WIP: Understanding the Experiences of Women Engineering Students that Depart from Engineering Design Clubs

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***Abstract*—This WIP research paper investigates the experiences of women undergraduate engineering students that depart (stop participating) from engineering design clubs. A pilot phenomenological analysis of interviews from three students identifies sense of belonging and alignment of expectations between club and member as key elements of design club participation.**

***Index Terms*—extracurricular, design projects, retention**

I. Introduction

One of the most undervalued resources in higher education is student time [1]. The challenge for educational institutions, thus, becomes using students' time inside and outside the classroom to the maximum extent to achieve educational outcomes. In an engineering education context, out-of-class activities (e.g., clubs, research, internships) have been lauded for contributing to technical education, professional development, and persistence [2]. However, many engineering students do not participate in these activities due to an already time-intensive course schedule.

Engineering student organizations that focus on engineering design are a common extracurricular opportunity that allows students to pursue technical interests outside the classroom. While 40.4% of engineering students listed a design or research based activity as one of their two most significant extracurriculars [3], a majority of engineering students do not participate in these high impact activities. Women are especially underrepresented in engineering extracurriculars [4] despite women being more likely to participate in out-of-class activities than men [5]. Motivations for club participation have been investigated [3], [6], but there is a dearth of research on barriers that discourage or prevent participation [7].

This study focuses on the understudied population of women undergraduate engineering students that joined an engineering design club and subsequently became inactive or left the organization. Using a phenomenological analysis for the pilot of this project, we seek to determine the personal experiences that contribute to club departure and the interactions of personal decision-making with structures of the institutional context. This study is guided by the following research questions: 1) What are the key essences of women undergraduate engineering students' experience departing from an engineering design club after previously being an active member?, and 2) What contexts or environmental factors have contributed to women undergraduate engineering students' experience of departing an engineering design club?

II. Background

A. Engineering Out-of-Class Involvement

A large body of literature in higher education and student affairs supports the idea that out-of-class activities are a quintessential part of the college experience [8]. In general, engineers are less involved in out-of-class activities compared to other majors [2]. Limited time due to coursework is one explanation for the difference. In a large-scale assessment of the differences between engineering and other majors, Lichtenstein and colleagues found that engineering majors spend significantly more time on coursework [9]. Once necessary activities (e.g., homework, sleep, job) are completed, engineering students only have an estimated 19 hours of residual time per week to devote to out-of-class activities [10]. Despite curricular demands, 66% of engineers participate weekly in a wide variety of out-of-class activities [3] and spend an average of six hours per week [11]. Job, sports, and design competition teams were the three most common "most significant activities" in a survey of 845 undergraduate engineering students, each with more than 10% of responses [4]. When investigating what motivates engineering students to participate in out-of-class activities, Johnson and Main found that the three most common reasons were to fulfill personal interest, to make friends or find community, and to socialize with other students [3].

Beyond opportunities to make friends and socialize, out-of-class activities foster a plethora of benefits. In a meta-analysis of benefits of out-of-class participation, intellectual development and career and professional development were the most cited outcomes [2]. Professional skills, namely teamwork and leadership, are also common outcomes of out-of-class activities due to their student-directed nature [12]–[14].

The list of positive outcomes that have been linked with out-of-class involvement is lengthy, but there are negative outcomes that accompany the positives. Finelli et al. cite over-involvement outside of class as a threat to academic integrity and ethical development of engineers [15]. Participation out-of-class also varies by gender and ethnic group [4]; activities geared towards engineers, like design competition teams, tend to favor men and majority ethnic backgrounds. So, not only do the outcomes vary extensively by activity, participation also varies by person. This variety necessitates a narrower focus. We chose to focus on the experiences of women in engineering design clubs due to the underrepresentation of women in these activities and the connection between design clubs and engineering practice.

B. Engineering Design Clubs

Design competition teams were one of the three most common activities in the Simmons et al. survey of over 800 students [4], and the Design/Research category was the second most popular activity category in Johnson and Main's survey [3]. Clearly, design-based activities are important to engineering students. Engineering clubs are student-led organizations that can be sorted into many types beyond those focused on design, including professional societies (e.g., ASCE, IEEE, BMES), and affinity groups (e.g., SWE, NSBE, SHPE) [16]. Examples of design teams are competition teams (e.g., Formula/Baja SAE, Concrete Canoe, Robotics) and community focused groups (e.g., Engineers without Borders, Runway of Dreams) [17]. Engineering design clubs (EDCs) are characterized by a technical focus, hands-on prototyping, and student-led organizational structure [6]. Very few studies have focused solely on engineering clubs. The few that do focus on EDCs (e.g., [6], [13], [18])—and the majority of studies on all types of out-of-class activities in engineering—focus on student motivation or outcomes from EDC participation. However, this focus on outcomes often results in inconclusive and inconsistent results [11]. Previous studies have employed a black-box approach that only considers the inputs (motivation to join) and outputs (educational outcomes) of EDC participation without examining the student experience within the club. This study utilizes a qualitative approach to interrogate the realities of EDC participation and departure, filling the 'black box' with lived experience.

C. Theoretical Framework

Although less permanent or life-changing than an institutional departure, the act of leaving an extracurricular organization is a form of student departure. To gain the best sense of this experience, we turn to Astin's involvement theory for a student-centered framework of departure [1]. Involvement, according to Astin, is "the amount of physical or psychological energy that the student devotes to an academic experience" [1, p. 518], and involvement is an essential ingredient of learning. Involvement theory is also a common framework to study co- and extra-curricular spaces in STEM disciplines [12], [16]. In this study, involvement theory directs our focus to the ways that clubs and institutions can increase involvement in the high impact activity of engineering design clubs. The theoretical framework was employed as a sensitizing concept during study planning, source of interview questions, and a lens for synthesis of in-vivo codes.

III. Methods

This study employs a phenomenological methodology [19] to distill the essence of experiences when women engineering students depart from EDCs. The principles of phenomenology guided all decisions in study design, and all procedures were approved by the IRB at Virginia Tech.

A. Recruitment & Sampling

To obtain a diverse array of student perspectives on the phenomenon, the researchers recruited participants from a variety of EDCs at two institutions. Virginia Tech, a large, public university in the Mid-Atlantic region of the US, was the primary location of the study. Only one participant studies at Duke University, a medium-sized, private university in the Mid-Atlantic. EDCs were identified through a central university website that lists registered student organizations. Criteria for organizations to be classified as an EDC were as follows: members work on team(s), the goal of the organization is to design and build a physical device, membership is more than 50% engineering students, and the organization holds in-person meetings [18]. Two participants from EDCs agreed to an interview. Both participants that agreed to an interview were selected. To gain an additional perspective, a third participant was recruited from Duke University via convenience sampling. Self-described demographics of the participants are included in Table 1. We did not originally plan to focus only on women and recruited club members of all genders. When all the participants were women, we chose to narrow our focus to investigate how women experience club departure as an underrepresented group in EDCs.

Pseudonym	School	Race/Ethnicity	Class Year	Major
Clara	A	Hispanic, White	Sophomore	Civil Eng.
Juliet	B	White	Sophomore	Mech. Eng.
Rose	A	Jewish	5th Year	Civil Eng.

TABLE I
PARTICIPANT DEMOGRAPHICS

B. Data Collection & Analysis

All three participants completed one semi-structured interview, approximately one hour in length [20]. Sample interview questions include: "Can you tell me the story of your involvement in [EDC]?" and "Do you think your life is different because of the change in your extracurricular participation?" Interview data was analyzed using a four-step phenomenological analysis process [19]. To bracket personal presuppositions, reflexive memos were written by the first author throughout analysis of interview transcripts [21]. Each interview transcript was read in its entirety to gain a holistic sense of the experience. Notable excerpts were assigned in-vivo codes [22] to

maintain the meaning made by the participant. Examples of in-vivo codes include "it's important that people want to be there" and "it felt like I wasn't wanted there." To synthesize the descriptions, the in-vivo codes were organized into textural descriptions that vividly characterize what was experienced by each participant as they departed their respective EDCs. Textural descriptions were synthesized into essences of the phenomenon [19]. Participant quotes are relied upon for description to maintain multivocality and credibility [23].

C. Researcher Positionality

Acknowledging one's subjective understandings is a way to increase quality of social science research [24]. The first author's experience as a woman and former member of engineering design clubs during her undergraduate degree allowed her to build rapport with participants. However, her identity as a White person may have prevented her from seeing systems of oppression present in student organization spaces that were salient for participants of different racial/ethnic identities.
Regarding data analysis and interpretation, we believe that extracurricular participation in EDCs provides a unique type of beneficial involvement for engineering students. While committed to the epoche required of a phenomenology, we hope that the findings of this study can identify ways to increase access to EDCs.

IV. Findings

Through a synthesis of the textural descriptions from Juliet, Rose, and Clara, two distinct elements of the phenomenon emerged.

A. Lack of Early Sense of Belonging as a Push Factor

Participation in an EDC typically begins with a club fair or recruitment email followed by an interest meeting. What happens after the interest meeting differs by organization, but the early engagement of members is key to their retention. Participants of this study found some engineering clubs to be welcoming, while others had established social groups that were difficult to penetrate. Juliet tried to join an affinity group for Hispanic engineers during her first year, but found that "everyone was very, very close, but so close that it felt like they were a friend group, and I was just kind of like the awkward one there." Engaging with existing members can help the prospective members feel wanted in the club community. If they were not actively welcomed into the group, participants did not begin to develop a sense of belonging in the club environment. This is illustrated by Clara's experience:

> I actually at first absolutely hated it, like, I just forced myself to go to meetings because I just felt incredibly awkward and felt like I couldn't, like, I didn't know what I was doing… I also feel like at the time the culture was kind of like everyone had their own little project, and then like, didn't really look up to welcome people in who weren't already ingrained in the group.

Clara was very interested in the technical focus of this EDC, but her interaction with the design was limited because she was not welcomed into a project.
Sense of belonging was also measured in relation to the perceived norms of the organization. When Juliet was a sophomore, she joined a competition team for civil engineers. Some of the meetings took place in a lab off-campus. Before the first meeting at the lab, Juliet faced a conflict:

> I was like, well, actually, I'm busy this weekend, but I could probably do next weekend. But then I saw in the group chat that, like, people were organizing rides, and I was like, once you have rides, I feel like everything's set.

A previous engagement for one week may seem trivial, but this experience was a major contributor to her eventual departure from the team. She perceived the organization of rides to the lab as a permanent norm, a norm where she was not included. As a new member, she did not yet have the connections to reach out to other members or find alternate transportation. This seemingly minor hurdle made Juliet feel as if she was not a member of the team, which had major repercussions on her participation.

B. Differing Expectations Between EDC Leadership and Members Hinder Participation

Expectations are present in every relationship, and this extends to EDCs. Participants each joined organizations with expectations about the activities they would engage in, outcomes they would take away, and ways that the organization would be run. When these expectations did not align with the reality of the EDC, participants had to reconcile the differences. Rose was the co-captain of her competition-focused EDC, but studying abroad made communication of expectations difficult:

> This year I was supposed to be a captain again, but I studied abroad last semester… But it just didn't work out. There wasn't great communication between me and the other cap. Well, I thought I had good communication. But basically it just turned into, like, [the other co-captain] didn't want to put in the effort to, like, have me as a part of the team and she felt like she had enough support where she didn't need me.

Rose's expectations of her involvement while she was abroad did not align with her co-captain, which led to several miscommunications and Rose's eventual departure from the club. When expressing her profound sadness about leaving the EDC, she noted that she did not want to stop participating, but felt like her work was not recognized.

While Rose experienced a difference of expectations within club leadership, alignment between the expectations of leaders and members is just as important, especially as more time passes. For example, after more than a month of weekday meetings, the competition club that Juliet had joined changed the meeting day to Saturday. To Juliet, it felt like a "bait

and switch." She had invested significant energy into this organization to get the requisite safety trainings, but with the change she was now unavailable for the meetings. Juliet is a leader for another EDC, and she believes that it is "student org 101" to know that "if you switch up the meeting time, then you're going to get a different crowd... and that'll probably not be as many people either." Her expectation was that once the meetings started for the semester, the day and time would stay the same. By changing the meeting day, the club leaders violated Juliet's expectations and made it very difficult for her to keep participating. While the participants acknowledged that others are unaware of their personal expectations, actions of EDC leaders were constantly compared to the participants' expectations. In cases where differing expectations could not be reconciled, departing the EDC became a reasonable option.

V. Discussion

A. Research Question 1

The key essences of engineering design club departure are a lack of sense of belonging and differing expectations between the club leaders and members. These essences are present in the textural description of every participant. When considered together, these essences describe women's involvement in EDCs as heavily reliant on interpersonal relationships and implicit assumptions. Relationships with peers and supervisors foster sense of belonging [25], and expectations are more likely aligned if a member interacts with club leadership and other members. Expectations are a form of implicit assumption, but these assumptions are also at play when members perceive group norms and whether they belong in the group. Postulate four in Astin's involvement theory asserts that involvement relies on both quantity and quality of involvement [1]. A member's relationships and assumptions impact the quality of involvement in an EDC, thus impacting the worth of the organization to the student.

The importance of relationships in EDCs aligns with research on students' motivations to join clubs. Johnson and Main found that the second and third most popular reasons for participation in an out of class activity were "to make friends or find community" and "to socialize with other students." If students are looking for community in an EDC and do not find it, they have limited reason to stay in that organization. This is particularly relevant for women in engineering, as an underrepresented group with typically lower sense of belonging in the discipline [26]. The fact that all three participants are women and all experienced events that harmed their sense of belonging in an engineering design space cannot be ignored. When commenting on her EDC departure, Clara mentioned that "[she] missed having another female" in the club after the only other woman went abroad. For women, the challenges of finding out-of-class engineering activities that fit their interests and expectations are compounded by a lack of gender diversity.

B. Research Question 2

Each participant mentioned elements of their unique context that impacted their experience of departure. Due to the synthesizing nature of phenomenology, the elements present across contexts are highlighted. One such environmental element is time. Juliet struggled to continue participating in the competition team once the time was changed to Saturday. Astin refers to student time as a "precious institutional resource" [1, p. 522]. Students have limited free time, and they are unable to become available during class times or previous commitments. In a survey by Buckley and Lee, 32% of respondents said that time was a concern with out-of-class activities [27]. While time constraints made it difficult for participants to be as involved in EDCs as they like, none of the participants mentioned EDCs as a threat to their coursework or other responsibilities. This refutes literature that asserts that out-of-class participation detracts from curricular participation [28].

Another key factor present in all three participants is involvement in other out-of-class activities. While all participants departed from an EDC, two transitioned to a different EDC and one transitioned to other non-engineering activities. This is interesting because it suggests that leaving an EDC did not deter Juliet and Clara from EDC participation in general. This could be explained by a previous study that posits that co-curricular participation can increase technical and academic self-efficacy [11]. Students with higher self-efficacy are more likely to participate and succeed in academic endeavors [29].

C. Limitations

This study is inherently limited by several parts of the design, namely participant diversity, data collection, and confidentiality measures. The participants only represent two racial/ethnic groups, two majors, and two years. While phenomenology relies on the commonality of experience, a diverse sample of participants provides the richest diversity of meaning-making. In this study, we were only able to conduct one interview with each participant. Follow-up interviews could have added additional detail to the participants' stories. Lastly, due to the small number of participants and the detail of their stories, the specific EDCs in which they participated cannot be identified. This limits the ability for club leaders, advisors, and administrators to connect findings to their own organizations. With a larger sample size, it could have been possible to note the specific organizations without connecting them to a participant. Despite limitations, we are confident that the experiences of Juliet, Rose, and Clara represent common essences of club departure for women engineers.

VI. Conclusion & Future Work

This phenomenological study examined the essence of departure from an engineering design club for women undergraduate engineering students. Sense of belonging, relationships, and alignment of expectations were key characteristics for successful participation in EDCs. A deficit in these areas can lead to club departure. This work supports the importance of diverse engineering design clubs with different goals, roles, and levels of commitment. With a wide range of offerings for students to engage with engineering design, the possibility of good alignment between student and student organization

increases. This study also underscores the need for inquiry into the climate within EDCs, not just studies about academic outcomes of EDC participation. Future work will focus on sampling more participants with a diversity of gender, race, major, year, and EDC experience. Since all of the participants in this study transitioned to new forms of out-of-class participation after their departure, a future area of research could pursue students' experience within multiple EDCs or the interaction between engineering and non-engineering out-of-class activities.

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