, and participants were more invested in learning concepts relevant to club design work. About 16% of responses also indicated a change in their academic and/or career trajectory because of club participation.

Self-Efficacy Assessment

The self-efficacy assessment was scored with an average of scores from the eight individual statements. The average total score was 3.98. Figure 5 shows the distribution of total scores separated by engineering club participation. Competition and impact-focused clubs had an average close to the overall average, while students who do not participate in engineering clubs had an average two points higher. The largest range existed for students in professional/affinity groups.

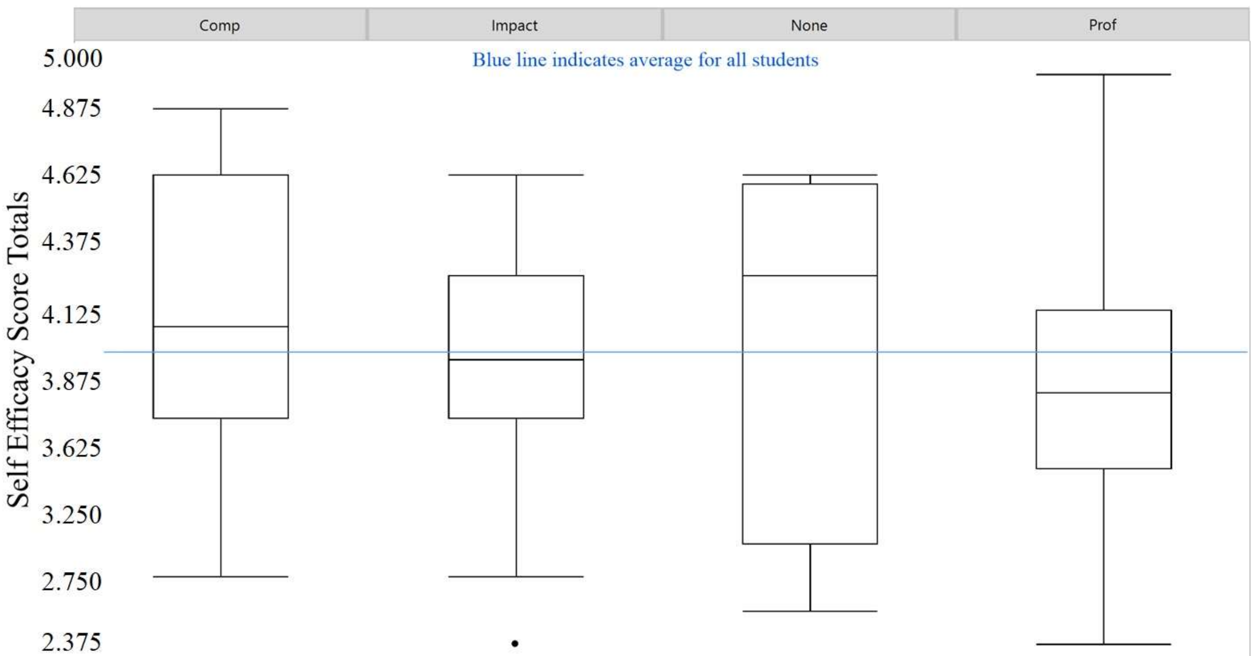

Figure 5: Box Plot of Self-Efficacy Scores for Competitions Teams (comp), Impact-Focused (impact), No Engineering Clubs (none), and Professional/Affinity Orgs (prof)

To break down the self-efficacy assessment, Table 6 lists the average score and standard deviation for each of the 8 statements in the assessment. The highest average is 4.27 for statement c, while the lowest was statement g with an average score of 3.60. Statement g also had the highest standard deviation (1.04).

Table 6: Average Responses to Individual Self-Efficacy Statements

Statement	Average Score	Standard Deviation
a) I will be able to achieve most of the goals that I have set for myself in my engineering career.	4.09	0.69
b) When facing difficult tasks in engineering projects, I am certain that I will accomplish them.	4.02	0.77
c) In general, I think that I can complete engineering design projects that are important to me.	4.27	0.90
d) I believe I can succeed at almost any technical task to which I set my mind.	3.87	0.88
e) I will be able to successfully overcome any challenges in an engineering design project.	3.76	0.82
f) I am confident that I can perform effectively on many different technical and nontechnical tasks.	4.09	0.89
g) Compared to other people, I can do most technical tasks very well.	3.60	1.04
h) Even when things are tough in a design project, I can perform quite well.	4.13	0.62

The answers to the free-response question after the assessment reflected positively on engineering clubs. The most common response was that club participation had improved the participant's score. Thirteen percent of the open responses said that clubs had no impact on their answers, while 60% said that clubs improved their score. No response indicated a lower score because of clubs.

4. DISCUSSION

Residual Time

This data set follows the residual time assessment conducted by Olewnik & Kashyap [1]. The median residual time for participants is between 10 and 30 hours per week, which appears to center around the average of 19.5 hours measured [1]. The least time was spent at a job, doing research, and on mental/physical wellness. Since this survey was targeted toward students in extracurriculars, it is possible that the respondents have less time to spend on jobs and/or research.

Table 3 proposes a wide range of time spent in extracurriculars. Respondents that only participate in competition teams spend a median of 10-14 hours on extracurriculars per week, which was the highest of all groups. The three groups that include two of the three categories of engineering clubs all had a median of 5-9 hours per week. This result contradicts the assumption that membership in more clubs correlates with more time spent in club activities. The two respondents that participate in all three categories of engineering clubs each reported spending 0-4 hours in clubs per week. This is less time than most other groups, but since the sample size is so small, few conclusions can be drawn about that group.

Participation in Engineering Extracurriculars

Engineering students at Duke University are involved in many extracurricular activities beyond engineering clubs. The most popular type of extracurricular participation in club sports/intramurals was the most common response (33% selected). Competition teams and pre-professional activities were the next most popular, respectively. Engineering competition or pre-professional activities were not separated from other types of competition or pre-professional activities in this section of the survey. Of the 63 respondents that answered this question, only 1 did not select any extracurricular activities.

Competition Design Teams are the most common category of engineering extracurricular in this data set, followed by Professional/Affinity Groups, and Impact Focused Design Teams last. The trends in participation when separated by gender reveal significant differences. Participation by women is more diverse and more prominent in non-competitive engineering clubs. The high participation of male engineers in competition teams may serve as a push factor for female engineers. One of the most common clubs reported in the survey was the Society of Women Engineers, so this could account for an increase in affinity group participation among females.

The top three motivations selected for club participation were ‘Build technical knowledge’, ‘Form relationships with other engineering students’, and ‘Having fun.’ The least popular response was ‘To form relationships with people from other universities,’ likely because this opportunity is mostly limited to teams that compete with other universities and colleges. These motivations are not obviously limited to one type of engineering club, or even to clubs in general. A student can learn technical skills in any of the three categories, and all clubs include working with peers. An interesting observation from this question was the high response rate. Students selected an average of 8 motivations for joining engineering clubs, and this high number verifies students’ the assumption that students join extracurriculars for more than boosting a resume. Student motivation incorporates desires for both interpersonal connection and technical experience. The distribution of motivations was not significantly different between categories of engineering club, but rather equally diverse.

These motivations are even more interesting when paired with the free response question about skill development. The responses were coded with the potential motivations, and the two most common themes were the same as the two most selected motivations. Responses highlighted technical knowledge and relationships with peers as the most important factors for their skill development in engineering clubs. Knowledge about industry was also a popular theme in the free response which did not match directly with one of the motivations listed. Networking, bolstering your resume, and building technical knowledge are all motivations that relate to learning about industry. This free response verifies the motivations for joining clubs, as students currently in clubs perceive the same benefits (and more) as they wanted when they joined.

Design Skill Competencies

One of the goals of engineering school is to help students develop both technical and professional skills that will aid them in the design process. This was the most common motivation listed for joining engineering clubs. Based on the before and current skill competencies section of the survey, there is a perceived increase in skills unique to club participation. Table 5 shows a Proficiency Scale increase of at close or over 1 point for every skill category. This is expected, we hope that engineering students improve their design skills over the course of their undergraduate education. Respondents that are members of engineering design clubs (either Competition and/or Impact Focused) began with lower proficiency scores and currently rate higher than the entire sample. The lower scores before joining clubs could have been a motivation for participants with less design experience to join design clubs. However, it must be acknowledged that the design club participants' score averages were only a few hundredths of a point higher than the entire sample. It is remarkable, though, that the average score was equal or higher for every skill category.

Whether in design clubs or elsewhere, engineering students are learning design skills somewhere. Figure 4 seeks to reveal where this development occurs. A trend visible in Figure 4 is the shift toward extracurricular learning as students progress in their education. First- and second-year students perceived more learning in classes for the Engineering Design Process and Hands-On Design groups, where third- and fourth-year students were more likely to attribute their skills to extracurriculars. This trend makes sense; upperclassmen have had more time to observe, practice, and teach skills in extracurriculars while underclassmen are still in the process of understanding fundamentals in both classes and extracurriculars. Classes rated highly across all graduation years in the Computation group. Figure 4 shows that there is not a clear consensus among students as to where they develop key design skills.

Classes, clubs, and other student experiences are not isolated events. There are many connections between curriculum and extracurricular learning. The free response that targeted this connection received mixed responses. When asked how club participation changed their engagement in classes, some students reported being less engaged. Interest level could be a factor that draws students away from classes and toward clubs. One student described this situation during final exams: "during finals week I am frequently thinking "why am I studying book knowledge for an exam when I could be doing real engineering with my club?"" More students, however, reported an increase in course relevance. Club experiences seemed to provide the context that there is not always time for during lecture. Several responses noted moments when a concept from class 'clicked' while working on a club project. It is difficult to say when and where the curricular building blocks may fall into place for a given student, but for many survey respondents, that place was in an engineering club.

Self-Efficacy

Overall, the total self-efficacy scores are relatively high. 3.98 roughly corresponds to the Agree response for every statement. The average for an undergraduate age population taking the general form of the New General Self-Efficacy Assessment is 3.87 [11]. While participants in this study did not take a general self-efficacy assessment, the average value is 0.11 above the overall average. The variation in scores was high, as evident in Figure 5. There was not one category of engineering club that had significantly higher self-efficacy scores than another. As evidenced in the residual time section (Table 3), there are varying levels of involvement in extracurriculars and varying levels of impact that result. Self-efficacy is also impacted by numerous other factors than club participation, many of which were unaddressed by this survey.

Most of the self-efficacy assessment statements had similar average values in the 4.0-4.2 range. Statements d, e, and g, however, had averages below 3.9. Statements d and e asked students about their ability to be successful in any project despite challenges, while statement g asked students how they perform compared to 'most people.' Statement g had the lowest average score, 3.60, but also the highest standard deviation, 1.05. Statements d and e highlight the importance of resilience and overcoming failure in engineering design. Dealing with failure is always difficult, but engineering clubs are a safer and lower-stakes environment in which to fail. Several responses in the free response questions highlighted the opportunity to fail as a benefit of clubs.

Self-efficacy and self-confidence are distinct but related concepts, and both were present in the free responses after the self-efficacy assessment. Many responses specifically highlighted increased confidence in their design abilities because of clubs. One student explained that "the confidence and determination reflected in the above answers are almost entirely a direct result of having work on the fly, defend my decisions, and learn to take criticism in a productive way. All of these things come from being in a club, not a classroom."

5. CONCLUSION AND FUTURE WORK

Throughout the many sections of this study, a common theme is the personalized nature of extracurricular experiences. Students choose to participate in numerous and diverse organizations for equally numerous and diverse reasons. The complex and unique combinations of motivations are difficult to uncover in a multiple-choice survey. It is apparent that participants of this study have positive experiences in clubs and perceive their outcomes to be similar to their original motivations for joining. Engineering clubs appear to be seen as a valuable addition to engineering coursework, a strong community of peers, and only rarely a distraction from homework.

There is significantly more work to be done to analyze connections between engineering club participation and skill development or self-efficacy. The development of an engineer over four years of undergraduate study is a holistic process that is difficult to cleanly separate into distinct contributions from curricular or extracurricular activities. We hope to further analyze the survey data to compare perceived design skills and design self-efficacy scores. Further breakdown of engineering clubs into more specific or differently organized categories may also reveal new trends. Additionally, to fill in some of the gaps from a multiple-choice survey, the research team hopes to conduct follow-up interviews with engineering students active in engineering clubs. By pairing survey responses with more detailed qualitative data, we hope to be able to identify the types of formative experiences students have in clubs that are different from curricular experiences. For students that participate in multiple categories of engineering clubs, interviews will also be useful to isolate experiences in different types of clubs. Students that are not involved in engineering clubs or joined and left clubs will also be interviewed to better investigate negative perceptions and/or experiences.

This paper asks in its title, ‘why should you join?’, highlighting our goal to understand the benefits of engineering club participation. It is obvious that the answer is highly individual. Each student uses extracurriculars to fill a need in their undergraduate experience, whether it be finding friends or learning CAD. Based on this work-in-progress analysis, a diverse pool of extracurriculars is necessary to fill all the individual needs of students. A balance between competition teams, impact-focused organizations, professional/affinity groups, and non-engineering clubs ensures a wide pool of opportunities for students.

6. REFERENCES

[1] Olewnik, A, Kashyap, S. (2021) A Study of Available Time for Engineering Undergraduates' Involvement in Co-curricular Activities. Presented at ASEE St. Lawrence Sect. Conf. [Online] Available: https://peer.asee.org/a-study-of-available-time-for-engineering-undergraduates-involvement-in-co-curricular-activities

[2] N. S. of S. Engagement, "U.S. summary frequencies by related-major category," National Survey of Student Engagement, 2018.

[3] C. Allendoerfer et al., "Strategic pathways for success: The influence of outside community on academic engagement," J. Eng. Educ., vol. 101, no. 3, pp. 512–538, 2012, doi:10.1002/j.2168-9830.2012.tb00060.x.

[4] V. I. Sessa, N. Alonso, P. Farago, G. Schettino, K. Tacchi, and J. D. Bragger, "Student organizations as avenues for leader learning and development," New Dir. Student Leadersh., vol. 2017, no. 155, pp. 21–32, 2017, doi: 10.1002/yd.20247.

[5] S. Kovalchuk, et. al., "Transitioning from university to employment in engineering: The role of curricular and co-curricular activities," 2017.

[6] J. D. Foubert and L. A. Grainger, "Effects of involvement in clubs and organizations on the psychosocial development of first-year and senior college students," NASPA J., vol. 43, no. 1, pp. 166–182, 2006, doi: 10.2202/0027-6014.1576.

[7] L. R. Lattuca, D. B. Knight, H. K. Ro, and B. J. Novoselich, "Supporting the development of engineers' interdisciplinary competence," J. Eng. Educ., vol. 106, no. 1, pp. 71–97, Jan. 2017, doi: 10.1002/jee.20155.

[8] B. Johnson, J. Main, "Investigating Factors that Inform Engineering Students' Choice of Extracurricular Activities," Presented at ASEE Annual Conf. [Online] Available: https://peer.asee.org/investigating-factors-that-inform-engineering-students-choice-of-extracurricular-actvities

[9] Gonzalez, A., & Millunchick, J. M. (2016, June), Extracurricular Engineering Activities and College Success Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.26875

[10] National Institutes of Health, "Competencies Proficiency Scale" nih.org, https://hr.nih.gov/working-nih/competencies/competencies-proficiency-scale (accessed Feb. 1, 2023).

[11] Chen, G., Gully, S., and Eden, D. "Validation of a new general self-efficacy scale." *Organizational research methods*. vol. 4 no. 1 pp. 62-83, Jan. 2001. Accessed Feb. 7, 2023. DOI: 10.1177/109442810141004. [Online]. Available: https://journals.sagepub.com/doi/pdf/10.1177/109442810141004?casa_token=gdwDALR

CDJUAAAAA:VYMFTyEAf_YKU2F8bsvu2dbPPzAnx7O6VBM4fk_laxtpPNlzzmT32uK5me0QhMXIEpyZx6MbJs5o

APPENDIX A: SURVEY QUESTIONS

1. During a typical week, how much free time do spend outside of class and schoolwork? This can include time engaging in extracurriculars, jobs, time with friends, etc. Do not include sleep time in your estimate.
   a. Less than5 hours
   b. 5-9 hours
   c. 10-14 hours
   d. 15-19 hours
   e. 20-24 hours
   f. 25-29 hours
   g. 30+ hours

2. During a typical week, how many hours do you spend doing the following activities:

   a. Sleep
      i. 0-4 hours
      ii. 5-9 hours
      iii. 10-14 hours
      iv. 15-19 hours
      v. 20-24 hours
      vi. 25-29 hours
      vii. 30+ hours
   b. Jobs/Work Study
      viii. 0-4 hours
      ix. 5-9 hours
      x. 10-14 hours
      xi. 15-19 hours
      xii. 20-24 hours
      xiii. 25-29 hours
      xiv. 30+ hours
   c. Classes/Labs/Homework
      xv. 0-4 hours
      xvi. 5-9 hours
      xvii. 10-14 hours
      xviii. 15-19 hours
      xix. 20-24 hours
      xx. 25-29 hours
      xxi. 30+ hours

xxii.

d. Research

xxiii. 0-4 hours
xxiv. 5-9 hours
xxv. 10-14 hours
xxvi. 15-19 hours
xxvii. 20-24 hours
xxviii. 25-29 hours
xxix. 30+ hours

e. Extracurriculars

xxx. 0-4 hours
xxxi. 5-9 hours
xxxii. 10-14 hours
xxxiii. 15-19 hours
xxxiv. 20-24 hours
xxxv. 25-29 hours
xxxvi. 30+ hours

f. Mental & Physical Wellness

xxxvii. 0-4 hours
xxxviii. 5-9 hours
xxxix. 10-14 hours
xl. 15-19 hours
xli. 20-24 hours
xlii. 25-29 hours
xliii. 30+ hours

g. Social Activities/Time with Friends

xliv. 0-4 hours
xlv. 5-9 hours
xlvi. 10-14 hours
xlvii. 15-19 hours
xlviii. 20-24 hours
xlix. 25-29 hours
l. 30+ hours
li.

h. Digital Leisure (TV, movies, gaming, social media)

lii. 0-4 hours
liii. 5-9 hours
liv. 10-14 hours
lv. 15-19 hours
lvi. 20-24 hours

lvii. 25-29 hours
lviii. 30+ hours

Club Involvement:

1. Select the extracurricular categories you currently participate in. Select all that apply.
    a. Arts/Performance/Publication
    b. Club Sports/Intramurals
    c. Competition Team
    d. Cultural/Identity Group
    e. Faith/Spirituality
    f. Greek Life
    g. Health/Wellness
    h. Living-Learning Community
    i. Mentorship
    j. Political
    k. Pre-professional Organizations
    l. Public Service/Volunteering
    m. Selective Living Group
    n. Other:_____________
2. Select all of the **[Duke University School of Engineering] clubs** you have been/were an active member of for more than 1 full semester.
    a. AERO
    b. AMA
    c. ASCE
    d. ASME
    e. ASME
    f. BMES
    g. Combat Robotics Team
    h. DEID
    i. DFA
    j. DISI
    k. [Duke University] Applied Machine Learning Group
    l. [Duke University] Conservation Tech
    m. [Duke University] Hyperloop
    n. [Duke University] Undergraduate Machine Learning
    o. DUQIS
    p. Electric Vehicles
    q. eNable
    r. Engineering World Health
    s. FEMMES+
    t. Girls Engineering Change
    u. Hack[Duke University]
    v. IEEE

w. Innoworks
x. Material Advantage
y. MEDesign
z. Motorsports
aa. NSBE
bb. Pi Tau Sigma
cc. Project Tadpole
dd. Robotics
ee. Runway of Dreams
ff. SHPE
gg. SmartHome
hh. SWE
ii. Tau Beta Pi
jj. Tech for Equity
kk. Other:_________

3. On average, how much time do you spend each week in meetings for **Pratt clubs**?
    a. 0-4 hours
    b. 5-9 hours
    c. 10-14 hours
    d. 15-19 hours
    e. 20-24 hours
    f. 25-29 hours
    g. 30+ hours

4. On average, how much time do you spend doing work for **Pratt School of Engineering clubs** each week outside of meetings?
    a. 0-4 hours
    b. 5-9 hours
    c. 10-14 hours
    d. 15-19 hours
    e. 20-24 hours
    f. 25-29 hours
    g. 30+ hours

5. What percent of the time you are doing **Pratt club-related activitie**s are you working in a team? *(Slider from 0%-100% included in survey)*

<u>Competition Design Team Specific:</u>

1. If you are a member of a competition design team or club, what made you interested in joining? Select all that apply.
    a. Form relationships with other [Duke University] engineers
    b. Form relationships with people from other universities

c. Form relationships with faculty
d. Form relationships with engineers in industry
e. Design components
f. Manufacture components
g. Test components
h. Build technical knowledge
i. Competition
j. Networking
k. Having fun
l. Bolster your resume
m. Helping others

Skills:

Options for Questions 1. a-f and 2. a-f:

N/A- Not Applicable to my club(s)

0 – No Experience

1 - Basic (basic awareness of procedures, terms, principles)

2 - Novice (need significant resources/help)

3 - Intermediate (use knowledge in practical applications with limited help)

4 - Advanced (well-versed and able to work without outside help most of the time)

5 - Expert (teaches/helps other members of the club with these skills)

1. Please rate your ability in the following skills before joining engineering extracurriculars:
    a. Communication, Teamwork, & Leadership
    b. Ideation
    c. Low Fidelity Prototyping
    d. Manufacturing; CAD/CAM
    e. Programming; Electronics
    f. Professional Development
2. Please rate your ability in the following skills now:
    a. Communication, Teamwork, & Leadership
    b. Ideation
    c. Low Fidelity Prototyping
    d. Manufacturing; CAD/CAM
    e. Programming; Electronics
    f. Professional Development
3. How have extracurriculars helped you build skills?

4. Where have you learned the following skills? Use the slider to rate between classes and extracurricular activities. *(Slider included in survey with the following options: all classes, mostly classes, neutral, mostly extracurriculars, all extracurriculars)*
    a. Communication
    b. Critical Thinking
    c. Computation
    d. Hands-on design
    e. Manufacturing
    f. Teamwork
    g. Engineering Design Process
5. How has your involvement in clubs changed how you engage in your classes? (Things to think about: Are you more/less interested in certain topics? Can you connect course material with club experiences? Have you used class material in your club work? Have clubs made you more/less successful in classes?)

Self-Efficacy/Confidence:

1. Please use the below rating system to rate your agreement with statements a-h.

   1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree.

   a) I will be able to achieve most of the goals that I have set for myself in my engineering career.
   b) When facing difficult tasks in engineering projects, I am certain that I will accomplish them.
   c) In general, I think that I can complete engineering design projects that are important to me.
   d) I believe I can succeed at almost any technical task to which I set my mind.
   e) I will be able to successfully overcome any challenges in an engineering design project.
   f) I am confident that I can perform effectively on many different technical and nontechnical tasks.
   g) Compared to other people, I can do most technical tasks very well.
   h) Even when things are tough in a design project, I can perform quite well.

2. Looking at your answers to questions a-h above, how has your involvement in a club changed your answer?

Biographical:

1. How would you describe yourself?
    a. Female
    b. Male
    c. Something Else
    d. I prefer not to answer this question
2. How would you describe yourself? (Select all that apply.)

a. Asian or Asian American
b. Black or African American
c. Hispanic, Latino/a/x, or Spanish origin
d. Middle Eastern or North African
e. White or Caucasian
f. A race, ethnicity, or origin not listed, please specify: ___________________________
g. I prefer not to answer this question

3. What is your graduation year?
    a. 2026
    b. 2025
    c. 2024
    d. 2023
    e. Other:______
4. What is/are your major(s)?
    a. Biomedical Engineering
    b. Civil Engineering
    c. Electrical and Computer Engineering
    d. Environmental Engineering
    e. Materials Science
    f. Mechanical Engineering
    g. Other: _________________________
5. Are you pursuing any minors/certificates? Select All that Apply.
    a. Aerospace Engineering
    b. Architectural Engineering
    c. Electrical & Computer Engineering
    d. Energy and the Environment
    e. Energy Engineering
    f. Global Development Engineering
    g. Machine Learning/AI
    h. Materials Science
    i. Other:_____________