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An exploratory study on how mechanical engineering undergraduates perceive participation in professional disciplinary engineering student organizations that influence their engineering identity

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Abstract

Involvement in professional disciplinary engineering student organizations (PDESOs) positively influences engineering students' college experience. While extensive research about engineering student societies and organizations has demonstrated various benefits for students, few studies explore professional disciplinary engineering student societies and organizations that provide unique opportunities tailored around specific engineering disciplines. To better understand how participation in PDESOs influences engineering undergraduates, we conducted an exploratory study, interviewing thirteen mechanical engineering undergraduates with six months to three years of experience with PDESOs. The overarching conceptual framework is derived from a combination of motivated identity construction theory and engineering identity, allowing us to see how participation in these organizations contributes to students' engineering identity and professional development. Participants indicated that involvement in PDESOs provided

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unique professional development opportunities that enhanced their self-esteem and efficacy and provided a welcoming environment where they experienced a sense of belonging. These results demonstrate that participation in PDESOs contributes to professional development, interpersonal skills, and community engagement, preparing them for the engineering workforce, which contributes to a strengthened engineering identity.

Keywords
engineering student organizations, engineering identity, identity motives, mechanical engineering education, professional development.

Introduction

Engineering student organizations (ESOs) are ubiquitous among engineering programs. Engineering student organizations have established enriching communities that have become popular among engineering undergraduates. There is a broad range of engineering student organizations such as community-based organizations, professional-disciplinary based organizations, or Greek-based organizations. Professional-disciplinary-based ESO's are of particular interest because of their uniqueness in being tailored around a specific engineering discipline. They have demonstrated to provide participating students with opportunities corresponding to the disciplinary areas, such as academic support, professional development, expanded networks, and hands-on training within a technical domain.[1] These college or university chapter organizations are typically an extension of a national organization that provides the opportunity to compete in a national-level competition with other colleagues from different institutions across the nation. In addition to providing valuable resources to actively participating students, ESOs also contribute to student success[2–4] and students' engineering identity development.[4] Despite the documented benefits of involvement in ESOs, these opportunities do not seem to be available to all undergraduates in an equitable manner. For example, a recent American Society of Mechanical Engineering (ASME) consortium of department heads found that participation in disciplinary engineering student organizations was 20%–35% of the engineering student body with a lower participation among under-represented groups.[5] Given the role ESOs play in students' academic pathways, exploring what drives engineering undergraduates to participate can provide insight into mechanisms that will broaden participation for engineering undergraduates. Therefore, exploring how participation in ESOs contributes to engineering undergraduates' academic success and engineering identity is imperative.

Understanding how the ESO environment impacts engineering undergraduates' participation requires consideration of the underlying motives that may influence how undergraduates see themselves develop through their participation in these organizations. Motivated identity construction theory (MICT) indicates that individuals are motivated to construct their identities through six characteristics.[6,7] Therefore, applying MICT is ideal for understanding how organizations provide a basis for identity construction that

may influence how individuals see themselves.[8] Per MICT, individuals identify with groups (or in this case, organizations) to fulfill one or more of the six characteristics. For purposes of this study, professional disciplinary engineering student organizations are defined as organizations sponsored by academic colleges or departments and consist of a technical project that engages the student in intercollegiate engineering design competitions, such as building a vehicle, robot, or bridge. This study aims to investigate how engineering undergraduates perceive participation in professional disciplinary engineering student organizations (PDESOs) and how these organizations contribute to students' engineering identity.

Literature

Involvement in engineering student organizations has been demonstrated to be an essential engineering undergraduate experience in college. In a research study exploring how student services improve the student experience in higher education, Ciobanu[9] emphasizes that effective student services are necessary to help decrease the student dropout rate. Furthermore, by supplying these important connections, student support services contribute to the quality of students' learning experiences and academic success that meet their academic, personal, or career professional development needs.[9–11] In terms of professional development, student services assist with preparing students for active participation in society, mainly through encouraging and establishing methods of making decisions and rationally resolving conflicts. While student services are generally thought of as academic support services, academic advising, and career services, student organizations, like engineering student organizations, also provide an important outlet for engineering students. In some colleges, an advisor to engineering student organizations is a part of the student services staff. Engineering student organizations offer unique and disciplinary-focused opportunities for engineering students to enrich their experience in higher education. For example, community-based engineering organizations establish communities with similar cultural or ethnic backgrounds and professional-disciplinary organizations focus on career networking and workforce preparation tailored to a specific engineering discipline. Typically, these organizations are an extension of a national organization that organizes intercollegiate competitions, providing students with valuable practical experience, professional development and the opportunity to network with industry.

Social and extracurricular involvement in college can influence several aspects of students' lives. Research on student involvement suggests student organizations positively influence college students because they develop a greater sense of belonging,[12,13] provide unique experiences and opportunities that support leadership development[13,14] and provide a support system to be successful in college.[14,15] These well-designed student organizations construct mechanisms for members to work as a team, supporting and encouraging each other to succeed.[13] In an exploration of student experiences who participated in various student organizations within the field of Psychology, Hall[14] referred to these student organization environments as positive "student-based learning communities." In a different study, Baker[16] examines the effect of extracurricular student

involvement of under-represented college students in six different types of student organizations: athletic organizations, Greek letter organizations, political organizations, religious organizations, arts organizations, and minority-based organizations. Results indicate that under-represented students benefit academically from organizational involvement; however, the type of organization they consider participating in is essential.[16] Although these findings reveal the importance of student involvement in student organizations, Baker[16] noted that the influence of organizational involvement varies by the student's racial and gender identity, and there are additional types of organizations to explore from which students derive academically.

Consistent with the literature on student involvement in organizations, research has also shown that professional disciplinary engineering student organizations positively impact engineering undergraduates. One type of professional disciplinary engineering student organization is tailored around a specific engineering discipline that provides leadership skills, professional development, network opportunities, and peer support in the corresponding engineering discipline.[1,17–20] For instance, the Institute of Electrical and Electronics Engineers (IEEE) serves an engineering field that primarily supports a population of students who primarily want to become electrical engineers and the American Society of Mechanical Engineers (ASME) is an organization with activities that mainly support mechanical engineering students. Examples of other types of engineering student organizations include affinity-based organizations such as the Society of Hispanics Professional Engineers, the National Society of Black Engineers, the Society of Women Engineers, or social/Greek-based organizations such as Phi Sigma Rho (Social sorority for women in engineering and technology) and Sigma Phi Delta (international fraternity for men in engineering).

Research on student involvement in engineering student organizations has demonstrated how participation in these organizations helps develop transferable cognitive and intellectual skills that positively impact career and professional development.[1,19–21] In addition, these professional engineering student organizations have established an environment of outreach and community building for their members that help students embrace campus life, connect them to the institution and provide leadership opportunities.[2,19,20] A unique aspect of these professional disciplinary engineering student organizations is the hands-on experience through engagement in nationwide or international intercollegiate competitions. For example, a study centered around students who participated in an extracurricular activity that required building a race car and participating in an international competition found that these opportunities allowed the ability to put theory learned into practice, an experience that prepared them for their future career.[20] Although studies have shown the positive benefits of student involvement in engineering student organizations, limited research explicitly addresses the positive influence of professional disciplinary engineering student organizations on engineering students' identity.

Engineering identity

Prior research correlates the benefits of involvement in social groups to an individual's identity. Research has shown that people make choices partly because of their identity

and the way in which they see themselves.[22,23] For example, in a study exploring the impact of an individual's need for in-group inclusivity and their need to be distinctive from others, Pickett[22] discusses how participating in social groups can contribute to self-esteem and influence how one sees themselves. One can gain self-esteem by perceiving oneself as a member of important and valued groups that make an individual feel good about themselves.[22] Swann et al.[23] discuss how critical resources that flow from shared social identities and group memberships are social support exchange opportunities. It has been suggested that motives contribute to constructing an identity and identify with social groups that share similar identities.[7,8] In engineering education, engineering students who are part of an engineering student organization are more likely to identify as engineers and commit to an engineering career than students who are not part of these organizations.[18] Additionally, students who identify themselves as engineers in their early educational careers are more likely to successfully complete their college degrees.[17,18,21,24] Early stages' experiences in professional or non-professional engineering contexts are essential to establishing and committing to an engineering identity.[21,24] For example, Godwin[24] describes that students develop an engineering identity during their experiences in an engineering community of practice, and Huff[21] emphasizes how early experiences in various engineering contexts contribute to students' engineering identity that supports students as they transition to new roles in the beginning stages of their engineering career. Prior investigations of engineering identity have focused on whether students consider or see themselves as an engineer and what are the qualities that students describe that are needed to be an engineer. There are also psychological approaches, which focus primarily on engineers' self-perceptions. For example, researchers have explored factors associated with students' self-identification as engineers[25,26] investigated connections between identity and persistence[26] and reviewed intentions to pursue engineering careers. The uniqueness of this study is to explore engineering undergraduates' participation in disciplinary professional engineering student organizations using motivated identity construction theory, which will allow us to see what components are provided by these organizations that contribute to constructing students' engineering identity.

Conceptual framework

The overarching conceptual framework utilized for this study is derived from a body of literature on motivated identity construction theory (MICT) aligned with engineering identity to understand how engineering undergraduates perceive participation in professional disciplinary engineering student organizations (PDESOs) and how these organizations contribute to students' engineering identity. MICT is based on the premise that identity is both a personal and social construction[7] and proposes that psychological needs, called 'identity motives,' predispose people toward seeing themselves in certain ways.[27] Specifically, the theory predicts that individuals will be motivated not only to see themselves in a positive light (the self-esteem motive), but also to believe that their identities are continuous over time despite significant life changes (the continuity motive), that they are distinguished from other people (the distinctiveness motive), that

their lives are meaningful (the meaning motive), that they are competent and capable of influencing their environments (the efficacy motive), and that they are included and accepted by others (the belonging motive).[7] Although all six motives are predicted to be universal, different environments may influence how each motive is met.[7] These six identity motives are defined as "pressures toward certain identity states and away from others, which guide the processes of identity construction."[6] It has been suggested that these motives are involved in the process of defining the self and identifying with social categories.[8,28] For example, Sheldon & Bettencourt[28] state that people commit more strongly to groups that provide them with greater feelings of interpersonal relatedness, a concept synonymous with belonging. Furthermore, an essential outcome of identity is identifying how identity is accepted and internalized as part of the overall self.[8]

As an analytic lens, the use of engineering identity will allow us to explore how engineering contexts influence constructing of undergraduates' engineering identity.[29] Tonso's[4] work on engineering identity describes how identifying as an engineer means finding a sense of belonging within the engineering culture. Stevens et al.[30] present an analytic framework on how students become engineers based on a longitudinal ethnographic inquiry, consisting of three dimensions: disciplinary knowledge, identification, and navigation. Stevens et al.[30] found that identifying with and by others in engineering was important for becoming an engineer. There are other factors that students use to identify as engineers. For example, Meyers et al.[25] found that students identified as engineers because they made "competent design decisions, working with others to share ideas and accepting responsibility." In a study, Rodriguez[29] states that in order to become part of a professional engineering community, students must recognize themselves as "engineering-minded individuals" and be recognized by others. By using an identity theoretical framework, researchers will be able to understand why students decide to participate in engineering student organizations as it relates to their engineering identity. Understanding what factors influence their engineering identity can provide a sense of what motivates the student's decision to join and commit to an organization.

Professional disciplinary ESOs have established an enriched environment that influences engineering undergraduates' decisions to participate. At the same time, through participation, these spaces contribute to fostering the development of students' engineering identity. In order to gain a more comprehensive understanding of the experiences of students in professional engineering organizations, it is pertinent to explore the factors that hinder involvement and that contribute to their engineering identity development. With this in mind, MICT alongside engineering identity is used to explore the following research questions:

- In what ways does participation in disciplinary engineering student organizations relate to students engineering identity motives?

Methods

Understanding students' motives and decision-making is critical for informing mechanisms that encourage their involvement in PDESOs. To address our research question and

gain a rich understanding of participants' experiences related to PDESOs, we used qualitative inquiry and analysis methods.

Study participants

We recruited undergraduate engineering students who were at least 18 years of age from a department that offers mechanical engineering and industrial engineering programs at a large R1 university in the United States. Students were participants in some of the dominant disciplinary professional societies within mechanical engineering, having large numbers of student participation and membership. An online recruitment survey was developed in Qualtrics and was emailed to all undergraduate students in the department during the 2020–2021 academic year. The participants were selected before COVID restrictions, and some interviews were initially conducted in person. However, because of COVID restrictions, the rest of the interviews were conducted online via Zoom. The recruitment survey was designed to elicit basic demographic information, such as major, college year, gender, age, ethnicity, and level of participation in an engineering student organization from respondents. Additionally, the survey concluded with a prompt inquiring about respondents' interest in volunteering to participate in a research interview.

From the recruitment survey responses, we identified and selected participants who were willing to be interviewed using purposeful sampling. A purposeful sampling technique is acceptable because it allows the researcher to achieve intensity and variation in the data by recruiting information-rich participants[31] in relation to the research goals.[32] Through this approach, we selected participants to best help understand what motivates engineering undergraduates to participate in PDESOs. Sample size guidelines suggested for the interview-based method approach typically range from 3–10 interviews to be sufficient.[33] Fugard & Potts[34] recommends more than six participants for interviews as a guideline for conducting thematic analysis. Eligibility criteria for an interview were to be older than 18 years of age, be involved in a professional disciplinary engineering student organization for a minimum of two academic terms, be an engineering undergraduate, and are willing to participate in an interview. Based on these guidelines, we ultimately invited 13 students to participate in a semi-structured interview about their motivations for participating in PDESOs. Of the 13 participants, six identified as female and seven identified as male. By ethnicity, seven participants identified as White, five identified as mixed ethnicity, and one identified as Native American. All participants were mechanical engineering majors except for one who was an industrial engineering major. Participants indicated that they were affiliated with the following organizations: American Institute of Aeronautics and Astronautics (AIAA), Society of Automotive Engineers (SAE) Baja, Robotics Club, or American Society of Mechanical Engineering (ASME).

Semi-structured interviews

Semi-structured interviews were held virtually via Zoom with the 13 participants. The interviews ranged from 30–60 min and the average interview length was 50 min. All

interviews were audio-recorded and later transcribed verbatim. The interview protocol was designed to investigate a general sense of the students' underlying motives to participate in a PDESO and how involvement in these organizations contributes to the construction of their engineering identity. The interview protocol was initially semi-structured to elicit conversations about experiences of involvement in PDESOs by asking open-ended questions. Upon implementing the interview protocol with three students, the interview protocol was revised to enhance clarity and align the questions with the six characteristics of the MICT. The MICT was used as a guide in the development of the interview protocol to understand the factors contributing to developing students engineering identity, characterized by feelings of self-esteem, continuity, distinctiveness, meaning, efficacy, and belonging.

The interview questions were designed to evaluate each of the six motives through student's experience in participation in professional disciplinary engineering student organizations. For example, Vignoles[7] described the belonging motive as involving the need to be accepted by others. Therefore, the belonging motive can be assessed with the following question: How does the PDESO make you feel like you belong—that you are included among or accepted by people who matter to you? With this overarching question in mind, the following interview questions were designed: What interested you to attend a (name of professional disciplinary engineering student organization) meeting? After your first attendance at a general body meeting, what motivated you to come back? What made you feel like this professional disciplinary engineering student organization was a good fit (or not a good fit) for you? This process was repeated for the six motives as shown in Table 1. The overall goal of the interviews was to stimulate conversations about experiences and motivations to participate in disciplinary professional engineering student organizations.

Data analysis

Throughout the study, the first author performed the majority of the data analysis. The interview transcript data were analyzed using Atlas.ti. Following accepted coding practices guided by Saldaña (2021),[35] coding was conducted by the first author and then shared with two of the co-authors for their review, clarifying emergent ideas, and obtaining new insights about the data. This is an acceptable approach, as coding in most qualitative studies is a solitary act[35] and the team's discussions provide an opportunity to clarify emergent ideas and gain new insights from the data.[35] The first stage of the analysis incorporated inductive coding in order to identify common patterns within the individual interview transcripts. A summary of the initial findings was presented and reviewed by the co-authors. Additional coding passes were conducted through the transcripts incorporating emergent and in-vivo coding in order to preserve the language and terms used by the participants. This is fundamental in this study because it helps identify keywords constantly emerging throughout the interviews.

Following the exploratory first cycle of coding, second cycle of coding was carried out to group analogous keywords that emerged in the first cycle of coding using simultaneous and process coding methods. Simultaneous coding was chosen in order to allow for more

Table 1. Categories developed around identity motives.

Identity Motive	Identity Motive Description	Overarching Objective	Example Question
Distinctiveness	The belief is that the characteristics of a level of distinctiveness are needed to set them apart from others. Keywords that emerged when inquiring about the distinctiveness motive show that students see their involvement distinguishes them from their non-participating peers.	How do PDESOs contribute to participants' feelings of distinctiveness?	In what ways is participating in the ESO different from other activities? Follow-up: How do you feel that participating in the ESO activities distinguishes you from others?
Belonging	The desire to experience closeness to as well as acceptance by others or the need to belong. Keywords that emerged when inquiring about the belonging motive imply that students felt welcomed in these organizations.	How do PDESOs contribute to participants' sense of belonging?	What interested you to attend and ESO meeting? Follow-up: What made you feel like this ESO was a good fit (or not) for you?
Self-esteem	Is concerned with incentives to uphold positive notions of the self. Keywords that emerged when inquiring about the self-esteem motive imply that students viewed these organizations to bring a sense of fulfillment and pride for their accomplishments.	How do PDESOs contribute to the participants' self-esteem?	What is your favorite part about being involved with this ESO? Follow-up: How does this [mention response] make you feel about yourself?
Meaning	The need to feel that one's life has intent and value, or concerns that effort to obtain a sense of purpose. Keywords that emerged when inquiring about the meaning	How do PDESOs contribute to the participants' enhancement as an engineer?	In what ways does your involvement in the organization give you the sense that it is meaningful to be part of (ESO name)?

(continued)

Table 1. Continued.

Identity Motive	Identity Motive Description	Overarching Objective	Example Question
	motive imply that students viewed that these organizations provided meaningful opportunities that will contribute to their goals.		
Efficacy	The requirements to feel capable to manage and direct one's life. It involves the aspiration to be competent and influence their environment. Keywords that emerged when inquiring about the efficacy motive imply that students viewed the benefits of these organizations' professional development opportunities to enhance their career goals.	How do PDESOs contribute to the participants' feelings of competence and ability to influence their environment?	Can you describe the benefits and support you receive from participating in (ESO name)?
Continuity	Is concerned with the belief that identities are continuous over time despite significant life changes. Keywords that emerged when inquiring about the continuity motive describe contributing factors in students' academic engineering journey.	How do PDESOs give participants a sense of continuity between past, present, and future in your life?	Can you describe how you knew you wanted to pursue an engineering career? How does participation in (ESO) contribute to continue pursuing an engineering career?

nuance in the data. With simultaneous coding, the researcher can apply two codes to the same data "if data suggests multiple meanings that necessitate and justify more than one code."[36] With process coding, the researcher codes instances where the participant "uses gerunds ('-ing' words) exclusively to connote actions in the data. Particularly appropriate for those that search for ongoing action/interaction/emotions taken in response to situations, or problems, often to reach a goal or handle a problem."[36] Process coding was chosen because of the developmental nature of identity given that psychological

processes like identity formation are inherently comprised of actions, interactions, and emotion as responses to situations or problems. Lastly, while coding the transcripts, responses were grouped by the related questions under each identity motive to ultimately determined common themes within them.

During the interviews, participants were asked to comment on a wide array of experiences concerning their involvement in the PDESO. One of the primary goals of using thematic analysis was to identify repeated keywords that contribute to engineering identity development and repeated reasons for why students choose to participate in a PDESO. As an example, the belonging motive refers to the desire to experience closeness to others and feel socially accepted in both interpersonal relationships and within groups. The responses to questions inquiring about the belonging motives had consistent keywords such as the following: 'interesting,' 'inviting environment,' 'cool projects,' 'hands-on projects,' 'welcoming,' 'familiarity,' 'networking,' 'support,' 'building community,' 'bonding,' and 'comfortability.' Related keywords were grouped into a central topic or idea that closely aligned with the corresponding identity motive. For example, similar keywords that emerged in questions inquiring the belonging identity motive in the first cycle of coding were grouped under central topic. As a result, 'inviting environment,' 'welcoming,' and 'comfortability' were grouped under 'inviting environment.' Similarly, 'familiarity,' 'networking,' 'building community,' 'bonding' were grouped under 'collegiality.' Throughout the coding process, at least two students had to state the same keyword for that result to be considered part of a central topic. Table 1 lists the six identity motives, along with a brief description of each identity motive, followed by the overarching objective for the interview questions inquiring about each identity motive, and example interview questions.

Results and discussion

Distinctiveness

The distinctiveness identity motive represents the need for individuals to see themselves as distinguished from others and may be constructed through difference or social position.[7]

In this context, distinctiveness refers to the different experiences gained from participating in the PDESO that the participants described as setting them apart from other students who did not participate in a PDESO. In three particular cases, participants shared how they felt distinguished from peers because of their involvement in a PDESO, which they viewed as a positive advantage that sets them apart from their peers who were not participating in PDESOs. In their responses, students felt that their involvement in the PDESO set them apart from other non-participating students because of the professional development, hands-on experiences, and expanded networks they obtained through participation. For example, one student expressed the challenges of obtaining hands-on project experience and how participation in a PDESO provided unique opportunities to gain hands-on experience in rocket or rover building:

> Getting to be able to do these projects are really unique because there are very few opportunities in [State] that allow you to build rockets, that allow you to build rovers that go

> inside rockets, and that allows you to launch them up and participate in competitions. (Casey [pseudonym], 4th year mechanical engineering undergraduate, AIAA participant)

Some students felt that their involvement and commitment to a PDESO could be an asset in terms of future employment. And distinguished them from non-participating peers. One student shared how involvement in the PDESO provided participants with professional development and workforce preparation that potential employers would appreciate, as seen in the following quote:

> I think being a part of [PDESO], I wouldn't say that I'm any like more well prepared for the job market than other people, but I think if I were a hirer and I looked at someone who had done [PDESO], especially now being in [PDESO], I understand that there's a lot of work that goes into it [participation], and you know, I think I might just appreciate the commitment that that student made. (Jess [pseudonym], 4th year mechanical engineering undergraduate, SAE Baja participant)

Other participants expressed that they had a higher chance of job recruitment by industry employers than non-participating students because their involvement in a PDESO provides an experience that makes them more marketable or better prepared for the job market. For instance, the following student is aware that the industry prefers participation in certain PDESOs for entry-level mechanical engineering job positions:

> it's probably gonna get me a better job than other students. If you look at Tesla, SpaceX, Lockheed Martin, they all say [PDESO-1 and PDESO-2] participation preferred most of the jobs for like entry-level people. (Ash [pseudonym], 5th year mechanical engineering undergraduate, SAE Baja participant)

As evident from these representative quotes, obtaining hands-on experience and professional development from a PDESO is an important aspect of feeling better prepared for the engineering workforce that would in turn help students stand out from other non-participating students. These experiences that they described as 'unique' also contributes to a sense of distinctiveness from others and contributes to a meaningful development of their engineering identity, which is regarded as the need to uphold awareness of separation from other people.[7] The distinctiveness motive is universal because a meaningful sense of identity emerges from the conviction that a level of distinctiveness is a necessary attribute.

The students' motive for being a part of the professional disciplinary engineering student organization was more about other people's perception of how they were distinguishing themselves from other students. In relation to how they compared themselves to their non-participating peers, students indicated that these unique experiences set them apart from other non-participating students and will help set them apart when looking for a job in the engineering workforce. This emphasis on distinguishing themselves from other students aligns with prior research that emphasizes the importance of participation in outside-the-classroom experiences, like engineering student organizations, to be

essential for students to build competencies and differentiate themselves from their peers.[37] In addition, these PDESOs provide professional development that students find to be great relevant experiences to prepare them for the workforce and contribute to their engineering identity, building on the importance of participation in various engineering contexts in the early stages of their academic journey.[21,24] Participant responses further imply that students are motivated by the recognition they obtain from being involved in these engineering student organizations, helping them become more marketable in the engineering industry. Having this recognition of their stature as engineers seems to be an essential factor in participating in these well-established engineering student organizations that have been built on reputation and recognition. There have been few studies examining how student recognition affects engineering students.[38] In other fields, such as STEM[39,40] and student retention in higher education,[41] student recognition and award systems have been shown to be valuable tools for improving student success. Given the opportunities for recognition that PDESOs may provide, future research could examine outlets for recognition, such as participation in PDESOs and similar extra-curricular or co-curricular activities.

Belonging

The belonging motive refers to the desire to experience closeness to others and social acceptance in both interpersonal relationships and within groups.[7] Participants expressed a sense of belonging through their involvement in a PDESO in multiple ways. Responses to questions inquiring about the belonging identity motive highlighted that an inviting environment, interesting projects, and a sense of collegiality among peers were key attributes to continuing participation in the PDESO. In this context, collegiality is defined as the interest in bonding with colleagues, making connections with people in their related field of study, feeling comfortable, and having a sense of familiarity among colleagues. Participant responses also showed that students are more likely to participate or continue participation in a PDESO because of the welcoming and inviting environment they experienced. In the following quote, the student mentioned how overall s/he enjoys the collegial environment experienced, whether working in lab work or after conference meetings:

> I like the environment that comes with that. So, like, a lot of times in [Lab] we'll just set up in the conference room after a meeting, and then we'll just, kind of, work on all of our stuff. (AIIx [pseudonym], 4th year mechanical engineering undergraduate, Robotics Club participant)

This collegial environment made students feel comfortable being amongst their peers and allowed them the opportunity to bond and create new friendships. In addition, students expressed high interest in the hands-on projects that motivated them to volunteer and participate in these peer competitions. Some students expressed how these projects were "interesting" and doable, which compelled them to volunteer many hours and be part of this team. One student shared how as a freshman participating in a team

project, the PDESO made them feel included. In addition, they noted that the project seemed possible to do and that they would be able to help and not just be on the sidelines:

> The people were really nice and the projects seemed possible to do, and it seemed like I was gonna be able as a freshman to really help as opposed to sitting in a corner and watch the big kids play (laughs). (Casey [pseudonym], 4th year mechanical engineering undergraduate, AIAA participant)

Many students indicated how first impressions in their first PDESO general body meeting were important. In their first attendance to a PDESO general body meeting, students expressed a sense of welcome from the leaders of these organizations, which made them feel comfortable to return and participate. One student emphasized how participation in the organization has helped build relationships with other colleagues through sharing common academic and career goals:

> Like, but like nothing has built relationships better than what I've done through the club perspective. So having a common goal that you're trying to achieve together, and like all being super passionate about this convoluted goal that you want is like something that I haven't found a better bonding mechanism. (Ash [pseudonym], 5th year mechanical engineering undergraduate, SAE Baja participant)

The results inform how important it is for students to feel welcomed, to feel included, feel like they can contribute something to the organization, and feel like they belong in this engineering student organization. This emphasis on collegiality was recurring among participants, which aligns with prior research suggesting participation in ESOs is essential for building collegial networks while having a sense of belonging.[38] Collegiality is essential as it invites the student to create new friendships and networks in a field of interest. These sensations of feeling welcomed or accepted among their peers that emerged during the interviews support the belonging motive of the MICT, which is regarded as the need to be involved, included, and accepted by others.[7] Students described being part of an organization as being part of "people like me," with common academic and career goals, who support each other and want to see each other succeed. This positive teamwork environment made them feel a sense of belonging and encouraged them to engage in competitive interesting projects, which motivated them to continue participation in the PDESO.

Student responses emphasize that opportunities for hands-on engineering projects relevant to their field of study were key elements that incited ongoing involvement in the professional disciplinary engineering student organization. In some way, these hands-on projects provided a welcoming team-building space for students to engage with each other and make them feel included among their peers and a sense of belonging in this engineering context. Results imply that having this sense of familiarity among colleagues motivated them to find a way to be involved in the activities and opportunities provided by the professional disciplinary engineering student organization. At the same time, the continuing involvement and feeling like they belonged in this engineering

community influenced their engineering identity because it helped them see themselves more like an engineer. Experiences through involvement in PDESOs provided a sense of belonging amongst peers that contribute to their engineering identity, further emphasizing how essential it is to nurture the students' sense of belonging by cultivating relational experiences in these engineering spaces. Based on previous work on engineering identity and belonging, these findings are consistent with the importance of being acknowledged by other engineers to recognize one's own identity as an engineer.[4,29,30] This welcoming environment gave participants a feeling of inclusion and acceptance by their peers, leading to them becoming more involved in these professional disciplinary engineering student organizations.

Self-esteem

The self-esteem motive concerns incentives to uphold positive notions of the self.[7] In this context, self-esteem refers to the positive feelings that students seek within these PDESOs to feel good about themselves. Participants expressed how involvement and efforts in PDESO projects made them feel successful, accomplished, and validated by their peers. It made them feel more competent as engineers and enhanced their self-esteem (self-perception of competence). Responses to questions inquiring about the self-esteem identity motive revealed that participants felt accomplished, validated, and confident throughout their involvement in a PDESO. These experiences made them feel good and motivated them to continue participating in a PDESO. Within this context, to feel accomplished means students feel good or proud to see their contribution to a PDESO project lead to its successful completion. One student shared how finishing a PDESO project brought a sense of fulfillment and pride for what they had accomplished:

> I'd say the projects are overall very fulfilling. Like, when I get done with my project, I feel accomplished, and I feel very proud of my work, which I really enjoy, which is something that I have looked for in work and school as well. (Allx [pseudonym], 4th year mechanical engineering undergraduate, Robotics Club participant)

Other students felt that participating in a particular PDESO would expose them to "smart" students and make them see themselves as smart, making them feel good. One student shared their belief that a good team is based on successful projects and therefore, participating in the PDESO projects allowed them to learn from "a lot of smart people." This is expressed in the following quotes:

> They were a good team, you know, that they're successful, and just based off that, you know, that there were gonna be things to learn there. Joining the team I could see there's a lot of smart people too. (Jess [pseudonym], 4th year mechanical engineering undergraduate, SAE Baja participant)

> it [participation in an PDESO] makes me feel smart. (Ash [pseudonym], 5th year mechanical engineering undergraduate, SAE Baja participant)

In addition to expressing how participation in a PDESO made them feel smart, the students also described how contributing to the successful completion of a project made them feel good. In the following quote, the student felt proud that the data collected from the testing s/he performed contributed to improving the engine performance, in a way, validating their volunteer efforts:

> The test data we got helped us be faster, pretty much like our engine was better because of the testing I did. So just an actual, like what the work produced, it was clear that it was useful and good. (Ash [pseudonym], 5th year mechanical engineering undergraduate, SAE Baja participant)

Overall, results inform how student involvement in PDESO projects contributes to or enhances their self-esteem. In this perspective, self-esteem refers to the positive experiences gained from participating in the PDESO that contributed to participants feeling good or proud about themselves. This aligns with findings of previous studies regarding the benefits that students may be able to gain from being involved with student-led organizations.[3] In addition to having them feel "smart," many implied that this sense of accomplishment through the projects helped them feel more like an engineer, which made them feel good about themselves. These positive notions of accomplishments in project involvement support the self-esteem motive of the MICT, which is concerned with an incentive to uphold positive perceptions of the self and contribute to their identity.[7]

In addition to gaining hands-on relevant project experience, the PDESO also provided opportunities for students to travel and participate in nationwide competitions with other colleagues. Students described how being surrounded by "smart" students also contributed to helping them see themselves as competent, making them feel good. It also means that being validated as a future engineer by their peers was important, and the validation made them feel good and motivated them to be involved. This positive perception of participation in PDESOs suggests that involvement plays a key role in participants' development of an engineering identity, which is consistent with previous research that suggests that engineering identities are influenced by their experiences in engineering communities of practice.[25,26,37] Students expressed how their unique contributions to the PDESO projects helped them see themselves as an engineer, validating their engineering identity. Students enjoyed these experiences, which motivated them to continue their participation.

Meaning

The meaning motive refers to the need to feel a significance or purpose in one's life.[7] Through their involvement in the engineering student organization, students expressed how meaningful it was to be actively involved. Participant responses to questions inquiring about the meaning of identity motive demonstrate that gaining experience, expanding their network, and the time commitment required for this PDESO were worthwhile and motivated them to continue participation in the PDESO. In this context, time commitment

refers to students finding PDESO participation meaningful enough to invest many hours of volunteer work on the projects. Students described that participating in PDESOs provides them with a unique opportunity to gain hands-on experience that will prepare them for "real-life" engineering projects, taking them through the engineering design process and, at the same time, learning teamwork skills. In this context, experience refers to the interest in gaining meaningful hands-on experience on interesting engineering projects. One student elaborated that despite the number of volunteering hours, seeing their contribution efforts "coming to fruition" in a PDESO project was meaningful. This is shown in the following quote:

> …the product of all your efforts coming to fruition is, is pretty meaningful. You put in all these hours, a bunch of work, you know? And then it comes out and it's successful, or even if it's not, it's just a product. Like you do finish, you get it done. For us, we've been very successful and that's been cool. (Ash [pseudonym], 5th year mechanical engineering undergraduate, SAE Baja participant)

Students also expressed how meaningful it was to find ways of being involved in a PDESO because it provided opportunities to network with colleagues with similar interests. Networking in this context refers to establishing cooperative and friendly relationships between colleagues and the industry. One student shared that being involved in a PDESO was meaningful because it allowed them to expand their network to different industries aligned with their interests:

> Yeah, it's meaningful because I'm getting those experiences and exposure to different industries and yeah, it's meaningful in that, I kind of see where my interests lie. (Paris [pseudonym], 3rd year mechanical engineering undergraduate, ASME participant)

As evident from these quotes, obtaining hands-on experience and the opportunity to network are strong reasons for students to find it meaningful to commit many volunteer hours to a PDESO. Students saw the projects as fulfilling and found the hands-on experience as an opportunity to prepare them for the engineering workforce. These notions of fulfillment that students see valuable to their engineering development support the meaning motive of the MICT, which indicates the need to feel that one's life has intent and value or efforts to obtain a sense of purpose from one's life.[7] These meaningful experiences that sets out to perceive themselves positively, motivate students to participate in a PDESO.

Participants shared that volunteering hours to the engineering student organizations was worthwhile because the opportunities provided were relevant to their short- or long-term engineering career goals. Students were motivated to participate in hands-on projects because they saw them as a fulfilling, engaging, and enjoyable experience with the hopes of preparing them for their engineering careers. Students find these opportunities meaningful to their development as engineers, motivating them to participate in an PDESO. As a result of involvement in PDESOs, students expressed that their involvement in these PDESOs enabled them to navigate their engineering experience as

meaningful. Students found community building with engineering peers with similar academic and career goals a meaningful experience, aligning with Wenger's concept of communities of practice,[42] emphasizing how social participation contributes to constructing their identities through these communities.[42] Additionally, students expressed that they gained meaningful experiences expanding their network in the engineering industry that supports their career goals, which supports previous research studies in which they associate how students find networking as a significant experience in engineering student organizations. By finding a community with peers, participants found an on-campus support network. This led them to recognize their peers as engineering majors and see their identities mirrored back at themselves, empowering them to claim their emergent professional identity. These findings support previous research on the importance of disciplinary-based organizations as spaces for developing peer connections with other engineering students.

Efficacy

The efficacy motive encompasses feelings of competence and is capable of influencing one's environment.[7] Students expressed how involvement in a PDESO helped prepare and feel competent for the professional engineering workforce after graduation. As participants responded to questions inquiring about efficacy, we noticed how much they valued professional development opportunities provided by the PDESO. Within this context, professional development pertains to learning new skills and gaining related engineering experience to help grow, prepare, and succeed in the professional engineering field. Some students described how participating in a PDESO helped them develop teamwork, problem management, and soft skills. For example, one student expressed how participating in the PDESO helped improve communication skills and develop conflict management techniques, which the student emphasized are not typically learned in an academic classroom:

> I can't speak highly enough of clubs. Like you learn so much. You learn how to, like, deal with difficult situations, you learn how to communicate with people, you learn, a lot about yourself, and how you handle things. And it definitely progresses you professionally, I would argue more than school. (Allx [pseudonym], 4th year mechanical engineering undergraduate, Robotics Club participant)

Participant responses inquiring about efficacy also revealed how participants found that being involved in a PDESO provides them the opportunity to make them feel competent and prepared to go into the engineering workforce. Competence in this context refers to participants feeling prepared with the ability to interact with colleagues in the professional engineering field. This can be from gaining the hands-on experience that will help them stand out from students who are not participating in a PDESO. One student highlighted how involvement in the PDESO demonstrated additional preparedness and competence for the engineering workforce:

> The fact that I've been a part of it [PDESO], people will say like, "Oh, he's been exposed to some of that higher-level organization that you might not see in a general capstone," as well

> as then when we go to a competition, even right now with virtual competition, uh, they say like, "Oh, you know, he's, he's presented in like these highest stress environments or whatever. You know, he knows what it's like to prepare for, you know, a speech or, you know, learn some topics that you might not be comfortable with, and then present on them." (Jess [pseudonym], 4th year mechanical engineering undergraduate, SAE Baja participant)

Students shared the various benefits (or advantages) gained by participating in the PDESO that contributed to their development as an engineer. As evident from these representative quotes, students expressed how participation in the PDESO helped them feel more prepared for their future engineering careers and comfortable contributing to the competitive projects. These perceptions of competence that emerged during the interviews support the efficacy motive of the MICT, which involves the aspiration to be (feel) competent and influence their environment.

Students described how engaging in these hands-on projects and nationwide competitions made them feel competent as future engineers. Students described how they provided more effort in projects when they perceived more confidence in their worth and abilities and therefore were seen as competent by their teammates in their group, leading to feeling validated as future engineers. One explanation may be that students have to put forth more effort when they have more autonomy in a team because they would be "in charge" of certain aspects of a problem or project. This experience encouraged them to be involved in the engineering student organization and be part of these nationwide competitions. Their collaboration on hands-on projects also contributes to developing their engineering identity, consistent with previous research suggesting that collaborating with "engineering-minded individuals" to make competent design decisions contributes to developing an engineering identity.[25,29] The implications are that these PDESOs provided professional development opportunities that made students feel more comfortable influencing their environment and feel competent as future engineers. In addition, students felt happier regarding identity elements that provided strong feelings of efficacy, suggesting that the efficacy motive influences the process of developing an engineering identity.

Continuity

The continuity motive refers to the need to feel a sense of connection between one's past, present, and future identities, make people accountable for their past and allow them to form future goals.[7] Upon reflection of their past, present, and future, students were able to share their conceptualizations of how and why they viewed themselves as an engineer and how their engineering identity has evolved. When students were asked to describe how they knew they wanted to be an engineer, most responses included some type of early exposure to engineering through summer camp, extracurricular activities in high school, or hands-on experience prior to college. Many students reflected that their interest and strength in math and science led them to pursue an engineering degree. For example, one student shares how his experience prior to college contributed to his pursuit of engineering,

> I've always like had, I guess I've always worked on cars and just generally like tinkering and stuff, and I've had the opportunity to like, do those things. Um, had like some old project cars that I've worked on when I was a kid, and always done woodworking, stuff like that… and then in high school I was good at physics, (laughs) so it seemed like a good career path as far as money, what would interest me and what I would be passionate about. (Ash [pseudonym], 5th year mechanical engineering undergraduate, SAE Baja participant)

One student described how participation in a PDESO has provided the opportunity to network with "upperclassmen" and graduate students, which has led to consider pursuing engineering graduate programs,

> I thought I was just going to come in and get my bachelor's and get out but now I've been talking to some of my upper class and master's students, like graduate students and I'm kinda like, I wonder if I should do a master's degree now it, it sounded a little bit more interesting. (Rory [pseudonym], 3rd year mechanical engineering undergraduate, AIAA & SAE Baja participant)

> I think is the biggest benefit really probably a long term of what this club is going to give me, is like having these relationships in the future, connection wise and just interpersonal wise. (Ash [pseudonym], 5th year mechanical engineering undergraduate, SAE Baja participant)

Overall, students discuss how participating in a PDESO is beneficial to their engineering identity development as they think about moving forward in their engineering careers. As students describe a continuum of experiences, they also connect events that contributed to their engineering identity. This aligns with Vignoles[7] description of how people are motivated to believe that their identities are continuous over time despite significant life changes. People generally prefer information that validates their perceptions of themselves, and that continuity can be interpreted as being about remaining stable within an individual identity.

Throughout the interviews, students reflected on how their past experiences contribute to their decision to pursue an engineering career and how the present experience contributes to how they see themselves as engineers and their preparation for their role in the engineering workforce. These well-established and reputable professional disciplinary engineering student organizations provided students with identity continuity, providing reassurance that they are indeed developing their engineering identity. Participation in these PDESOs contributes to an ongoing continuum of experiences aligned with their engineering identity development, consistent with previous studies exploring factors contributing to engineering identity development.[21,24,25] This need for identity continuity forms a unique motivational basis for group identification. In this case, groups would be these engineering student organizations. The PDESOs can fulfill the need for identity continuity, and it could be that students are more likely to derive a sense of identity continuity from these organizations that are seen as relatively stable and enduring over time.

Summary of results

Engineering students involved in professional disciplinary engineering student organizations allow them to connect to campus life, develop professional skills, and connect to engineering peers who share their same interests. In addition, involvement in the PDESOs influences students. The PDESOs attracted students who had clear future goals and sought preparation for their careers in the engineering industry. They searched for field-related hands-on experience, connections to others who could assist them along their path, and experience to add to a resume. Students who continued their involvement in the PDESO shared that it was due to the welcoming environment and meeting their expectations. The opportunity to be involved at a level that meets their experience and expectation is key for students to be more likely to be active in these organizations. Understanding students' expectations from involvement in PDESOs and what encourages them to continue participation can benefit organizations to target recruitment efforts and provide these meaningful experiences to their students. Understanding the activities that keep students engaged in the PDESOs could help them discover a way to fulfill their needs. Highlighted activities that maintained an ongoing student engagement in these PDESOs are professional development opportunities, networking with other peers and the engineering industry, and team projects.

Conclusion

In this study, the motivated identity construction theory[7] displayed the underlying motives that influence the participation of thirteen students in these disciplinary professional engineering student organizations and how these organizations contribute to the development of their engineering identity. According to motivated identity construction theory, results indicate that students join or identify themselves with these engineering student organizations because it facilitates the capability to feel a sense of distinctiveness from other students, a sense of meaning, connection to the past and future, competent and capable of influencing their environment, accepted among their peers, or positive about themselves enhancing their self-esteem.[6] As evidenced by these results, involvement in a PDESO positively impacts a student's experience, aligning with previous studies[1,17,18] and significantly influencing the development of undergraduates' engineering identity. Furthermore, results indicate that students believe that participation in these professional disciplinary engineering student organizations provides them with unique opportunities for professional development that will prepare them for the engineering workforce, consistent with previous studies[17,19,20,37] exploring student involvement in engineering student organizations.

Engineering student organizations play a significant role in students' engineering identity and motivational beliefs, empowering them to choose their level of involvement. Participation in the PDESO provided students with opportunities to support their future engineering academic and career goals, which was the driving force behind students' involvement in PDESOs. Most students expressed enthusiasm for the hands-on projects and inter-collegiate competitions that attracted them to be involved in these organizations in some capacity. It is evident from these findings that each motive is relevant to understanding engineering

students' goals, engineering identity development, and reasons for participation in these professional disciplinary engineering student organizations. Clearly, these organizations have the potential to provide students with positive college experiences, academic support, and professional development that will facilitate their transition in the engineering workforce.

Finally, the results reinforce findings from other studies related to involvement in student organizations and engineering identity and remind us that although developing students' content and technical expertise remains a priority, student involvement in engineering student organizations contributes to their college experience and workforce preparedness. They provide unique opportunities that solidify engineering undergraduates' academic knowledge and professional development opportunities to prepare them for their future careers in the engineering industry. From the literature, we know that there is a history of these disciplinary professional engineering student organizations being a positive, unique experience,[13,15,20] preparing them for their career.[4,20] Like other research, this points to organizations contributing to undergraduates engineering identity development. While this is the case, it is essential to understand these PDESOs from the perspective of engineering identity development because it can help illuminate whether or not critical components of identity development originate as a result of participation in these organizations. The findings represent the opinions of a group of undergraduates in the mechanical engineering department. We recognize that the needs and goals of these PDESOs will vary with their institutional setting and the interests of the individual members.

Although findings and previous literature show the benefits of engineering identity and student involvement in these PDESOs, they are primarily focused on the collective experiences of engineering undergraduates, often neglecting the differences among engineering undergraduates from marginalized communities and resulting in minimal discussion around the challenges the non-participants have or what alternatives they seek that provide them with similar opportunities. There is currently a discussion regarding efforts to support engineering undergraduates as well as efforts addressing diversity and equity in engineering education. In light of the ongoing discussion regarding equity and diversity in engineering education and the findings of previous studies that indicate engineering student organizations correlate with educational attainment, it would be worthwhile to determine if these outcomes are consistent with engineering undergraduates from marginalized communities. Future research may focus on exploring the experiences of engineering undergraduates from marginalized communities and how they navigate within these professional disciplinary engineering student organizations.

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Data availability

Example text of a Data statement, as provided by the author.

Data availability statement

Some or all data or codes that support the findings of the study are available from the corresponding author upon reasonable request. This includes anonymized data, results, and tables.

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