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From Engineering Students to Student Engineers: Reflections, Identity, and Positioning in Co-curricular Activities

Dr. Zhiyi Liu, University at Buffalo

Zhiyi Liu is a researcher and educator with research interests in learning and instruction. Dr. Liu was a postdoctoral associate in the Department of Engineering Education at the State University of New York at Buffalo.

Dr. Andrew Olewnik, University at Buffalo, The State University of New York

Andrew Olewnik is an Assistant Professor in the Department of Engineering Education at the University at Buffalo. His research includes undergraduate engineering education with focus on engineering design, problem-based learning, co-curricular involvement and its impact on professional formation, and the role of reflection practices in supporting engineering undergraduates as they transition from student to professional.

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Abstract

In this research paper, we aim to examine whether an existing Professional Development Survey (PDS) captures evidence of student engineering identity. To do this, we consider students' descriptions of their co-curricular experiences through the lens of positioning theory to understand how they construct and develop their engineering and professional identities. The data used for this study was secondary and gathered by a large state research university in 2020. A positioning analysis of undergraduate engineering students' PDS reflections on co-curricular experiences (i.e., technical work and research) indicates that the students build their engineering identities primarily in the process of positioning themselves as: 1) an engineering intern; 2) a research assistant; and 3) taking up agentic positions related to successfully completing the tasks and future career goals. Storylines show how individual students take up their responsibilities within a particular context in co-curricular activities. The results also reveal that the students demonstrate their professional identity by positioning themselves as potential future engineers while reflecting on career goals. The PDS enables undergraduate engineering students to have opportunities to understand and reflect on their co-curricular experiences and see their reflections as an essential part of their ongoing development as engineers. It also serves as a reflection tool for educators to understand how students construct their engineering identity and develop their professional identity.

Introduction

Research concerning engineering students' engagement in co-curricular activities has received considerable attention [1, 2]. Several studies have focused on investigating undergraduate engineering students' co-curricular experiences and their effects [3-5]. Most of the literature has indicated that engineering students would benefit from co-curricular activities that included professional skill development (e.g., leadership, critical thinking, communication) and broadened students' career choices [6, 7]. A research focus on engineering identity and its development as an important issue receives increasing attention in higher education [8-9]. Rodriguez et al. [10] point out that engineering students might choose to leave the field due to a lack of identification of themselves as future engineers. Existing studies have shown that the experiences of engineering students within co-curricular activities influence students' engineering identity formation and professional identity development [11, 12]. However, little work has examined how particular co-curricular experiences will shape undergraduate engineering students' expectations of future careers and contribute to their professional identity development. Limited studies look at the connections among engineering students' identities, positions, and professional identity development within co-curricular activities.

This study contributes to bridging this gap by examining the reflections of undergraduate engineering students' co-curricular experiences (i.e., technical and research) through an existing Professional Development Survey (PDS). It contributes to reforming and further developing this work-in-progress PDS protocol by analyzing undergraduate engineering students' reflections on their co-curricular experiences to understand the students' engineering identities and the formation of professional identities through a positioning theory lens [13]. Positioning theory has been used in engineering education to analyze university students' interactions while solving physics problems [14], as well as research on emotions in engineering problem solving [15]. Limited research has been focused on examining engineering students' co-curricular experiences. In the current study, we particularly examine undergraduate engineering students' co-curricular experiences and look at how they position themselves within technical work and research experience in a limited way via PDS. We specifically investigate the following two research questions: 1) How do undergraduate engineering students position themselves and construct identities in relation to their reflected technical work experience? 2) How do undergraduate engineering students position themselves and construct identities in relation to their reflected research experience?

Literature Review

Co-curriculars Involvement

There is a growing body of literature examining students' involvement in co-curricular activities [4, 16]. Elias [17] has defined co-curriculars as comprising "university-affiliated activities that are outside the academic curricula and provide opportunities for intentional learning and development" (p. viii). University undergraduates can engage in various co-curricular activities such as student clubs, internships or co-ops, undergraduate research, study abroad, etc. [1, 3, 18]. As suggested by previous researchers, co-curricular involvement has been linked to a range of positive student outcomes, including: career-related professional skills acquisition and competencies developed, such as communication, leadership, and teamwork [3, 5, 16], academic achievement and persistence [19], ethical development [18], and cognitive development [20, 21]. Students, for example, are aware of the importance of co-curricular experiences in their future employment [22]. In a recent study, Jackson and Bridgstock [23] investigated students' perceptions of the impact of certain activities on enhancing undergraduate graduates' employability at three Australian universities. Researchers discovered that graduates perceived the most valuable among the activities was gaining experience and skills. Results further demonstrated that internships were considered an important activity that led to increased employment.

Co-curriculars and Identity Development

In engineering education, it is essential for students to develop their engineering identity so that they "see themselves as future engineers and be recognized by others as such" [10, p. 254]. One aspect of learning through professional practices is the development of a student's identity as an engineer [24]. To prepare students to become future engineers, helping students engage in professional identity development is also essential for the engineering education community [8]. Early studies have indicated that co-curricular experiences contribute to engineering undergraduates' professional identity development [8, 25, 26]. For example, Eliot et al. [27] found that engineering students' experience in internships, co-ops, and volunteer work helped them construct their professional identity. The researchers further suggested that students' professional identity formation was shaped by multiple factors, such as their interactions with their family, peers, faculty, and employers [27]. Similarly, Villanueva and Nadelson [9] demonstrated that professional identity development was influenced by their experiences, personal and professional knowledge, and professional interactions. Thus, it is important that engineering students be provided with opportunities to reflect on their experiences and how these experiences can contribute to their sense of themselves, their employment preparation, and their personal development [28, 29]. Kilgore et al. [30] have indicated that reflection opportunities through a professional portfolio on their experiences enable engineering students to develop their engineering identity and prepare to be engineers. Drawing on previous work about identity formation and development [31-33], we are particularly interested in how students construct their identities when reflecting on their experiences participating in technical work and research activities.

Theoretical Framework

The theoretical framework used to support this study is positioning theory. It is built on "a positioning triangle consisting of storylines, positions, and act interpretations, which all affect one another" [34]. In positioning theory, positions can be seen as "patterns of beliefs in the members of a relatively coherent speech community" [35 p. 4]. Positions in situated social contexts are more dynamic than roles as a static construct [35-36]. Positioning is defined by Davies and Harré [37, p. 48] as a discursive process where people assign positions to themselves and others in conversations "as observably and subjectively coherent participants in jointly produced story lines." Tan and Moghaddam [38, p. 183] argue that "positioning involves the process of ongoing construction of the self through talk." While people construct themselves and others not only with words, but also with written actions and acts [37, 39]. Storylines are viewed as "the contexts of acts and positions." [40, p. 325]. One type of positioning is *self and other positioning* [13]. Individuals can actively position themselves and reposition themselves in talk; this is *self-positioning*, which is also called *reflexive positioning*. During this discursive practice, individuals also position others which is referred to as *interactive positioning* [41, 42]. In this work, we focused on *reflexive positioning* to examine how undergraduate engineering students view themselves within their co-curricular experiences through PDS-written reflections.

Positioning theory is also considered a powerful tool to analyze and understand the issues related to identities in discourse (i.e., saying and writing) [36, 42]. As De Fina et al. [43 p. 8] wrote,

> Investigating levels of identity construction as a process of positioning, and discovering the means adopted to enact various positions, leads to reflecting on the many ways of doing identity, ranging from the proclamation and open assignment of membership into social categories to the enactment of different kinds of selves…(p. 8)

Thus, it can be used to investigate how students construct their identities in different learning contexts [44]. For example, Solomon et al. [45] applied discursive positionings to understand mathematics undergraduate students' "fragile" identities. The researchers suggested that some undergraduate women resisted traditional positions in mathematics by taking up an identity as mathematicians. In the engineering field, Khosronejad et al. [46] used the concept of positioning to investigate how students develop an implied identity as engineers. In this study, we particularly apply positioning theory to understand how engineering undergraduates construct and develop their identities through positioning.

Method

The goal of this cross-sectional study is to use positioning theory as a theoretical framework to understand undergraduate engineering students' certain conceptions of co-curricular experiences as they reflect on them in an annual survey and how those conceptions might be related to their engineering identity and professional identity development. The secondary data for this study was collected by the school of engineering and applied sciences at one public research university using the Professional Development Survey (PDS). The university has conducted the PDS annually among undergraduate engineering students since 2015 to evaluate their experiences across different co-curriculars. Students in the survey were asked questions related to their unique experiences across different co-curricular activities, including their roles and responsibilities in certain tasks they performed, specific professional competencies they developed in co-curricular activities (i.e., critical thinking, communication, teamwork, leadership, etc.), and their future career goals.

Data Collection and Analysis

The data used for this study came from PDS reports for 2020 and covered the academic year from summer 2019 through spring 2020. This time frame includes the early phase of the COVID-19 pandemic lockdown that began in spring 2020. Thus, many students' reflections were not yet impacted by that event. We particularly focused on students' reports in either technical activities or research activities and their career goals for analysis, which helped us answer the research questions. For technical work experience, we chose four open-ended questions from the survey to analyze in this study (see Appendix A). We also selected the four questions from students who reported on their research experience in the survey (see Appendix B). For data analysis, first, responses were excluded from the study if 1) the word count was less than 20, 2) the content of the students' responses was not relevant to the survey questions based on qualitative content analysis [47], and 3) there were no additional explanations of their experiences and no responses (no positions taken) to some of the survey questions. We acknowledge that these criteria may remove students with strong engineering identities who chose not to engage in the reflective activity or are otherwise unable to display such identity. This is a limitation of the study discussed in the conclusion.

After data reduction, a total of 445 (technical work experience) and 140 (research experience) students' responses to survey questions were coded (see Table 1). 246 and 69 responses were excluded based on three criteria about technical work experience and research experience, respectively. NVivo was used to analyze open-ended responses to the PDS [48]. In vivo coding and descriptive coding were used to code the data related to all content topics (i.e., internships, co-ops, research projects, etc.) in our first coding cycle [49]. The first author coded the data alone. The first author and the second author had regular meetings to review the codes and discuss data analysis. The codes were refined by consensus with the second author to ensure reliability.

Table 1. Participant demographics.

Co-curricular exp.	Gender	College level	Engineering discipline	Total
Technical work	Male: 359 Female: 86	Freshman: 32 Sophomore: 36 Junior: 142 Senior: 233 Missing data: 2	1) Aerospace: 35 2) Electrical: 35 3) Industrial: 12 4) Computer science & computer engineering: 102 5) Civil: 61 6) Chemical & Biomedical: 54 7) Mechanical: 77 8) General: 40 9) Environmental: 17 10) Other: 2 11) Missing data: 10	445
Research	Male: 97 Female: 43	Freshman: 6 Sophomore: 14 Junior: 41 Senior: 76 Missing data: 3	1) Aerospace: 16 2) Electrical: 10 3) Industrial: 4 4) Computer science & computer engineering: 29 5) Civil: 9 6) Chemical & Biomedical: 31 7) Mechanical: 23 8) General: 9 9) Environmental: 4 10) Other: 1 11) Missing data: 4	140

Second, deductive coding and deductive analysis were used to analyze the data in depth and relabel the categories [49]. We used theoretical perspectives on *self and other positioning* and *reflexive positioning* [13] to examine how engineering students position themselves through reflecting on their co-curricular experiences. Then, we revisited and reviewed the codes by identifying *reflexive* and *agentic positions* [13, 51]. We focused on how one individual positions himself or herself through the written reflections [42, 50]. Through a deductive analysis, we also looked at how students' identities were constructed through certain positions they took or actions they performed [42, 49]. Next, we classified the codes into two main categories: 1) positioning and 2) identity construction and development in the workplace, which were related to the content topic of each co-curricular experience [47]. Under each main category, we also identified several emerging subcategories based on previous literature and the positioning theory framework [36, 42, 51] (see Table 2). Even though the prompts asked students to respond based on the position title, this did not mean students' positioning should be in that position title during the analysis.

In the third step, we revisited and quantified the data (frequency) to make sure we could effectively use the data. To do so, we refined positioning categories and assigned them to position options based on previous analysis of positioning within coding experiences. Position options in technical work experience include: self-positioning as an engineering intern, an engineer, a student engineer, a teaching assistant, or an agentic position. We also found some students took on two positions, such as self-positioning as an engineering intern and an agentic position, in their reflections. Thus, we defined and included different combinations of positions. In students' research experiences, position options include: self-positioning as an undergraduate researcher, a research assistant, a helper, or an agentic position. We also included different combinations of two positions, such as an undergraduate researcher and an agentic position. The definitions of position options and examples are provided in Appendix C. Then, we concentrated on quantifying or determining the frequency related to different positions. If students take on two positions at the same time, such as an engineer and an agentic position, the result will only be represented once. As a result, each student indicated positions within technical work or research experience that he or she had only one category of position option. In addition to analyzing the frequency of positions students took, as we revisited the data, recurring themes emerged from the two main categories we identified in the second step of analysis.

Table 2. Coding, categories, sub-categories, and examples.

Categories	Sub-categories and explanations	Technical work experience examples	Research experience examples
Positioning	Reflexive positioning (self-positioning): *position oneself within the storyline of technical work experience or research experience*	"I was a Controls Intern that assisted the Software/Controls Team"	"I work as an undergraduate researcher under the guidance of…"
	Agentic position (actions has done or will do): *Students have the capacity or willingness to act when taking on agentic positions*	"I analyze test data, recommend which parts must be replaced, repair units, and test them."; "I hope to do another internship before the end of the spring semester."	"As an undergraduate researcher I am currently testing a new ultra high-performance concrete."; "I will continue to be involved in research."
	Expectations about employment: *Students' career plans*	"I want to become a Control Engineer."	"My career goal is to do lab research."
Identity construction and development	Competencies and knowledge: *Identify competencies and knowledge gained related to career preparation*	"I designed a project with another intern, which helped me learn team work skills."	"Combined with the strong set of communication and leadership skills I have built, I know I will be successful in getting a Ph.D. position."
	Personal and professional development: *Identify development (i.e., skills or qualifications needed to meet future career goals)*	"…go to graduate school after to enhance my knowledge in Civil engineering."	"During this processes I will conduct research projects…"
	Positioning acts: *Considering identity are constructed through positions or actions take on in positioning category above*	"I got an internship for Summer 2020 to help ease my way into industry."	"By joining the Nanosatellite Lab and becoming a team lead I have given myself a great opportunity to learn a lot about the engineering process."

Findings

Self-positioning Within Technical Work Experience

Table 3 shows information about how many times engineering students talked about positions in technical work experience. The majority (51.5%) of the students indicated that they took up a combination of two positions: engineering intern and agentic positions, when reflecting on their technical work experience and future career plans. 33.5% of respondents assigned agentic positions to themselves when reflecting on outlining their future career goals (i.e., the steps they will take, the opportunities they will pursue). Then, 5.2, 4.0, and 1.6 percent of the students took up three different combinations of positions: 1) student engineer and agentic positions; 2) engineer and agentic positions; and 3) teaching assistant and agentic positions, respectively. Next, 3.6 percent of the students only positioned themselves as engineering interns. They were able to reflect on their technical work experience without responding to their future career goals. The above results as a whole indicate that the top two positions taken up by a large majority of students (85%) are: engineering intern and agentic positions, and an agentic position. Thus, we mainly address those two positions students took on and describe below how those positions influence students' identities in relation to technical work experience.

Table 3. Frequencies for student positions within technical work experience.

Position options	Frequency			Percentage (100%)
	Male students reported	Female students reported	Total	
Engineering intern	12	4	16	3.6
Engineer	1	0	1	0.2
Student engineer	0	1	1	0.2
Agentic position	125	24	149	33.5
Teaching assistant	0	1	1	0.2
Engineering intern and agentic positions	181	48	229	51.5
Student engineer and agentic positions	19	4	23	5.2
Engineer and agentic positions	16	2	18	4.0
Teaching assistant and agentic positions	5	2	7	1.6
Total	359	86	445	100

Engineering Professionals

We found that those students who took up engineering intern and agentic positions were able to identify their position (job title), responsibilities, and the actions they have taken related to technical work. They also shared the tasks (i.e., software development, testing, updating products, project construction) they had done or contributed to when reflecting on their internship experience. When reflecting on their future career plans, those students demonstrated capacities and a willingness to act (i.e., complete the tasks). For instance, a senior technical student who was in the civil engineering major provided an example of how he helped with revising CAD drawings and visiting projects to document the construction progress. He wrote:

> Over the summer I helped revise the storm water design manual for DEC and the state of XX. The CAD drawings I revised and created were general approaches for storm water management with the use of bioretention filters. Having the previous knowledge of CAD allowed me to create very detailed drawings. These tasks I accomplished gave me a good understanding of biorientation filters and a full understanding of how storm water management works in a general approach. The tasks I completed gave head engineers time to work on revising the descriptions and requirements of these biorientation filters.

His reflections highlighted the importance of his internship experience. He took up both a civil engineering intern position and an agentic position who was capable of providing support in the project. When reflecting on his career goals, he was able to identify how his internship experience helped him achieve his career goals. In particular, he reflected:

> At the STEM job fair last fall I was hired by [XX Companies] for the summer of 2020. This opportunity bettered me as an engineer and will make achieving my goal easier. After I graduate I hope to continue working for the company with guided profession experience so I can achieve my goal of becoming a professional engineer.

Similarly, another senior student positioned herself as an engineering intern and took up an agentic position who could take responsibility for her intern job:

> I was responsible for maintaining tanks where different algae cultures grew. I also helped

> to identify biocontamination within these cultures and experimented with biocontamination control. My project task was to identify biocontamination within algae cultures. I tested four different methods of biocontamination control, including chemical sterilization and UV-C exposure, and quantified these results…This helped [XX company] identify a method to further experiment with as well as invest their time and finances in.

She also commented that the internship experience helped her promote critical thinking and problem solving skills and that she was capable of using them in her course work, as shown in her writings: "During this internship, I developed critical thinking and problem solving skills to effectively design a course of plan to solve the problem I was presented with." She further indicated that the skills she gained were also helpful for her to prepare to be a professional engineer. She wrote: "I completed an internship during the Summer 2020 semester to gain critical thinking and problem-solving skills for working as an engineer in professional applications. I have also started to job search and fill out applications."

As previously stated, two senior students exhibit a constructed engineering identity that is explicit about the ways that they are ready for the profession through how they position themselves as both an engineering intern and in an agentic position. They were also able to construct their professional identity by recognizing themselves as potential engineers and showing a willingness to improve their abilities to take action on their career plans. In this way, one would expect that others would recognize these individuals as engineering professionals.

Aspirational Engineers

Agentic position was constructed in students' reflections of their career goals. Taking up this position indicated that those students were able to share their expectations about employment and show their willingness to take actions to achieve their career goals. Engaging in an agentic position, students recognized the importance of internships in helping them prepare for a career as a professional engineer. For example, a senior technical student shared his career goals and steps he will take. He wrote:

> My career goals all lead to me eventually becoming a professional engineer and possibly starting my own consulting firm. Within in the next year I will succeed in all my classes and plan on taking the FE exam in the summer. I will also be working throughout the school year for the company that I interned over the summer, which will help me gain some more experience for when I fully enter the profession.

Another senior student, took up an agentic position who would like to gain co-curricular experience. He believed that was an important step toward achieving her career goal as a professional engineer. He reflected:

> For me, short term goals such as actively participate in each semester, engaging in engineering clubs and organization, work on project and research with department faculties are the current, most essential aspect. Getting an opportunity to study in a new environment, pursuing master degree in mechanical and aerospace engineering and accomplish all the short-term goals will open a door for me to become a performing

engineer and work for an engineering company in a larger range of achievement.

The quotes provided above indicated that students saw themselves as active agents and had certain expectations with regard to future career goals. Compared to students who took up both an engineering intern and an agentic position, these students lack evidence of their experiences that are explicitly situated in the profession. Through engaging in agentic positions, students were able to develop their professional identities by providing insights into their aspirations to become engineers, but their reflections may not be recognized by others as engineering professionals.

Self-positionings Within Research Experience

Table 4 presents how many times the positions occur when students reflect on their research experience. The agentic position (37.1%) was the most frequently listed position. When reflecting on the PDS, a larger proportion of students taking this position indicated their willingness to pursue Master's and PhD degrees and find an engineering-related research job as future career goals, whereas they did not have research experience or did not provide additional explanations on the research work they did. Then, it was followed by three different combinations of positions that students placed: 1) research assistant and agentic positions (34.3%); 2) helper and agentic positions (10.7%); and 3) undergraduate researcher and agentic positions (9.3%). Students who were taking positions in these categories were able to reflect on their research experience, identify themselves, and outline their future career goals. Following that, the least three reported research positions were self-positioning as a "research assistant", "undergraduate researcher," and "helper." Students in these categories were able to reflect on their research experience but were not sure about their future career goals, or their goals were not relevant to a research job in the engineering field. These different positions provide insights into how students construct their identities and develop their professional identities as researchers. We specifically address a combination of two positions (research assistant and agentic positions) that students took up and describe below how the positions could shape their identities.

Table 4. Frequencies for student positions within research experience.

Position options	Frequency			Percentage (100%)
	Male students reported	Female students reported	Total	
Undergraduate researcher	2	2	4	2.9
Research assistant	4	1	5	3.6
Helper	1	2	3	2.1
Agentic position	36	16	52	37.1
Undergraduate researcher and agentic positions	11	2	13	9.3
Research assistant and agentic positions	34	14	48	34.3
Helper and agentic positions	9	6	15	10.7
Total	97	43	140	100

Taking up research assistant and agentic positions, we found that students could understand the role of research assistants and had a willingness to act regarding their future career goals. Also, it indicated that research experience could promote their problem-solving, critical thinking, teamwork, communication, and leadership skills and prepare them to become future researchers and engineers. Students reflected on their roles as research assistants:

> As a remote research intern in the [XXX] Scholars Program, I collaborated with Dr. T and Dr. C [anonymous names assigned here] on a data analysis project to study patient compliance patterns with a mobile stroke rehabilitation system. I was responsible for compiling, organizing, and analyzing the data using a new data visualization method.
>
> Still currently ongoing, I have been working in the X Lab [anonymous names assigned here] for almost 4 years now, and have worked analyzing the role of ionic liquids as heat transfer fluids in volumetric thermal absorption systems. Responsibilities have included designing and executing experiments, collection and organization of data, building physical models to run my experiments in.
>
> Through this research experience, I investigate perceptions of fairness in algorithms within different contexts. This involved lots of literature review, designing of an experiment, submission of an IRB document, and networking with other teams related to the project.

Students also highlighted that they were able to hone professional skills within their research experience. For example, one senior student commented:

> I have greatly developed my ability to just go after a project no matter how difficult and complex it may initially look. Utilizing tools and programs that have learned in engineering [at my university] along with critical thinking and consulting other people for direction and advice, I was able to overcome many issues throughout my research process and work on many attributes crucial to being a successful engineer.

Another female senior student commented on her remote research experience that developed her communication skills. She wrote, “I further developed skills in using online data analysis tools and Excel. I also fine-tuned my communication skills as this was my first time working on a virtual research project and presenting virtually.” She also offered a reflection on her career goals: “I plan to pursue a PhD in biomedical engineering in the areas of tissue engineering and regenerative medicine. I ultimately hope to pursue a position in a research laboratory in industry, specifically in the pharmaceutical industry.”

Students’ self-positioning as research assistants and agentic positions occurred over time in previous examples when reflecting on their research experience. They prioritized their responsibilities as research assistants and recognized their research identity development through gaining and practicing skills in order to be a better engineer or in an engineering research-related position.

Discussion

Our results demonstrate students took up varied positions when reflecting on technical work and research experience, and those experiences played an important role in shaping their future career goals. By looking at the reflexive positions [38] students took up, we understood how students perceive themselves in their internships, co-ops, and research activities in relation to their responsibilities, tasks they had done, and future career goals. Similar to previous studies

[46, 47], students constructed their identities through positioning, which was emphasized in this study. Our results revealed that students' engineering identities and professional identities were shaped by their technical work and research experiences as they engaged in a process of positioning. For example, when asked to reflect on their future career goals, one senior student developed his engineering identity and professional identity by planning to take the FE exam and seeking to gain more internship experience to be a professional engineer. Within research experiences, for instance, one senior student developed a strong professional identity by identifying her abilities to overcome many issues throughout her research experience. As suggested in Eliot et al. [27] and Mann et al. [52], co-curricular experiences have an impact on students' engineering identities and professional identities. Echoing the previous study [53], compared to other students within technical work, those who had research experience were able to develop a research identity and had aspirations for future careers as researchers.

In addition, our findings revealed that the technical work and research experience helped students promote competencies such as problem solving and communication skills and prepare for future jobs as a professional engineer or a position in an engineering-related research field. Even students who did not have technical work or research experience were eager to find internship or research opportunities that would help them in their career preparation. Similarly, Kovalchuk et al. [54] provided examples of undergraduate engineering students' experiences within co-curricular activities (i.e., internships, co-ops) equipped with professional skills and knowledge (i.e., communication, teamwork, and leadership) that facilitate their transition to employment. Also, as Carter et al. [3] indicated, undergraduate research experience helps engineering students develop communication skills.

The findings further revealed that students' reflexive positionings and identities interplayed and impacted each other. For example, one female student recursively constructs an identity as a potential engineer when reflecting on technical work experience. That identity as a potential engineer influenced her to position herself as an active agent who was willing to take action in order to work in the engineering field after graduation. Just like undergraduate engineering students in Schell et al.'s [12] study, the students who could identify themselves as engineers within internship experience influenced their future plans to consider engineering as a career.

Implications for Practice

The findings of this study offered three important implications. First, findings revealed that students' reflections through PDS considered through a positioning theory lens helped us better understand the levels of students' technical work and research experience and how, in their view, co-curricular experiences are valuable for their professional development. The study supports the idea that engineering schools should engage students in reflective practices and guide their self-reflection processes as they engage in both curricular and co-curricular activities (i.e., student clubs, makerspaces). This is important because reflection is a key process for professional identity development [30]. Students could be encouraged to reflect on how those past experiences would benefit their professional development (i.e., communication skills practice and development, enhancing their engineering identity and professional identity), their current learning as an engineering student (i.e., what challenges they might face participating in co-curricular activities), and their future expectations with career plans. Engaging in such reflections may foster students' self-awareness with regard to their capacity to act as active agents [29].

Second, participating in technical work and research activities provided undergraduate engineering students with an opportunity to reveal their engineering and professional identities. As several previous studies [55, 56] have shown, some engineering students have difficulty identifying themselves as potential engineers (i.e., students who did not take agentic positions in this study) during their undergraduate education, and a lack of that kind of identification could influence students' engineering careers. This implies that engineering educators and faculty should encourage students to participate in co-curricular activities, especially internships, co-ops, and research opportunities. Further, there may be value in sharing and discussing reflective writing among students as part of the engineering education process. Allowing students to see how others respond to similar prompts and what it reveals (or does not reveal) about emerging identities may support students in their own thinking. This potential intervention represents a line of future work.

Third, reflections on co-curricular experiences may also support arguments for institutions to consider including co-curricular activities that clearly demonstrate identity development as a part of their engineering curriculum plan; particularly activities that may not currently be considered significant (e.g., technical club involvement). It will be important for those who lead the co-curricular activities to offer opportunities for students to develop skills that can expand students' co-curricular experiences to enhance their professional development and engineering identity formation.

Conclusion

This study has added to the existing literature on undergraduate engineering students' reflections on technical work and research activities. Positioning theory was particularly helpful for looking at how students position themselves within technical work and research experiences in order to understand how they construct and develop engineering identities and professional identities. It also contributes to the development of a coding framework for reflective writing that might help us understand how students' engineering identity development is supported by or emerges through these activities. However, one limitation is that our data analysis only focused on the open-ended questions from the PDS. Students do reflections in a very limited way. Positioning also occurs when people construct themselves through oral discourse. This suggests that future research needs to add interview data to have an in-depth understanding of how those co-curricular experiences have an impact on students' professional development. Member-checking with students will be used to increase the credibility of findings in our future work. Future research may also consider students' gender and ethnic identity. It is critical to consider how these identities will interact with engineering and professional identities within co-curricular activities. Addressing those issues will help develop co-curricular opportunities that will benefit student diversity.

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Appendix A: Selected open-ended questions from technical work experience.

*** Please give your position title and briefly describe your overall responsibilities :**

*** Please explain your primary project by considering the following: situation or task (the task/problem you were presented with), action (what did you do), result (what did you accomplish), impact (how did this help your employer) :**

Indicate which of the following courses were relevant to your work experience(check all that apply)

*** Check which of the following competencies you developed or improved during this experience:**

- ☐ Critical thinking/problem solving
- ☐ Engineering design, including use of relevant codes/standards
- ☐ Use of appropriate computer technology
- ☐ Use of engineering tool
- ☐ Oral/written communication
- ☐ Teamwork/collaboration
- ☐ Leadership
- ☐ Professionalism/work ethic/integrity
- ☐ Project/time management
- ☐ Foreign language

Provide a brief explanation of your response to the question above:

***Please tell us about your career goals, the steps that you have taken to achieve these goals, and the opportunities that you will pursue in the coming year to progress towards these goals. We encourage you to carefully consider your plans and to provide a thoughtful, professional response.**

Appendix B: Selected open-ended questions from research experience.

*** What was the nature of your research experience? Please include the overall scope of the project and your individual responsibilities.**

*** Please explain your primary project by considering the following: situation or task (the task/problem you were presented with), action (what did you do), result (what did you accomplish), impact (how did this help the overall project)**

Indicate which of the following courses were relevant to your work experience (check all that apply)

*** Check which of the following competencies you developed or improved during this experience:**

- ☐ Critical thinking/problem solving
- ☐ Engineering design, including use of relevant codes/standards
- ☐ Use of appropriate computer technology
- ☐ Use of engineering tool
- ☐ Oral/written communication
- ☐ Teamwork/collaboration
- ☐ Leadership
- ☐ Professionalism/work ethic/integrity
- ☐ Project/time management
- ☐ Foreign language

Provide a brief explanation of your response to the question above:

***Please tell us about your career goals, the steps that you have taken to achieve these goals, and the opportunities that you will pursue in the coming year to progress towards these goals. We encourage you to carefully consider your plans and to provide a thoughtful, professional response.**

Appendix C: Position options.

Co-curricular exp.	Position options	Definition	Example
Technical Work Experience	1) Engineering intern	The position was constructed through the storyline of "working as an intern."	"I worked as a Software Engineer Intern on the Performance & Engagement Team."
	2) Engineer	The position was constructed through storyline of "was used to be an engineer."	"I have been working for XX for 14 years."
	3) Student engineer	The position was constructed within the storyline of technical work experience but was not related to internships.	"Process Development Engineer Co-Op."
	4) Agentic position	Students shared the tasks they had done or had the willingness to act towards future career plans.	"I am planning on taking my FE exam in early March to try and pass before I graduate."
	5) Teaching assistant	The position was constructed through the storyline of "working as a teaching assistant."	"Assessing student performance and submitting final recommendations to Professor for consideration"
	6) Engineer intern and agentic positions	Considering a combined the definitions of 1) & 4)	"Electrical Engineering intern - Assisted my mentors with their projects working in Revit and AutoCAD…" "I have started applying to internships for this summer."
	7) Student engineer and agentic positions	Considering a combined the definitions of 3) & 4)	"I am responsible for helping customers through the engineering design process." "I want to help the company grow by efficiently taking on and finishing projects."
	8) Engineer and agentic positions	Considering a combined the definitions of 2) & 4)	"I have been CEO of a company for last 12 years. I will use my experience and education for the well being."
	9) Teaching assistant and agentic positions	Considering a combined the definitions of 4) & 5)	"Assist multiple professors with delivery of course content." "Due to the uncertain job market, I plan to attend Graduate School immediately upon graduation."
Research Experience	10) Undergraduate researcher	The position was constructed through the storyline of "doing research" and "collaborating with someone," not as an assistant.	"My research was on creating a resorbable intercranial flow diverter. It was part of my senior design project as well."
	11) Research assistant	The position was constructed through the storyline of "working as a research assistant under professors."	"For the research project, my task was to develop an algorithm using python or Matlab…"
	12) Helper	Position was constructed through the storyline of "helped to do" related to research experience.	"I helped program a code for ImageJ."
	13) Agentic position	The position was constructed through the storyline of "helped to do" related to research experience.	"I will make sure to strengthen my resume (volunteering hours, take the MCAT) for medical school admissions…"
	14) Undergraduate researcher and	Considering a combined the definitions of 10) & 13)	"I took part in developing multiple data analysis codes on MatLAB…" "At the

	agentic positions		same time I plan to continue working on my own projects…”
	15) Research assistant and agentic positions	Considering a combined the definitions of 11) & 13)	“I worked as a research assistant.” “I hope to do some work at an internship that involves fluid mechanics”
	16) Helper and agentic positions	Considering a combined the definitions of 12) & 13)	“I helped model a series of networks in Mathematica…” “To help myself prepare for this career, I am choosing electives and courses that pertain to this field.”