STUDIES IN ENGINEERING EDUCATION

The Role of Engineering-Adjacent Involvement in Engineering Students' Development of Future Time Perspective: An Exploratory Study

EMPIRICAL RESEARCH

VIRGINIA TECH PUBLISHING

ALEXANDRA JACKSON
BRIANA LAVINE
CASSANDRA JAMISON
JUSTIN C. MAJOR

*Author affiliations can be found in the back matter of this article

ABSTRACT

Background: Having strong motivation is crucial to students' ability to engage and persist in engineering. Motivations to persist in engineering can be developed through students' involvement in activities, including those that are "engineering-adjacent," that students feel contribute to their future goals.

Purpose: This paper explores how motivation to persist in engineering is influenced by undergraduate students' "engineering-adjacent" involvement. This knowledge may influence practice that encourages participation and retention in traditionally unwelcoming engineering programs.

Scope/Method: We interviewed ten engineering students from one mid-Atlantic institution, where they were asked about their involvements and career goals. We coded transcripts borrowing from Kirn and Benson's (2018) research on future time perspective and future possible selves. We then developed overarching themes based upon relationships among the codes.

Results: Engineering-adjacent involvement was found to affect students' engineering goals in three ways, as: 1) pulling students away from their engineering futures, 2) helping students temporarily escape the stress of engineering, or 3) enabling students to integrate further into engineering through meaningful connections between their future possible selves.

Conclusions: We found that students' perceptions of themselves and their engineering-adjacent involvement were influenced by the cultural expectations of engineering, leading to unique impacts on their motivations and engineering futures. We believe that researchers and educators can use the results of this study to inform educational practices that allow students to better perceive themselves as integrated into engineering, influencing their motivation to pursue engineering futures.

CORRESPONDING AUTHOR:

Justin C. Major

Rowan University, US

majorj@rowan.edu

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INTRODUCTION

Despite long-standing initiatives to promote engineering retention, students still choose to withdraw from engineering programs for many reasons, including a traditionally competitive culture and the expectations that come with it (Male et al., 2018; Pawley, 2019). As such, it is critical to find alternative ways to improve engineering students' overall motivation and projections of their own futures (Foor et al., 2007; Godwin, 2016; Scheidt et al., 2019). Students who do not perceive themselves as "fitting" into the expectations of engineering often struggle to see themselves as engineers in the future, leading to difficulties with goal setting and persistence (Foor et al., 2007; Jensen et al., 2023; Rohde, Satterfield, et al., 2020). However, many expectations of engineering are perceived as problematic and even antagonistic to positive goal development. For example, students have expressed feelings that it is normal for the engineering discipline to be more stressful, and that those who cannot manage the stress and exclusivity are unable to become engineers (Jensen & Cross, 2019). In an overwhelmingly male-dominated, White, and competitive engineering culture, students may struggle to balance aspects of their personal and engineering goals with the expectations of engineering, leading to difficulty in seeing themselves as future engineers (Godwin, 2016; Pawley, 2019).

Student involvement in co-curricular and extra-curricular activities has been studied as one mechanism to support students' navigation of engineering (Simmons et al., 2018; Woodcock et al., 2020; Yasuhara et al., 2012). Students who are more involved in extra-curricular activities tend to have a stronger feeling that they are an engineer, which may contribute to their motivation and choice to persist (Godwin & Kirn, 2020; McIntyre et al., 2024; Simmons et al., 2018). Students select to involve themselves in extra-curricular activities for many reasons, including opportunities for skill development, networking, and personal enjoyment (Bielefeldt et al., 2021; Simmons et al., 2018). In doing so, they sometimes connect even traditionally non-engineering-related activities, such as physical activity (e.g., sports, knitting), to their engineering goals (Sheppard et al., 2010). This connection may be due to students' perceptions that non-engineering involvement better prepares them to problem-solve within a variety of disciplines. It is also possible that students may become disheartened in engineering programs, which encourages them to pursue other disciplines or careers outside of engineering (Sheppard et al., 2010).

This exploratory qualitative study examines how students related their "engineering-adjacent" involvement to their engineering motivations and goals for the future. Our pilot work (Jamison et al., 2023) described engineering-adjacent activities as those activities that students view as related to their engineering goals but that are typically considered unrelated to engineering by the discipline. In the present study, if students were able to make connections between a nominally non-engineering activity and their engineering futures, we considered the specific activity as engineering-adjacent. As we claim throughout this paper, understanding the reasons why engineering students involve themselves in engineering-adjacent activities can be useful for understanding students' holistic motivational profiles and how those profiles connect to their goals of becoming an engineer.

To better understand the above connections, we pursue answers for the following research questions (RQ):

> RQ1) In what ways do students' engineering-adjacent involvement shape their motivation to persist in engineering?
>
> RQ2) How does engineering-adjacent involvement inform how students perceive themselves within engineering?

LITERATURE REVIEW

In this section, we contextualize our research questions by exploring how relevant background related to activity involvement, future perceptions, and engineering expectations, have been studied in relation to one another.

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ENGINEERING STUDENTS' INVOLVEMENT IN ACTIVITIES

According to Astin's (1999) work, involvement in experiences outside the classroom directly contributes to a student's learning and skill development. Astin defines involvement as the amount of physical and psychological energy that a student devotes to an experience. Initiatives to increase engineering student skill development have led to studies on student involvement in activities outside their discipline-specific courses (Fisher et al., 2017). These outside activities may provide additional incentives such as networking opportunities, or personal enjoyment outside the classroom (Feldmann et al., 2011; Fisher et al., 2017). Students involved in these activities are more likely to persist toward their degree, formulate positive relationships with faculty and peers, and develop professional skills that are not a direct part of their course content (Astin, 1999; Kuh et al., 2008; Woodcock et al., 2020).

These activities can include undergraduate research, engineering and non-engineering clubs, and service, all of which contribute positively to students' engineering interest, overall motivation, and skill acquisition (Bonesso et al., 2018; Yasuhara et al., 2012). Students also tend to get involved in activities like industry experiences, internships, and off-campus employment (Chen et al., 2017). These structured experiences help students develop leadership skills, curiosity, and professionalism, while also contributing to their career readiness (Chen et al., 2017; Yasuhara et al., 2012).

Though students achieve notable engineering-relevant outcomes from their involvement in activities and experiences, their motivations for involvement in these activities are not well understood. The few studies that explore these connections have found that students often select activities they feel are beneficial for their future careers even when involvement does not include work directly related to their discipline (Mulrooney, 2017; Woodcock et al., 2020). However, literature has also suggested that students get involved in activities to seek support and commonality amongst their peers (Dalrymple & Evangelou, 2006). While current literature has documented students' positive experiences with out-of-class engineering-specific involvement, both personally and professionally, more work is needed to understand the impact of students' involvement in engineering-adjacent activities on their motivation to achieve their goals within engineering.

ENGINEERING STUDENTS' MOTIVATIONAL DEVELOPMENT IN ENGINEERING CONTEXTS

Campus cultures, informed by students' exposure to specific topics, curricular interventions, and co-curricular offerings, have also been linked to student motivations and engineering goal-setting (Dalrymple & Evangelou, 2006; Matusovich et al., 2011). Engineering programs are generally critiqued for being competitive and unwelcoming, especially for marginalized students such as women and non-White students (Jensen et al., 2023; Pawley, 2019). Research suggests that students have expectations that engineering should be difficult (Jensen & Cross, 2021) or will include "shared hardship" (Godfrey & Parker, 2010, p. 12).

Furthermore, engineering students tend to perceive engineers as having certain characteristics and performing certain tasks, which influences their engineering motivations and goals (Tonso, 2006). In Tonso's (2006) study, students grouped engineering majors as belonging to three sub-groups: "nerds" (p. 29; problem-solving-focused students who keep to themselves), "academic-achievers" (p. 29; students who excel at coursework and have high GPA's), and "greeks" (p. 29; social students who often serve in leadership positions). Students who struggle to perceive themselves amongst their arbitrary depictions of who engineers are, and how they should behave (often non-White and non-male), tend to lack motivation and persistence (Godwin, 2016), leading to substantially lower diversity rates in engineering programs. As such, it is important to understand how students' perceptions of the expectations of engineering are shaped by their involvement in activities and how those perceptions subsequently inform engineering motivation and goals.

THEORETICAL FRAMEWORK: FUTURE-TIME PERSPECTIVE AND FUTURE POSSIBLE SELVES

To explore the role that engineering-adjacent involvement plays in students' interest in engineering and motivation to persist in engineering, we draw on two frameworks: Future Time Perspective and Future Possible Selves. Both theories have been used productively in prior studies of engineering students and thus offer useful lenses for this exploration.

FUTURE TIME PERSPECTIVE

Future Time Perspective (FTP) theory "can be defined as the present anticipation of future goals" (Husman & Lens, 1999, p. 115), speaking to how students' perceptions of the future may influence their motivations in the present. While some students have many more defined short- and long-term goals, and thus a more developed FTP, others have less, leading them to engage in more or less motivation-oriented behaviors, respectively (Nelson et al., 2015). Students with more defined (i.e., seeing further into the future and with a firmer understanding of the necessary steps to get to that future) FTP are more likely to engage in academic tasks and persist through challenges (Husman & Lens, 1999). In fact, the personal value students place on their future goals has been associated with improved academic performance (de Volder & Lens, 1982).

Prior research has linked engineering students' FTP to their problem-solving approaches (Kirn & Benson, 2018; McGough Spence et al., 2022). Specifically, students modify their problem-solving strategies based on how well specific engineering tasks align with their personal future goals, such as career aspirations. More aligned tasks led students to engage in stronger problem-solving strategies while tasks that felt irrelevant led students to use more surface-level or expedient strategies (Kirn & Benson, 2018).

Given that the instrumentality, or usefulness, of present action to future goals plays a significant role in the connections that students make between their future goals and present action (Husman & Lens, 1999), FTP offers a productive lens to explore students' involvement in engineering-adjacent activities. FTP research indicates that students are likely to assign stronger, more positive, valence or feeling to present involvement that they feel aligns with their future goals, further motivating them to involve themselves in the same or similar activities again. In contrast, if students perceive involvement as misaligned with their future goals, they may be demotivated to continue and may seek other opportunities that are more useful (Husman & Lens, 1999). We hypothesize that the ways students involve themselves in engineering-adjacent activities instead of present engineering tasks reflect this behavior.

FUTURE POSSIBLE SELVES

Future Possible Selves (FPS) theory refers to how individuals perceive themselves ideally, realistically, and in avoidance of a possible future self (Markus & Nurius, 1986). Ideal selves point out the ways individuals wish to perceive themselves in the future if they had full control of their pathway. Realistic selves reflect, in light of what individuals may experience, who they actually think they can be. Finally, avoidant selves acknowledge who individuals wish to avoid being, or who they do not want to be in the future. Individuals typically behave in ways which make them feel their ideal or realistic selves are more attainable (Markus & Nurius, 1986).

In relation to FTP, FPS provides motive or incentive for present action. That is, individuals' present actions are motivated by who they wish to be in the future including any goals they wish to attain (Husman & Lens, 1999; Markus & Nurius, 1986). However, FPS are influenced by changing situational context, specifically what they believe is possible for them in the given moment (Markus & Nurius, 1986).

In the context of the present project, we frame engineering-adjacent involvement as a vehicle by which students seek to attain the ideal and realistic selves that they have built for themselves. We hypothesize that engineering's harsh expectations influence the situational context in which students reside, influencing what students think is possible for themselves, leading them to "escape" to activities that may otherwise provide positive valence.

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METHODS

In this section, we describe the design of our study, our data collection and analysis methods, and the quality considerations of our processes. We also discuss details of our participants, our positionality, and some limitations of our exploratory qualitative study.

STUDY CONTEXT

The present study takes place at a mid-Atlantic, R2 Carnegie classification institution with six engineering disciplines. We interviewed students using a semi-structured approach, where we asked questions about students' future goals, involvement in activities, and the relationship(s) they see between them. This study, including all mechanisms for handling data, were approved by Rowan University's IRB office before human subjects research was conducted (PRO-2022-288).

DATA COLLECTION

Undergraduate engineering students were recruited through the College of Engineering's undergraduate email list to participate in 45–60 minute semi-structured interviews. After receiving interest from 20–30 students, we used stratified sampling techniques to purposefully select ten students across year and discipline for interviews, maintaining consistency with recommendations for qualitative research studies (Saldaña & Omasta, 2018) and pragmatic validation (Walther et al., 2013). We acknowledge that other strategies for diversifying our participant pool (e.g., gender, race/ethnicity) may have further enhanced our recruitment strategy. Nonetheless, we asked participants to self-describe these demographics upon completion of the interviews. Our sample included representation from five out of the six disciplines offered at the institution, all four academic years, and four different self-described race/ethnicity. We also asked students to self-identify their gender using their preferred pronouns, wherein we had four students identify with he/him pronouns, four students identify with she/her pronouns, one student identify with she/they pronouns, and one student who did not specify.

Students were first prompted to give a pseudonym for privacy purposes and asked about their personal and career goals for the future. Then the interview questions transitioned to asking about their involvement with activities in and out of engineering. A particular follow up question included "How do you see these activities contributing towards your efforts to reach your [personal and career] goals?" which gave the students time to reflect on how they see their involvement relating to their future goals. Responses to this question allowed us to designate an activity as engineering-adjacent.

Each interview consisted of two undergraduate student interviewers, one faculty interviewer, and the student interviewee. One student interviewer was responsible for asking the protocol questions, one was responsible for taking notes and asking necessary follow-up questions, and the faculty member was responsible for asking clarifying questions and mentoring the undergraduate researchers in the interview process. These interviews acted as a training opportunity for undergraduate students without interviewing experience, wherein the faculty member acted as a quiet observer, interjecting only to clarify the student interviewers' process. Prior to the interviews, the interviewees were made aware of the number of people who would be present. However, we do recognize that the number of individuals in the room may have impacted the interviewers' ability to develop rapport with the participants. These interviews were conducted and recorded using a portable audio recorder and then uploaded to, and transcribed via, Otter.AI Business Edition (preserving confidentiality), which was further checked/changed by undergraduate researchers for accuracy as needed, maintaining process reliability (Walther et al., 2013).

DATA ANALYSIS

After transcripts were verified, two other members of the research team (a (then) PhD student and a (then) undergraduate researcher researcher new to the project, the first and second authors of this paper, respectively) deductively coded the transcripts to capture constructs of FTP (theoretical validation; Walther et al., 2013). Our initial deductive codebook (Table 1) was developed based on

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the FTP/FPS work of Kirn and Benson (2018). First, the first two authors became familiar with the data by deductively coding one transcript together and discussing emergent patterns specific to answering our research questions, following recommendations for maintaining process reliability (Walther et al., 2013). As they engaged in this process, they focused on how students viewed themselves and their experiences in relation to their involvement. The process was reviewed for appropriateness by having the two researchers code two additional transcripts separately and reaching a consensus to ensure minimal variability between interpretations of the codes. The rest of the transcripts were then coded by one researcher, who kept track of patterns that were discussed at weekly, full team meetings throughout the analysis process. Finally, the full research team engaged in discussions to identify themes and to determine how those themes addressed our research questions.

QUALITY CONSIDERATIONS

We pursued research quality by following Walther et al.'s (2013, 2017) research quality framework for making and handling qualitative data. *Theoretical validation* was addressed by ensuring literature was reviewed for our theoretical framings in Future Time Perspective and Future Possible Selves. We used our theoretical backing to develop and refine our interview protocol and inform our thematic analysis. *Communicative validation* was addressed with participants by allowing interviewees the space to elaborate on each question, and with the research team by having frequent meetings to discuss changes to the codebook and themes throughout our paper writing. *Pragmatic validation* was addressed by ensuring data was gathered from engineering students in engineering contexts. *Process reliability* was addressed by keeping meeting notes, having multiple researchers review the transcripts, creating an audit trail, and discussing discrepancies with the entire research team. Finally, *ethical validation* was addressed by protecting participant privacy through self-selected pseudonyms and redacting identifying information in their transcripts (Sochacka et al., 2018).

Table 1 Initial Codebook.

CODE	DEFINITION	EXAMPLE
Future career	Any aspect of a potential future career, including specific outcomes, goals, and characteristics	"I would like to go into power for my engineering profession" (Matt)
Ideal future	The student's view of their ideal future, including who they want to be and/or what they want to do	"[Ideally] I'd work in California, have a cool mid century modern house outside of LA and then work somewhere where the commute isn't crazy" (Henry)
Steps toward future goals	The steps the student intends to take or can see themselves taking to achieve their future goals	"[The steps to reach my goals are] Get good grades and an internship and then eventually graduate. Like, do like a whole bunch of applications for the grad school or for jobs in the industry. Then take it from there" (Larry)
Alternate pathway	An alternate option to the student's ideal future career, which may or may not involve engineering	"[I'll] probably end up in either biology/molecular biology... somewhere still within the biological field, just not engineering." (Alex)
Future influence on present	How a goal or future plan influences how students view themselves or a situation in the present	"I'm always trying to do better [...] I'm trying to find the best job for me. I'm trying to make as many connections now [...] so then I can see which job is best." (Larry)
Influential people	A specific experience with an individual or group of people that directly impacted the student's goals	"[My] parents are incredibly supportive of me pursuing an engineering major and studying. And they both have backgrounds in STEM fields. So they know they've been through what I've been through, or I'm going to go through." (Jear)
Influential experience	A specific experience a student describes as having directly impacted their goals	"In the fifth grade [...] my teachers had this group of female engineers come in; they had a little girls in STEM Day. And they showed us how to make lip gloss and [...] I just loved it. I was like, Oh my gosh, I want to be an engineer. I love lip gloss" (Bella)

STATEMENT OF POSITIONALITY

We approached our study design through a constructivist lens. At the time of data collection, analysis and initial write up, our research team consisted of two early career faculty, one graduate student (now a faculty member), and one undergraduate student. The study was the result of a collaborative exploration between Drs. Cassandra Jamison and Justin Major (i.e., the projects' Principal Investigators) who, at first, would describe relatively little overlap between their research interests (i.e., professional preparation of engineering students for Dr. Cassandra Jamison and identity, motivation, and belonging for Dr. Justin Major). Dr. Cassandra Jamison, a White woman, also brings expertise in studying co-curricular involvement of students in engineering programs. Dr. Justin Major, who identifies as White, non-binary, and disabled, brings specific expertise in using and applying FTP/FPS due to previous involvement with foundational FTP/FPS publications in engineering education research (Major et al., 2016). This conversation informed the decision to focus on motivation, and also pushed the authors toward exploring engineering-adjacent avenues students see as relevant for their career preparation. Our constructivist perspective also informed our decision to ask students to identify involvement that they considered to be engineering-adjacent. Dr. Alexandra Jackson, a White woman, led the data collection, analysis, and writing process, and Briana Lavine, also a White woman, was brought on to the project to provide assistance during the data analysis process. Dr. Jackson and Briana guided the directed coding of the data presented, exploring alignment of the data with constructs present in FTP/FPS. Their perspectives allowed us to see emergent influences of engineering expectations on how students interpreted the relevance of their involvement for their future goals, informing our decision to explore how expectations of engineering showed up in how students made decisions about what should be considered engineering-adjacent and how it influenced their engineering motivation and goals. In alignment with constructivism, we recognize that the data collection, analysis, and dissemination procedures that led to this published work may have also been impacted by our many identities and the powers and privileges that come with them in ways that we have not considered here. For example, we expect that the questions we asked, our discussions of themes, and more, were guided by our particular positionality.

LIMITATIONS

Though we believe our work positively contributes to engineering education research, we would like to highlight some limitations. Student participants were only interviewed from one institution, which limits the transferability of our work to other programs with student populations of differing backgrounds and programs with differing messaging or opportunities for out-of-class involvement like those we were studying. Additionally, the number of present interviewers may have negatively affected our ability to develop rapport with the participants. While our sample overrepresented non-white and marginalized populations at our institution, the representation of students with marginalized identities was still limited, which may have limited our ability to develop themes that are representative of how marginalized populations think about engineering adjacent participation.

FINDINGS

Our study sought to answer our two research questions: *RQ1) In what ways do students' engineering-adjacent involvement shape their motivation to persist in engineering?,* and *RQ2) How does engineering-adjacent involvement inform how students perceive themselves within engineering?* In the following sections, we discuss the answers to these research questions in depth, exploring themes of motivation and expectations of engineering that were identified across participants.

We identified three main ways in which students described the types of activities they were involved in. They identified them as either 1) engineering activities recognized by the expectations of engineering; 2) unconnected, non-engineering activities students articulated as separate from the expectations of engineering; or 3) in a in-between space we call "engineering-adjacent" where students saw their non-engineering activities as influencing their development as an engineer. These three ways of viewing their involvement manifested in the following three themes that guide our results: 1) engineering-adjacent involvement as a mechanism that pulls students away from engineering; 2) engineering-adjacent involvement as a mechanism to balance the culture of stress in engineering; and 3) engineering-adjacent involvement as a mechanism to integrate further into engineering through meaningful connections. Moving forward, we present results based on the perceptions of our participants, prioritizing what they articulated as engineering-adjacent in our analysis.

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By exploring what participants were involved in, we saw how students were relating their engineering-adjacent activities and engineering futures, and thus, their sense of their own integration into engineering. Exploring these connections more in-depth, we found that engineering-adjacent involvement manifested itself in our participants' perceptions of engineering and of their futures in three ways, as: 1) pulling students away from their engineering futures, 2) helping students temporarily escape the stress of engineering, or 3) enabling students to integrate further into engineering through meaningful connections between their future possible selves.

ENGINEERING-ADJACENT INVOLVEMENT AS A MECHANISM THAT PULLS STUDENTS AWAY FROM ENGINEERING

In some cases, our participants described their engineering-adjacent involvement as in conflict or *tension* with their career goals, serving as an activity that they felt could pull them out of engineering altogether. In this theme, the perceived connection between participants' involvement and engineering was the least integrated, and the conflicts participants described manifested in students' inability to balance their engineering and engineering-adjacent involvement. Furthermore, the perceived conflicts often resulted in participants describing an anticipated choice between giving up their other involvement to pursue engineering fully or switching career paths to continue pursuing their engineering-adjacent activities. These students expressed struggles with reconciling and integrating their engineering and outside interests leading to difficulties viewing themselves as part of engineering long-term. These students frequently struggled to articulate connections between their involvement in activities and engineering futures in ways that they felt could be sustained after entering a career.

For example, Alex described enjoyment within the biology field, articulating biology as engineering-adjacent as he views it in connection with biomedical engineering. He stated he would "probably end up in either biology [or] molecular biology…somewhere still within the biological field, just not engineering." Alex described his engineering-adjacent interests as in conflict with his future path to the point of potentially dropping the engineering part of biomedical engineering and instead exploring biology more in-depth.

Similarly, Larry, a student who described a misalignment between her personal traits and the expectations of engineering discussed her development of communication skills in intramural sports as relevant to a her potential engineering future, but also noted feelings of incompetence when communicating with engineers as opposite to her feelings when communicating within engineering-adjacent activities,

> I just have mixed feelings because I'm excited to talk to [engineers]… But then also, I'm kind of put in this awkward position where if I'm asking them every three words 'What does it mean?' It's kind of like, 'Oh, maybe I'm not at like the spot that I'm supposed to be at'… it's just easier for me [to talk to people involved in intramural volleyball and softball] cause I feel like I know more about it and it's more like an enjoyable topic to talk about.

In Larry's interview, we saw a distinct difference between how she described how she perceived herself within engineering and within her engineering-adjacent involvement, suggesting perceived uncertainty in her engineering goals. In further discussion, we learned that Larry was considering multiple pathways, some of which she would not qualify as engineering given the expectations of the discipline. She described her future goals in engineering as developing, saying things like,

> At the end of the day, like, I'm trying to find the best job for me. I'm trying to make as many connections now, […] so then I can kind of like see which industry, which job is best. So, I'm still exploring and getting to learn everything in my field. I do think I want

> to lean to pharmaceuticals and go into that industry. But also I've been considering grad school as well. So, I guess whatever is my best opportunity I'm gonna go with.

The main goal for Larry was to find the best suited job for her, whether that is in industry or graduate school; she did not necessarily feel committed to engineering and could see herself pursuing something completely separate from an engineering job.

Another student who described his engineering-adjacent hobbies as in conflict with his future was Matt when he discussed his involvement in tennis. He related some of his tennis involvement to his engineering future goals when he acknowledged his improvement in organizational, communication, and problem-solving skills. However, with his advancements in the tennis community he stated,

> I have been in the past year or so moving my way up in the tennis world, so to speak, and have seen increased position recognition for some of the things that I do. So, switching to that profession rather than engineering which I could foresee that happening, and tournament direction and stuff involved in the tennis world.

Matt saw his involvement in tennis as engineering-adjacent because he was building organizational, communication, and problem solving skills that can be used for his engineering path, but also saw it in conflict with his engineering future because tennis could lead him to switch career paths away from engineering. Generally, students in this category resonated more on a personal level with their engineering-adjacent involvement and struggled to integrate them into their traditional perceptions and expectations of engineering. As a result, many expressed feeling like their future goals were less integrated with engineering and emphasized many potential alternate pathways. These students' responses highlighted an important tension to consider between the perceived demands of an engineering career and the other interests that many students want to continue engaging in their engineering futures (Huff et al., 2019; Rohde, France, et al., 2020).

ENGINEERING-ADJACENT INVOLVEMENT AS A MECHANISM TO BALANCE THE CULTURE OF STRESS IN ENGINEERING

While a number of students described a conflict between their engineering future and engineering-adjacent involvement that could pull them away from an engineering future, a group of our participants instead described their engineering-adjacent involvement to be separate from their engineering future, where they described the involvement as a balancing mechanism. These students tended to pursue involvement as a way to step outside of engineering to recharge or refresh in moments of stress while still viewing themselves as part of engineering based on qualities they possess that they associated with the expectations engineering. In doing so, these participants insulated their motivations in engineering with their interests elsewhere. Some participants in this group saw preliminary connections between their engineering-adjacent involvement and engineering, but overall, described the two as separate, parallel aspects of their lives.

Jear, for example, described engineers as individuals who benefit people and society through 'making things', describing his crocheting hobby in a similar way,

> The way I've always viewed engineering is like, making things that are…beneficial to the people around you. And I feel that crocheting nurtures that kind of spirit in me. It's like, oh, I want to be an engineer so that I can make something for someone to make their life better.

Jear viewed his crocheting hobby as an engineering-adjacent activity that aligns with his expectations of engineering due to it involving hands-on work with a physical product as an outcome. Despite acknowledging potential areas of alignment across their personal traits, their engineering-adjacent involvement, and their expectations of engineering like Jear did, students in this theme tended to articulate a desire to keep their engineering and non-engineering goals separate. Jear fit this pattern as he described wanting to pursue an engineering career that would

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allow him to continue crocheting saying, "I'd also like to find myself in a position where I can balance my hobbies and career, because the hobbies I do, like crocheting, they take a considerable amount of time. And I hate to throw them out for my career." Jear's response highlights the same tensions experienced by students who saw their engineering adjacent involvement as pulling them away from engineering, but places a different emphasis on engineering future plans, allowing him to prioritize balancing the two. Another student who described the goal to balance engineering goals and other involvement in activities was Ann who said, "I really want to, obviously, graduate and get my masters and things like that. But I'd really like to be able to do something with theater as well as just sort of like on the side." Ann, like Jear, had well integrated engineering goals, but also a goal to make time for her engineering-adjacent involvement, illustrating the insulating effect of engineering-adjacent involvement on her engineering goals.

Our participants who viewed engineering and engineering-adjacent involvement as separate commonly discussed the value in "taking a break from engineering" to avoid burnout. For example, Jear said, "some of the stuff I'm thinking about studying, obviously, takes a lot of time out of my day. But there's something there [within engineering] that I really enjoy doing. So being able to balance my schoolwork with my hobbies is keeping me going most of the time." Engineering-adjacent involvement manifested in Jear's future by allowing him to continue working toward his engineering goals with breaks and outlets to destress, further protecting his engineering self. Another student, Mari, discussed her engineering future as parallel to her engineering-adjacent involvement with an example of seeing a heat transfer project in the role-playing game "Dungeons & Dragons," where she stated that she involved herself in the game as a way to "just avoid burnout, which is, again all the stuff I've been kind of doing to try to make sure I don't end up burning myself out, because that would be bad." Mari explained the importance of her engineering-adjacent involvement as geared towards avoiding disengagement for her engineering career path, providing the same sort of protection as we saw with other students. Students in this theme often expressed comfort within engineering while acknowledging the usefulness of their engineering-adjacent involvement as a mechanism that allowed them to step away from engineering as needed, leading to a healthy balance of engineering-adjacent involvement and traditional engineering in their projected futures. These students' responses highlighted the potential balancing, or protecting, mechanism that students saw engineering-adjacent involvement as playing in their engineering futures, and speak to the culture of stress (Jensen & Cross, 2019; Wilson et al., 2022) and expectations present in engineering degree programs that informs their perceptions of their future engineering careers.

ENGINEERING-ADJACENT INVOLVEMENT AS A MECHANISM TO INTEGRATE FURTHER INTO ENGINEERING THROUGH MEANINGFUL CONNECTIONS

The third group of students in our sample instead saw their engineering-adjacent involvement and their engineering future career as actively influenced by one another in an interwoven fashion. These students often viewed themselves as different from what they perceived to be traditional engineers, but described more defined engineering futures and tended to use their involvement in engineering-adjacent activities to justify their commitments to those futures. Students in this group described feeling that characteristics they possess are not commonly associated with engineers, but potentially could be, balancing and interweaving their ability to pursue other interests and their views of themselves as engineers in the future.

These participants were students who not only saw the overlap between their involvement in activities and engineering, but also described wanting to go into a field where they could pursue both simultaneously. For example, Charlie talked about how her future career and involvement as a runner aligned in a description of her oral presentation on inventions saying,

> I gave a speech on shoes [in class]. Because they wanted us to give a speech on an invention. And I was like, okay, shoes that light up, first thing I thought of, and my professor was like, Oh, my niece works for [a company], which is a running shoe company. She goes to marathons and analyzes the runners and takes notes on their biomechanics so that they can improve the shoes. I was like, Oh my gosh, that's it. That's my dream job.

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Charlie was able to use her engineering-adjacent involvement to further her goals which involved both engineering and interests in running. Additionally, Charlie found value in her axe-throwing job because it benefitted her in interviews, she said, "I was an axe-throwing coach. And I thought that was worthy of it. Because it like, brought up conversation when I was trying to get my [builder] internship, because they asked me, what is that?" Charlie explained that she was able to add her axe-throwing coaching job to her resume and it sparked conversation later when applying for internships. Another student who found value in her engineering-adjacent involvement and saw it helping in the future was Bella, who said, "For [my club], it definitely taught me a lot of people skills. Because it has a little bit more interpersonal skills, like talking to people, which I think if I didn't do that, I'd be a lot more awkward at my engineering role" Bella saw a direct impact of her engineering-adjacent involvement to her future goals.

Similarly, Mari, a student who sometimes described her engineering-adjacent involvement as balancing mechanisms, also described her engineering-adjacent involvement in creative activities like playing music or painting complementary to how she viewed herself within engineering. When describing the value she saw in having friends who value creative activities in engineering, she said,

> [Expressing our creativity] tends to make us goof off when we're in class sometimes. But it ends up [with my classmates and I] coming up with some really creative and interesting solutions [to the problems in class] instead of just sitting in a class really quiet. You don't really get that [creativity] in my ECE classes. [...] That's why I think mechanical engineering is so much more fun than electrical engineering, just because like, I think we're the same level of miserable when it comes to how hard the coursework is.

In Mari's interview, she described sitting in a silent class as a clear part of the projected expectations of engineering and engineering students, at least for her original electrical and computing engineering courses, which was misaligned with how she saw herself and her desired engagement with engineering. Originally, Mari had seen her creative side as separate from engineering, but later shared with us how her trait can complement her engineering future in the present mechanical engineering classroom experience.

Despite the potential to perceive misalignment between their engineering-adjacent involvement and expectations of engineering, students in this group typically remained confident in their choice of engineering as a career. Mari described a continued interest in music and art, and instances where her involvement in them not only solidified and strengthened her desire to pursue engineering, but informed who she will be as an engineer. Below, Mari talked about a stressful time in engineering when she turned to art as a way to cope, but also how it helped her recognize her inability to picture herself in art long-term, and solidifying her desire to pursue engineering. This recognition allowed her to move from viewing music and art as just protective activities to ones that might be able to be interwoven into her engineering future. Building off theme two, the following series of quotes demonstrate this evolution from protection to interwoven.

> With art, I just like doing it because I just like doing it. [...] But would I want to do this every day, like it makes me it almost refreshes my drive to be here [in engineering] a little bit more. So I'm like sitting here and I'm like, Man, I could have been music education major, like, I could have really not had been dealing with the stress like so in doing that and like being like, Well, that [the art] was really nice. But like, I definitely don't want to do that [art] the rest of my life. It makes me feel a little bit better too about like the choice [of engineering].

Then, in a later quote, Mari similarly talked about how art, particularly a role she held as a band lesson volunteer, informed her confidence in her ability to perform engineering roles she is interested in,

> I think that it really helped with my understanding of people, because at the end of the day, the things that I do for fun it really helps me connect it back to people. [...] It's really allowed me to confidently say that I can walk into a room and talk to anybody. At the end of the day, I don't want to be an engineer that sits in a cubicle, and I don't talk to anybody.

Mari's interview highlighted the ways in which her engineering-adjacent involvement evolved in relation to her engineering future, suggesting that the relationship is not necessarily a stagnant one, and instead might be shaped by the context in which students find themselves (Markus & Nurius, 1986). Similarly, we also found that participants who had the opportunity to make connections between engineering-adjacent involvement and their engineering future before starting in an engineering degree program had an easier time describing the alignment between the two. This finding highlights the importance of the pre-college context on how students interpret and project engineering expectations in college and the future. In one example, Charlie, who had solid ideas about her future engineering goals, described an engineering experience from eighth grade saying, "they brought us to a women in STEM workshop here. And we made lip gloss and they, gave us little Minecraft [video game] keychains. And I was like, 'this rocks.' So I joined my high school's engineering academy." In this example, Charlie saw connections between her personal interests (lip gloss and Minecraft) and engineering early on, which motivated her to pursue engineering and supported her ability to perceive alignment with engineering expectations among her many other current interests (e.g., running).

Beyond reconciling their own engineering-adjacent involvement with the expectations of engineering and their personal engineering futures, students in this group often discussed the importance of re-shaping engineering to more broadly encompass the interests they experienced as engineering-adjacent. For example, Mari discussed her creativity and points out that she believes more engineers should be creative while Charlie described her personal interests in gaming and makeup and how they fueled her interest in engineering, allowing her to align with traditional engineering expectations throughout her engineering-adjacent involvements like running. These students found the connection between their engineering-adjacent involvement and engineering and saw how they could integrate it into their futures. The key difference between this group of students and those in the other themes was that they were able to recognize the distinctions between engineering and their other involvement in activities while appreciating and integrating the complementary characteristics of the two. Doing so allowed them to see their involvement as furthering their engineering futures rather than putting them at risk or being needed as temporary escapes from engineering stress.

DISCUSSION

Overall, we found three main ways students described their engineering-adjacent involvement as manifesting in their future career: 1) as entirely conflicting and causing tension with the engineering future; 2) as separate, yet parallel, insulating the engineering future; and finally, 3) as integrated and interwoven, strengthening the engineering future. These findings align with previous research indicating that engineering students have to balance their engineering sense of self with the other ways they perceive themselves (Matusovich et al., 2011). Keeping this distinction in mind, we note that the three views we identified were directly connected to how students felt integrated into engineering in that those students who saw more seamless connections between their different FPS tended to align more with their perceptions of their 'fit' within the expectations of engineering

Drawing on our theoretical frameworks of FTP and FPS (Husman & Lens, 1999; Markus & Nurius, 1986), our findings highlight the direct impact of the expectations of engineering on motivation, as they are contributing to the value students are attributing to engineering-adjacent involvement in relation to their futures (e.g., Jear with crocheting as a way to step away from engineering work as needed while affirming the engineering characteristics he sees in himself, Mari with the Arts as a way to make her a better engineer and push the boundaries of what engineering work 'typically' looks like). Those students who struggle to find balance between selves demonstrated less integrated FTPs, and some expressed feeling more recognized as professionals in fields besides engineering (e.g., Matt in tennis). These students were also unaligned with what they perceived as expectations of engineering, mentioning aspects of themselves that they did not recognize in other engineering students, such as communicative ability and social skills.

Engineering is generally unwelcoming to marginalized students and those with backgrounds and identities unfamiliar in traditional engineering (Jensen et al., 2023; Pawley, 2019). We have also shown through this study that even those students who fit the historical idea of an engineer are struggling with the expectations of engineering, leading them to seek engineering-adjacent involvements that can provide them with a stronger sense of self (Brobst et al., 2023; Dalrymple & Evangelou, 2006; Rohde, France, et al., 2020). In terms of FTP and FPS, some of our students' FTPs, given their perceived expectations of engineering, are being disrupted by their involvement. We saw the result of this process as: pushing students away from future engineering goals, developing engineering selves, and pulling them towards involvement in activities that make them feel more motivated and comfortable with their FPS. While this involvement may be supporting other elements of their development, the conflicts we found between some students' engineering-adjacent involvement and their motivational development raise questions about how we can reform cultural expectations of engineering to better accommodate and integrate students' broad interests within the discipline (Huff et al., 2019; Rohde, France, et al., 2020). Further research is needed to better understand how students transition into careers where they can integrate their engineering and engineering-adjacent goals.

Furthermore, students who perceived conflict between their FPS and unalignment with engineering expectations felt less integrated into engineering, which was an expected connection given our FTP/FPS framework. Like other work that explores these relationships, unaligned students in our study struggled to make connections between their present as engineering students and their future as engineering professionals (e.g., Larry feeling more comfortable talking to those involved with volleyball and softball; Rohde, Satterfield, et al., 2020). Godwin and Kirn's (2020) participants also described alternate pathways besides an engineering future and discussed tradeoffs between engineering and their desired future, which lead to less integrated futures overall. While our findings suggest unaligned students have less defined FTP, we find that these students are still developing a wide variety of valuable skills from their engineering-adjacent involvement (McGough Spence et al., 2022). Considering that these students are more open to a number of possible futures, their skill sets may prepare them for careers beyond only those in engineering which Rohde (2022) has suggested is pertinent for engineering educators to consider.

As stated above, students tend to involve themselves in activities that allow them to escape from the intense stress of their engineering programs (Wilson et al., 2022), which may contribute to some students needing to completely separate their engineering-adjacent involvement from their engineering sense of self as a protective mechanism. This separation, in addition to being involved in activities that they generally enjoy (Woodcock et al., 2020), can act as a coping strategy (Wilson et al., 2022). Helping students see their enjoyable activities as engineering-adjacent may motivate them to further engage in engineering, imagining a more aligned engineering career (Lee & Matusovich, 2016) in light of expectations.

Amongst our work, students who viewed engineering-adjacent involvement and their engineering futures as integrated tended to view themselves as engineers in multiple contexts (e.g., Charlie, who saw running as having engineering career options for her). In previous literature, students with these strong motivations often used their involvement in activities to fuel their engineering skills and prepare them for their careers (McGough Spence et al., 2022). Additionally, our participants who fit this description tended to align, or integrate, more with traditional engineering expectations, possessing skills and interests that fit their idea of how an engineer would behave, such as mathematics and science knowledge, getting good grades, and being academically gifted. These attitudes fit with what recent literature suggests students perceive it means to be "smart" in engineering (Dringenberg et al., 2022; Tonso, 2006). Recent work has highlighted the problematic nature of smartness in engineering, stating that students' smartness conceptualizations and engineering sense of self are interwoven (Braaten et al., 2023; Kajfez et al., 2025). This issue may lead students to the consideration that those who view themselves as engineers are smart and capable, which, depending on their own self-perceptions, may decrease their motivation to pursue an engineering career (Godwin & Kirn, 2020).

When students see their involvement as useful to their goals, it may lead them to more defined engineering futures. Research suggests that students with more defined futures commonly seek out involvement that they expect will fill gaps in skills that their courses do not provide (Kirn et al., 2014; McGough Spence et al., 2022; Woodcock et al., 2020), which may explain the surge in motivation and interest we saw with our students. Overall, students with a more defined engineering sense of self tended to view themselves as an engineer in the activities they were involved in and were motivated to pursue. We observed that students without a defined engineering sense of self preferred to be involved in their engineering-adjacent activities as a break from the stress they experienced and anticipated in engineering. Doing so allowed them to avoid forcing engineering expectations upon themselves, resulting in better balance between their FPS (Huff et al., 2019). We saw these students as less motivated to pursue an engineering-focused career, and with a less defined plan for the future. Our overall findings emphasize the importance of considering students' FPS when seeking to support their engineering development, and add to literature concerning stress and coping, co-curricular involvement, and motivation to enroll and persist in engineering.

IMPLICATIONS FOR RESEARCH AND PRACTICE

This work provides insight into the motivations we are nurturing through the expectations of engineering that we develop as educators, administrators, and professionals. Some of our participants expressed constant stress and feelings of being unable to integrate their FPS. These feelings were clearly impacting how participants thought about their present and future interactions in engineering. Our work is not the first to find that students are pursuing engineering degrees while considering career goals outside of traditional engineering positions. Engineering programs continue to emphasize models of success that only push students into engineering industry or higher education careers (Lichtenstein et al., 2009; Potvin et al., 2018; Rohde et al., 2018), which can push students away who do not perceive that future for themselves. To mitigate students' stress and feelings of misalignment, engineering education researchers and practitioners must begin and continue efforts to change the expectations of engineering in ways that allow students to see the different futures they see for themselves as integrated. Particularly, we should not encourage students to pursue the specific model of engineering that is currently a focal point of our programs, rather we must expand our ideas of what engineering could be to encourage students' further motivational development (Rohde, Satterfield, et al., 2020). For example, researchers and practitioners could acknowledge, and even bring in, many of the activities our students talk about here into classroom discussions and examples. Doing so, students may feel more able to recognize and integrate the different futures they see for themselves. As we continue to explore what it means to be an engineer in our own work, we simultaneously argue for the importance of educators and practitioners alike to explore the many roles engineering-trained professionals can hold that allow them to contribute to the advancement of society.

CONCLUSION & FUTURE WORK

Through this study, we qualitatively demonstrated that undergraduate engineering students involve themselves in many types of engineering and engineering-adjacent activities, though engineering-adjacent involvement plays a unique role in students' motivation and future projection. These students tend to seek engineering-adjacent involvement as an escape from cultural expectations that engineering is unwelcoming and stressful, instead piquing their general interests, engaging with other students, and integrating the many engineering futures they see among their FPS. Engineering students view their engineering-adjacent involvement in one of three ways, as: 1) pulling them away from engineering futures, leading to a lack of motivation to pursue an engineering career due to tension; 2) balancing, allowing them to involve themselves in enjoyable activities they view as both separate from engineering and a way to destress or avoid burnout, leading to insulation of the engineering future; or 3) integrating, by allowing them to see meaningful connections between engineering and their involvement in activities that lead to a more defined future. We showed that students who integrate their personal and engineering senses of self were rare in our sample, potentially indicating that the cultural expectations of engineering play a part in driving students away from their engineering sense of self to pursue other, more comfortable selves, or forcing students to set aside their personal selves in pursuit of an engineering self. Future work should continue to examine students' engineering-adjacent involvement and how it relates to the futures they imagine or pursue. For example, do the students who struggle to integrate their futures end up in traditional engineering careers or do they pursue other avenues, potentially related to their engineering-adjacent involvement? This answer will continue to highlight problems with the cultural expectations of engineering and how engineering culture, more broadly, impacts students' motivation, involvement, and their futures.

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

All four of the authors contributed adequately to the production of this submission. The first author, Dr. Alexandra Jackson, was responsible for writing many of the sections of this manuscript, and collaborated on the development of the themes and the data analysis. The second author, Briana Lavine, was responsible for most of the data analysis and writing some of the sections of this manuscript. The third and fourth authors Drs. Justin C. Major & Cassandra Jamison were responsible for the development of the project as the PIs, headed the data collection process, and revisions of the manuscript.

AUTHOR AFFILIATIONS

Alexandra Jackson orcid.org/0000-0002-4662-6653
The Pennsylvania State University, US

Briana Lavine orcid.org/0009-0005-3221-8121
Purdue University, US

Cassandra Jamison orcid.org/0000-0002-0253-1636
Rowan University, US

Justin C. Major orcid.org/0000-0002-3111-8509
Rowan University, US

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