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Comparison of Unique Co-curricular Engagement of Engineering Students and Self-reported Outcomes

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Abstract

In this research paper, we explore the outcomes of the one-time engagement of engineering students in different co-curricular activities during an identical period in time. There is a reported participation gap and uneven engagement of engineering students in co-curricular activities. We compare how student engagement in different co-curricular activities might vary in terms of the self-reported time spent, curricular courses utilized, and professional competencies developed. We use de-identified records data that were collected from a professional development survey at a large North American University. We specifically compare experience between groups of engineering students who reported participating in one unique co-curricular during 2017-18 and completed a professional development survey at the end of the year (between measures/co-curricular activities). Results of non-parametric analysis (Kruskal Wallis, $p<.05$) show students consistently self-report gaining more skills per engagement from Technical work experiences as compared to other co-curricular activities. However, students are spending a significantly larger portion of their time on the Non-technical, Services and Clubs as compared to Technical experiences and comparatively utilize a significantly lower number of curricular courses. Findings may suggest the need to identify and educate the contribution of each co-curricular, make technical work experiences more accessible to all, or infuse its attributes into other co-curricular to better support student practice of engineering skills.

Keywords Co-curricular, Professional Skill Development Survey, Engineering Education

Introduction

Co-curricular (also referred to as out-of-the-classroom) activities are an outlet to enable engineering students to acquire the professional skills they were unable or not offered to acquire in their curricular activities [1]. Institutions are as a result using resources (e.g., funds, administrator and student time and efforts) to strengthen and support student co-curricular engagements [2]. However, the engineering literature reports a lack of understanding of how the different co-curricular activities contribute to student learning and professional development which is a key indicator of student success during and beyond their studies [3]–[7]. At our institution, we find that only a fraction of undergraduate engineering students participates in co-curricular activities year after year. This issue is significant because institutions may unknowingly promote student co-curricular activities that contribute little to students' professional skill development. To help academic administrators assess the efficacy of different co-curricular activities, one approach is to compare the self-reported professional skills gained and roles of engineering students who engage in unique co-curricular activities. This approach is feasible since at present the common way of collecting data from students' co-curricular experiences is through self-reported surveys [8], [9]. Identifying prominent trends in the skills gained and roles described in various co-curricular activities can indicate how well engineering-related professional skills are instilled in students and what type and level of commitment from each co-curricular are needed.

The purpose of this research paper is to explore student efforts and the development of professional competencies across unique co-curricular activities, as reported by students. We hypothesize that students' self-reported efforts and outcomes (i.e., professional skills gained, time spent, courses utilized, roles described) are significantly different between co-curricular activities, which may act as a potential barrier and justification to students' inconsistent participation in different co-curricular activities. Our analysis can provide insight into the efficacy of each co-curricular, at least from a student perspective, against students' curricular commitments and more broadly inform necessary programming (curricular or co-curricular) changes. We utilize a mixed-methods approach to analyze and triangulate closed-ended and open-ended data on efforts (semesters of engagement, curricular courses utilized) and learning outcomes (professional skills gained and role description) of student groups who engage in different co-curricular activities during a year at an R1 institution. The activities are either;

- Technical: Off-campus summer or internship or coop industry experiences either within or close to the field of study of the student and using knowledge from the student's undergraduate learning,
- Non-technical: Off-campus casual, part-time, evening, and often paid experiences that are not deemed as engineering related work, outside the field of the study of the students and not using knowledge from the student's undergraduate learning,
- Research: On-campus analytical in the lab or simulated work conducted with a supervising faculty member at the university,
- Clubs: On-campus student-created and led communities that are intended to be focused on engineering problems but may also be centered around other areas such as sports, events, arts,
- Intramurals: On-campus student-created and led communities (more competitive to join than clubs) that are intended to be focused on engineering (often design) problems but may also be centered around other areas such as sports, events, arts, and
- Service: Off or on-campus in-kind engagement and social work in the community and educational setting.

This data was collected through an annual Professional Development Survey (PDS) of undergraduate engineering students conducted annually since 2015. Comparing groups of students' one-time engagement in unique co-curricular activities during a shared period enables studying the net impact of each co-curricular in a more controlled manner. Note that the one-time engagement lasted one up to four semesters and was more involved than limited participation such as volunteering at one session of an outreach program. The summary of the literature and methods that follow show there to be differences in self-reported efforts and outcomes of students, with higher value consistently being put on technical and paid work experiences. We conclude by discussing the implications of these differences and ways in which administrators can utilize such findings to enhance their curricular or co-curricular programming.

Literature review

The coordination of multiple competencies, both technical and professional, is critical to success in practice [10], [11]. However, engineering curricula mostly focus on the development of technical skills leaving little time to be spent on formal training of complementary professional skills [12], [13]. Professional skills are naturally developed through project-based and other technical work that occurs primarily outside of the classroom such as student club projects and internships [14]. Institutions, therefore, may facilitate pathways and advertise a range of outside the classroom experiences for students to engage in (herein we refer to as co-curricular activities). This is to better support the professional skill formation of students during and beyond their studies. Co-curricular engagement provides a promising result in student persistence in college and an overall improved educational experience [15], [16]. Prior work in engineering education literature also suggests that participation in co-curricular activities, especially ones that are closely related to engineering discipline is beneficial to student learning [11]. Co-curricular activities are more authentic learning experiences that may better support professionally developed, competent, and job-ready engineering graduates [17].

With institutions and industries giving recognition to students' co-curricular activities, research in engineering education is picking up on the role of co-curricular on student experience and professional skills (Broisin et al., 2017; Davis et al., 2011; Fisher et al., 2014; Ozturk et al., 2019; Simper et al., 2018. Past work has more often focused on the design of interventions to better facilitate student learning upon engagement in co-curricular activities. An example is the professional learning institute that provides students with various workshops, presentations, and opportunities on what is more known as generic professional skills such as cross-cultural communication and teamwork (Siller et al., 2009). Another work done is the Integrated Design Engineering Assessment and Learning System (IDEALS) which integrates learning that better supports students' professional development [18]. The 6-step IDEALS model (Initiate, Define, Execute, Assess, Learn, Show) promise to promote more of an active, reflective, and constructive social learning intervention that would guide students from problem scoping to concept generation and solution realization. Most institutions follow guidelines from accreditation agencies such as ABET but decide on their co-curricular programming in their unique ways [19]. Some institutions for example incentivize engagement in certain co-curricular activities by creating e-portfolios or co-curricular passports that may be reflected in student transcripts or showcased to potential employers [18], [20], [21].

It is still unclear in the engineering education literature which co-curricular activities are beneficial, in what ways, and to whom [3], [5]–[7]. There are, for example, divergent findings around the efficacy of paid versus voluntary work as past research has found paid work particularly useful for students' development of "soft skills" [4]. The benefits of paid work on students' discipline-based learning have also been expressed [22], [23]. Yet, others caution about the value of paid work that is not relevant to the discipline [24], [25]. Furthermore, there are reported issues with student self-assessment of professional skills. Students are seen rating themselves high for career competencies, believing they are ready for the workforce, and employers find otherwise [26]. To gain an understanding of the utility of different co-curricular activities on student learning, engineering programs or institutions may wish to evaluate student reflective responses on their co-curricular engagements through conducting surveys. This can in turn help the institution to identify current roadblocks and advise co-curricular activities that are more supportive of professional development in students as outlined by accreditation agencies such as ABET [19]. In this work, we consider as a starting point, an analysis of students' self-reported perceptions and performances towards their engagement in a co-curricular space they had only participated in a year and compare across different types of co-curricular activities.

Methods

We wish to compare the self-reported responses of students who participated in different co-curricular experiences once in a co-curricular during an identical year. Because we do not have much insight from the literature on how involvement in different co-curricular types influences students' efforts and outcomes, we use grounded theory as our methodological framework. Instead of using a theoretical framework to guide our analysis, grounded theory aims to find insight and trends of a research question from the data [27]. We hypothesize that students' self-reported efforts and outcomes (i.e., s professional skills gained, time spent, courses utilized, roles described) are significantly different between co-curricular activities, which may act as a potential barrier and justification to students' inconsistent participation in different co-curricular activities. This analysis can provide some clues as to why students under participate in certain co-curricular activities. The self-reported student data collected from the PDS survey can help find the degree to which each co-curricular is on average demanding in terms of semesters and curricular course concepts used. Further, analysis of students' professional skills gained and roles described can tell us the contribution of each co-curricular to students' professional formation and the tasks that are being operationalized in each co-curricular.

Data collection and processing

We analyze de-identified records data that were collected from the PDS survey during 2018 and contained student self-reported experiences from the year before (2017-2018). The student responded to the survey at the end of the year for each experience they had participated in. We took data from students who only had one engagement during the year. The PDS survey provides several questions, some of which are identical across different co-curricular experiences. Student responses to identical questions that were part of the PDS survey, therefore, were used as our data collection instrument. For each type of co-curricular activity reported by a student, the survey asks them to 1) indicate the number of semesters of participation (fall, spring, winter, summer), 2) indicate the curricular courses they utilized in that engagement, 3) describe their role and responsibilities, and 4) Select the types of skills they developed from a list 10: Critical thinking/problem solving, Engineering design, including use of relevant codes/standards, Foreign language, Use of appropriate computer technology, Use of engineering tool, Oral/written communication, Teamwork/collaboration, Leadership, Professionalism/work ethic/integrity, and Project/time management.

Inclusion criteria were students who had participated in one offering only and neither did multiple offerings within a co-curricular space nor engaged in multiple spaces (between measures/co-curricular activities) across the four terms. A total of 2591 students reported participation in unique co-curricular activities and were used in our analysis. At our institution, students self-report on their commitment and professional skills gained per co-curricular engagement to report their participation in different co-curricular experiences (either Research, Intramurals. Clubs, Service, Non-technical, or Technical) from the prior year.

Data analysis

For data analysis, we took student responses to the Professional development survey responded in 2018 which covered student engagements from 2017-to 2018. We then extracted data from those who participated in only one type of co-curricular activity and further extracted data from those who participated only once in that type of experience. We then removed participants who had partially responded to questions used in our analysis.

The data analysis included descriptive and statistical analysis of outcomes data between the six co-curricular activities (i.e., Research, Technical, Non-technical, Research, Clubs, Intramurals) with the frequency count of students' self-reported roles and responsibilities. The outcomes data analyzed across co-curricular streams were:

- Individual and total of professional skills self-selected from a set of 10,
- Total curricular courses utilized,
- Total semesters spent,
- Raw word count of the role described, followed by,
- Processed word count of 10 most frequently noted words by students in each co-curricular stream,
- Processed word cloud summary of 100 most frequently noted words by students in each co-curricular stream.

We carried out descriptive summaries in the form of cross-tabulation. But since the participant sizes across the co-curricular streams were unequal, we divided the total count by the sample size of that group and derived a normalized ratio. The ratio would imply the acquisition of each outcome on average per person. Intuitively, we would want this value for skill acquisition to be 1 or higher and not less than 0.5. For statistical analysis between groups the Kruskal Wallis test ($p<.05$) was used as this test assumes that all observations are independent, and the data is non-normal. When statistically significant differences were found, the effect size was calculated based on the following formula [28], with effect sizes categorized as small ($r \leq 0.1$), medium ($0.1 < r \leq 0.3$), or large ($r \geq 0.5$) and reported together with the ranking of the differences. The qualitative analysis considered a content analysis of student's open-ended responses on their roles and responsibilities and included tokenizing each response, removing stop words, normalizing words, erasing punctuation, removing infrequent words, and creating a 10 most frequent word distribution and 100 most frequent word cloud summaries of student responses for each of the six co-curricular activities [29].

Results

The descriptive and statistical summary of student skills developed, curricular courses utilized, semesters spent, and the raw word count of the role described across the six co-curricular activities are presented in Tables 1 and 2, respectively. The participation size across the co-curricular activities varied, with the highest participation attributed to Clubs (n=957), Non-technical (n=761), Technical (n=647), followed by Research (n=128), Service (n=64), and

Intramurals (n=34) experiences, as shown in Table 1. For descriptive analysis that can allow comparison of co-curricular activities, participant outcomes are normalized by their associate group size.

On average and across all co-curricular activities combined students gain 4.97 skills (out of 10 available), utilize 3.13 courses, and spend 1.65 semesters per experience. Students also on average used approximately 25 words (unprocessed raw word count) to describe their role, activity, or responsibilities. Taking a closer look at the composition of skills developed per experience, we found: "Teamwork/collaboration" is most frequently reported (0.82 times per experience), followed by "Oral/written communication" (0.68), "Critical thinking/problem solving" (0.67), “Professionalism/work ethic/integrity” (0.62), “Project/time management” (0.57), "Leadership" (0.47), “Use of appropriate computer technology” (0.40), “Engineering design, including use of relevant codes/standards” (0.38), “Use of engineering tool” (0.3), and “Foreign language” (0.10). Since co-curricular activities often require individuals to join as a group and work together, it may be understandable to have "Teamwork/collaboration" and "Oral/written communication" as the most highly used skill per any experience. However, what is concerning is that skills that are more closely tied to the engineering practice such as engineering design appear at the bottom and show to be the skills least gained on average by the students for a co-curricular experience.

We also visually depict the quality of skill gained on average per student in each co-curricular activity through color shading in Table 1. A darker shade of gray implies an improved and higher quality of attainment whereas a shade of yellow denotes that the quality attained was less than 0.5 and insufficient. The skill “Foreign Language” was seen as yellow and hence underdeveloped for all co-curricular activities. This makes sense since almost all of the engagements were happening in North America or English-speaking spaces. Besides “Foreign Language” the remaining skills were acquired to different extents across the different co-curricular activities. Some information that can be deduced from Table 1 is:

- Technical work experience to enable attainment (student self-reported) of the highest number of professional skills (9/10),
- Service and Intramurals enable the attainment of the fewest professional skills (5/10),
- Skills that most relate to the engineering discipline such as “Engineering design, including use of relevant codes/standards”, “Use of appropriate computer technology”, and “Use of engineering tool” to be underdeveloped in Non-technical, Service, Clubs, and to some extent in Intramural activities,
- Research and Technical work experiences enable students to utilize their curricular learnings the most (5.8 and 5.3 courses respectively), followed by Intramurals (3.5), Clubs (2.3), Service (1.2), and Non-technical experiences (0.7),
- Clubs require student time involvement the most (2.1 semesters), followed by Non-technical (2), Service (1.7), Research (1.6), Technical (1.4), and Intramurals (1.1),
- Intramurals entail the highest number of words (unprocessed raw) for when students are describing their roles and responsibilities (30.9 words), followed by Research (35.2), Technical (26.3), Service (19.7), Non-technical (18.8), and Clubs (18.7). The use of more words may signal students’ level of understanding of their roles and duties. It may also cue the breadth and depth of work expected in different co-curricular activities (i.e., fewer words imply smaller work scope).

For most of the 10 professional skills and the total number of skills (out of 10) combined, students self-report gaining all skills at a significantly higher rate in Technical work experiences as compared to all other co-curricular activities, and particularly against Non-technical, service, and Clubs, as shown in Table 2. Students seem to perceive Technical work experiences as more valuable for professional development and most connected to their curricular learning (higher ratio of courses utilized). This is particularly the case for “Engineering design, including use of relevant codes/standards” and “Use of appropriate computer technology” that have larger effect sizes. However, despite the higher value students place on technical work experiences, they self-report having a significantly lower time of exposure to Technical work experiences as compared to Non-technical, Service, and Clubs.

After processing student responses (e.g., tokenizing each response, removing stop words, normalizing words, erasing punctuation, removing infrequent words) the top 10 words most frequently noted along with their counts were derived and are summarized in Table 3. As expected, the frequency counts are different since participation sizes varied across co-curricular activities. But the counts normalized by sample size could help us make comparisons. We see that there are some terms shared across co-curricular activities which we have color-coded in Table 3. Overall, the term "Work" is often noted across all (6) co-curricular activities, follow by "Design" (5), Student (4), Responsible/Responsibility (3), Project (3), Team/Group (3), Engineer/Engineering (2), Clean (2), and Make/Create (2). On the other hand, there are some most frequently noted words that are unique to each co-curricular stream. They are

- Technical: Intern, Test, Software, Construction,
- Non-technical: Customer, Food, Store, Order, Cashier,
- Research: Datum, Lab, Experiment,
- Service: Volunteer, Community, Service, School, Buffalo,
- Clubs: Club, Member, Meeting, Participate,
- Intramurals: System, 3D, Need.

We further created word cloud summaries (Top 100 words) from the role responses (processed) of students within each co-curricular activity and illustrate them in Appendix Figure 1. An observation around the top 100 frequent words is that they are mostly verbs (e.g., design, test) and nouns (software, experiment) that are generic and lack the theoretical engineering details that follow such verbs or nouns. None of the word cloud summaries exhibit technical names or theories from engineering, emphasizing that students at large are not frequently assigned to carry out tasks from similar theoretical topics but rather they are expected of more general non-theoretical duties or theoretical duties that are highly specific per individual, hence lacking frequency. An alternative explanation may be that students find themselves explaining their work in a few sentences to an unknown audience via the PDS survey and may be inclined to describe it in simple and jargon-free terms.

Table 1. Participant's outcome on average (normalized by n), a darker shade implies higher skills gained (yellow < cutoff 0.5 insufficient)

a. "Critical thinking/problem solving"
b. "Engineering design, including use of relevant codes/standards"
c. "Foreign language"
d. "Use of appropriate computer technology"
e. "Use of engineering tool"
f. "Oral/written communication"
g. "Teamwork/collaboration"
h. "Leadership"
i. "Professionalism/work ethic/integrity"
j. "Project/time management"

	n	Total skills reported	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	Total curricular courses utilized	Total semesters spent	Raw word count of role
Technical	647	6.5	0.9	0.7	0.1	0.7	0.5	0.8	0.8	0.5	0.8	0.8	5.3	1.4	26.3
Non-technical	761	4.2	0.5	0.0	0.1	0.2	0.0	0.7	0.8	0.5	0.8	0.5	0.7	2.0	18.8
Research	128	5.5	0.8	0.6	0.1	0.7	0.6	0.6	0.7	0.3	0.6	0.6	5.8	1.6	35.2
Service	64	4.0	0.5	0.1	0.2	0.1	0.1	0.7	0.8	0.6	0.6	0.4	1.2	1.7	19.7
Clubs	957	4.4	0.5	0.3	0.1	0.3	0.2	0.6	0.8	0.6	0.5	0.5	2.3	2.1	18.7
Intramurals	34	5.2	0.8	0.6	0.0	0.4	0.4	0.7	1.0	0.3	0.4	0.6	3.5	1.1	30.9
Average combined	**-**	**4.97**	**0.67**	**0.38**	**0.10**	**0.40**	**0.30**	**0.68**	**0.82**	**0.47**	**0.62**	**0.57**	**3.13**	**1.65**	**24.93**

Table 2. Statistical test between self-reported skills of different co-curricular activities, Kruskal Wallis test on non-parametric data (*p*<.05), and effect size

Variable statistical test was done	Significant differences	Effect size
Word count combined	**Research** > **Technical** > **Non-technical**, **and** **Clubs**	0.2, small
a.	**Technical** > **Non-technical**, **Service**, **and** **Clubs**	0.3, medium
b.	**Technical** > **Non-technical**, **Service**, **and** **Clubs**	0.5, large
c.	**N/A**	0.1, small
d.	**Technical** > **Non-technical**, **Service**, **and** **Clubs**	0.5, large
e.	**Technical** > **Non-technical**, **Service**, **Clubs**, **and** **Intramurals**	0.4, medium
f.	**Technical** > **Research**, **and** **Clubs**	0.2, small
g.	**N/A**	0.1, small
h.	**Clubs** > **Technical** > **Research**	0.2, small
i.	**Technical** > **Research**, **Service**, **Clubs**, **and** **Intramurals**	0.3, medium
j.	**Technical** > **Non-technical**, **Service**, **and** **Clubs**	0.2, small
Skills combined	**Technical** > **All Remaining Co-curricular**	0.4, medium
Number of relevant courses	**Technical** > **Non-technical**, **Service**, **and** **Clubs**	0.6, large
Number of semesters	**Non-technical**, **Service**, **and** **Clubs** > **Technical**	0.4, medium

Table 3. Participant's top 10 most frequently noted words (processed data) in each co-curricular stream with their frequency counts and frequency counts normalized by co-curricular sample size

	Technical	Non-technical	Research	Service	Clubs	Intramurals
n	*647*	*761*	*128*	*64*	*957*	*34*
1	**Intern 298, 46%**	**Customer 229, 30%**	**Research 71, 55%**	Help 18, 28%	**Club 287, 30%**	Work 12, 35%
2	Work 255, 39%	Work 215, 28%	Project 47, 37%	**Volunteer 15, 23%**	Team 189, 20%	Team 9, 26%
3	Engineer 192, 30%	Help 100, 13%	Work 37, 29%	Work 10, 16%	Event 180, 19%	Design 8, 24%
4	Project 172, 27%	**Food 97, 13%**	**Datum 21, 16%**	**Community 9, 14%**	Work 133, 14%	Project 8, 24%
5	Design 113, 17%	**Make 95, 12%**	**Lab 20, 16%**	Assist 8, 13%	**Member 130, 14%**	**System 7, 21%**
6	Engineering 108, 17%	Clean 91, 12%	**Experiment 20, 16%**	**Service 8, 13%**	Design 110, 11%	**3D 6, 18%**
7	**Test 94, 15%**	**Store 88, 12%**	Design 19, 15%	Clean 8, 13%	Help 102, 11%	Group 6, 18%
8	**Software 77, 12%**	**Order 74, 10%**	Student 18, 14%	Student 8, 13%	**Meeting 96, 10%**	Student 6, 18%
9	Responsible 71, 11%	Responsible 66, 9%	**Create 18, 14%**	**School 8, 13%**	Student 96, 10%	**Need 5, 15%**
10	**Construction 71, 11%**	**Cashier 61, 8%**	Responsibility 18, 14%	**Buffalo 7, 11%**	**Participate 92, 10%**	Engineering 5, 15%

Discussion

We were motivated to understand how student engagement in different co-curricular activities influences efforts and professional learning outcomes [7]. Institutions and engineering programs aim to create a holistic educational experience for students with an eye for competencies that are deemed essential by accreditation bodies such as ABET [30]. Professional development, therefore, is expected to happen anywhere and everywhere from curricular to co-curricular experiences. We wished to put the hypothesis to test on whether engineering students perceive to gain similar skills when participating in different co-curricular activities. The findings showed that students significantly rate Technical work experiences higher than other co-curricular activities for most of their professional skills. Students also self-report utilizing a significantly higher number of curricular courses in their technical work experience as compared to Non-technical, Service, and Clubs. However, students also self-report spending a significantly higher number of semesters participating in Non-technical, Service, and Clubs as compared to technical work experiences. Our frequency count analysis of students' self-reported roles showed there to be both similarities and differences in the work performed across the six co-curricular activities. When looking at the top 10 most frequently noted words, some terms appear across multiple co-curricular activities but can be considered generic or opening terms such as "work", "project", and "student". Terms that are important to the discipline such as design also come across multiple co-curricular activities, but their frequency varied (Intramurals had the most frequency count, followed by Technical, Research, and Clubs), with their percentage frequency noted being relatively low (between 11% to 24%). Some terms are unique and local to each co-curricular stream. Looking at the word cloud and top 10 most frequent words combined, we see the following trends:

- Technical: Tasks related to software development and testing, construction projects, and product and system integration,
- Non-technical: Tasks that face the customer on a technology-mediated end or face-to-face, such as shops and services,
- Research: Tasks related to data collection and analysis and following supervisor's or research guidelines and research plan,
- Service: Tasks related to volunteer work and community service such as working with kids, the elderly, religious centers,
- Clubs: Tasks related to event planning and participation, and activities in the form of games, social events, or competitions,
- Intramurals: Tasks related to fictitious or non-fictitious small-scale projects assigned to students such as 3D printing, energy conservation, and their information requirements gathering (formal design steps were not necessarily taken).

The shared terminology seen in the word cloud summaries of co-curricular activities may give the impression that co-curricular activities are not that different after all. However, we must pay attention to the differences in the activities and expectations between and within such co-curricular activities. For example, a non-technical student may have been a cashier and denote the use of tools as their skills gained because they were working with a point-of-sale terminal device. Another student in the same stream may have been working as a mechanic and denote gaining the same skill. Both had non-technical work experiences with using a tool, but their use of tools does not have the same level of complexity or require engineering-related knowledge. Mapping this idea across co-curricular activities, we can quickly find a major reason why the assessment of professional skills can become difficult. The context and requirements for each professional skill may vastly change from one co-curricular activity to another, making the comparison and classification of professional skills and their evaluation as competencies difficult.

While the motives for students' higher participation in Technical, Non-technical, and Clubs as compared to Intramural, Service, and Research experiences may vary and not be deduced from our data analysis, we speculate that financial compensation and job security offered in non-technical and technical work experiences, as well as flexibility and social aspects of clubs, might be a reason for higher student participation. The large student participation in clubs which is an unpaid experience seemed surprising to us. Our analysis of self-reported roles and responsibilities revealed that a sizable percentage of students see clubs as a place of social gathering and engagement in sports, arts, and cultural events, and for not learning theories or practicing technical skills or competencies that are more directly related to engineering (e.g., robotics). The lack of structure or supervision in clubs may seem attractive to engineering students who may be continuously evaluated in their classrooms. A larger population of students choose to spend their time and energy outside the class on social events that may provide less direct support for their engineering profession. Students also spend a variable length of time on different co-curricular activities and put their curricular learning into use differently.

The dominant regard for Technical as compared to other co-curricular activities has drawbacks for student learning. Even if students are practicing something remotely technical in a technical work experience, they may perceive it more seriously or find it to be more important and educational than other experiences such as research or intramural or clubs, because of where it occurs. Our findings suggested that from the 10 professional skills elicited, ones that more closely relate to the engineering discipline (i.e., Engineering design, including use of relevant codes/standards, Use of appropriate computer technology, Use of engineering tool) are less often developed even in technical work experiences. Students may mistakenly think that engineering design is only what they had experienced in their first-year design or capstone course. However, engineering students may be unknowingly using elements of design thinking in their engagements [31], [32]. For example, even in non-technical work experiences, students use creative concept development to solve small problems that arise. Students may be thus undervaluing certain experiences in terms of what they develop and so more needs to be done to help students in recognizing professional skills.

Institutions wish to help the engineering students' professional development through co-curricular spaces [11]. The way co-curricular activities are implemented and administered may fail and/or students may fail to acknowledge or pay attention to learning moments that may be granted through such spaces [14]. Further, the socio-economic classifications may taint how students see co-curricular activities and what they (can) make of them. As echoed by the students, technical work experiences offer a more authentic engineering educational experience than non-technical paid work. And so institutional and industry efforts should be put into making technical work experiences more accessible or if not possible simulated in on-campus co-curricular activities (e.g., clubs, intramurals). At the same time, the culture of the institution should not promote technical work experiences, at the cost of endangering and underscoring other co-curricular activities.

The goal of the institution is to instill engineering professionalism through co-curricular activities, yet our findings suggest students are spending more of the outside the classroom time on experiences that do not allow them to more directly link their curricular learning to the real world and this could be seen as a missed opportunity to provide student insight on engineering practice. Many participants view co-curricular engagement as more of leisurely activity. Yet even if we regard them as leisurely activities, only a fraction of students enrolled in engineering programs participate in co-curricular activities, perhaps due to the rigor and demands of the engineering curriculum [33]. Work by Crawford et al. denotes students also face constraints in participating in leisurely activities. Their work poses that students' choice of leisurely activity may be influenced by interpersonal (e.g., not finding partners), intrapersonal (e.g., work tension or unskilled), and structural (e.g., excessive cost, lack of availability) factors [34]. Using frameworks such as the leisurely activity hierarchy, institutions can attempt to find: a) what factors are deemed as leisurely/refreshing in co-curricular experiences and how they can be infused in all types of co-curricular activities and b) what interpersonal, intrapersonal, and structural factors, particularly for what populations and under what circumstances, come to influence student engagement in co-curricular activities.

Our between measures analysis at a cross-section of time reveals what portion of the population ended up engaging in what type of co-curricular activities. One key factor to consider is that the data reveals what the students turned out to participate in, not what they wished or had initially intended to engage in. For example, we may find that more students wanted to take part in technical work experiences but did not have the resources or skills to land a technical or research job and so had to turn to non-technical work experiences. Similarly, students may have wished to participate in engineering intramurals but did not have the support or encouragement they needed from a team and had to turn to clubs. The infrastructure of each of these co-curricular activities, their budget, and their capacity to attract students can thus play a role in student participation. Conducting a between measures analysis allowed us to compare students with one co-curricular activity workload at a cross-section in time. However, the length of engagement was dependent on students' preferences and curricular workload and so varied (one up to four semesters). Further, it was up to the students to respond to the PDS survey for each of their co-curricular engagements. So, a limitation of our work is that it may contain data from students who were participating in more than one co-curricular activity, but had filled in the survey for one experience only. Future work may wish to explore the trends in student participation more fully and in a longitudinal fashion with follow-up interviews and discussions with the students to gain more insight into their assumptions and goals. Also, more work needs to be done in defining what primary and secondary professional skills are and how students' various skills development contributes to each and their formation as engineering professionals. Potential future research is to explore the role of flipping learning in both curricular and co-curricular spaces, enabling co-curricular reflection in curricula as well as supporting PDS to collect data from both the students and academic and industry administrators.

Conclusion

Following the need to identify how students engage in different co-curricular activities, we analyzed self-reported participation trends of a cohort of students who had engaged in only one unique co-curricular activity (either Research, Technical, Non-technical, Service, Intramurals, Clubs) during the year. Results of descriptive and inferential analysis between co-curricular activities revealed students self-report gaining a significantly higher number and type of professional skills in the Technical work experiences as compared to others. Career security may be a driving factor for students to turn towards technical work experiences or perceive them to develop a higher number of professional skills as compared to unpaid co-curricular activities. Our analysis of students' self-report professional skills obtained (out of 10), time spent, and several curricular courses utilized per experience at snapshots in time can help us gain a better understanding of what most of the students make of different co-curricular spaces. This can inform how to level the learning environments by introducing non-financial but comparable forms of educational incentives in unpaid co-curricular spaces.

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Appendix

Word cloud summary of top 100 most frequently noted terms by students in different co-curricular activities

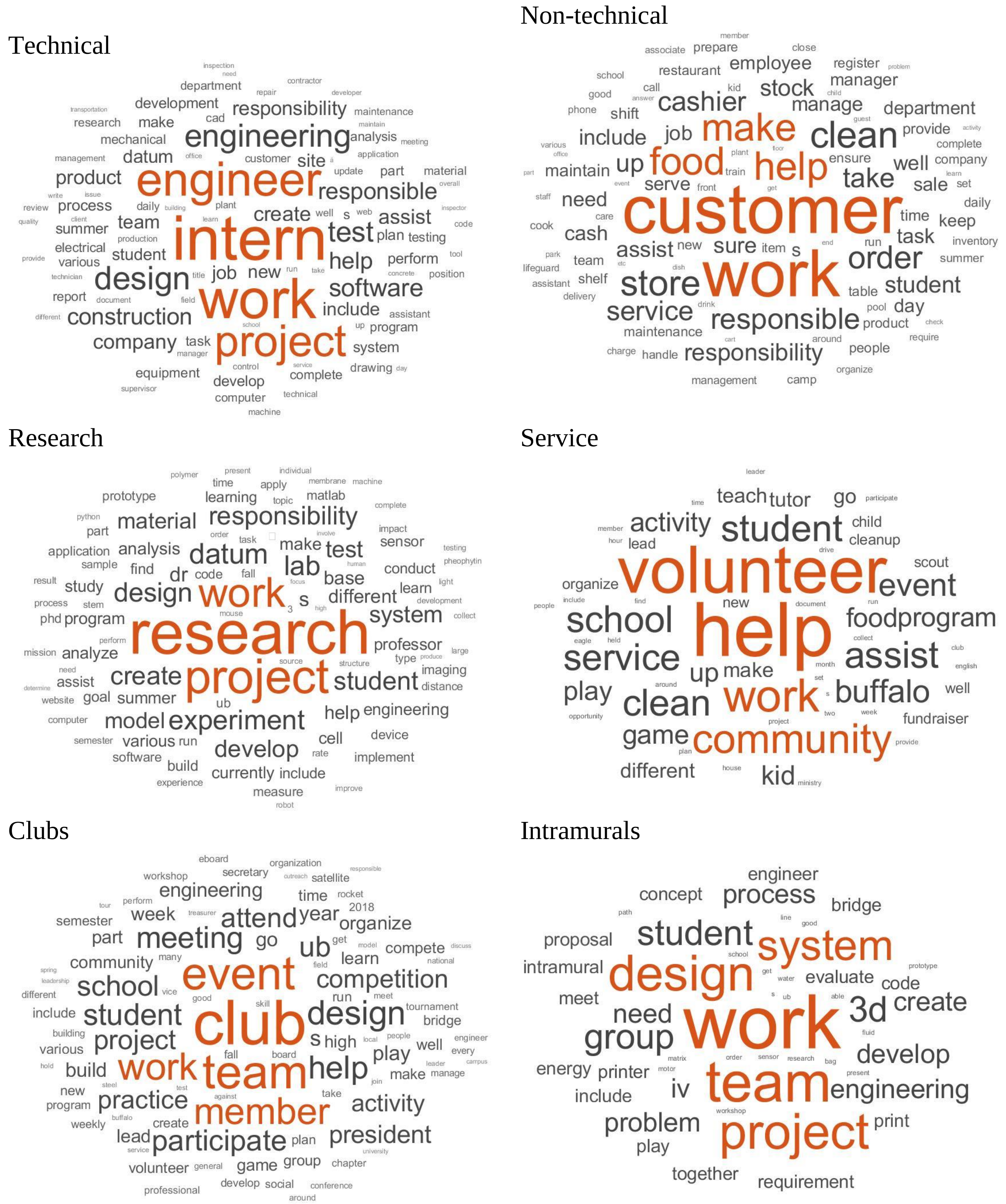

Figure 1. Word cloud of roles described (top 100) by students in different co-curricular activities