The Role of Practicing Engineers in Recognizing Students' Identities

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1. Introduction

This full empirical research paper explores how undergraduate engineering students experience industry recognition across a four-year undergraduate program. The extent to which students believe other people see them as engineers influences how they see themselves as engineers. Students' engineering identities can shape how they are motivated, persist, and learn engineering [1]-[3] which has inspired calls for the inclusion of identity development as part of the undergraduate engineering curriculum [4], [5], [6], [7], [8]. Research has shown that how students feel recognized by others as the kind of person who can do engineering is the most important element in the development of an engineering identity [9], [10]. Understanding recognition is critical for designing high-impact curricular practices that can effectively leverage recognition. While researchers have established the importance of engineering recognition beliefs toward identity development, less is known about how students develop these beliefs.

Most recognition work within engineering identity research explores how students believe peers, family, and faculty see them as engineers but does not include how students believe they are seen by practicing engineers in industry [11], [12], [13], [14]. Since engineering majors primarily prepare students for a specific disciplinary role, it is important to understand how students see themselves as part of the engineering community by those already embedded in it. How students experience recognition from practicing engineers is relatively unexplored and important to understand, as industry recognition includes a facet of recognition experiences that extends beyond educational experiences and could support engineering identity development across the transition into industry. This work seeks to explore students' perceptions of recognition from practicing engineers by answering these two research questions (RQ):

> **RQ1:** How do undergraduate engineering students experience the recognition of their engineering identities by practicing engineers in industry?
>
> **RQ2**: How do these industry recognition experiences change during a four-year undergraduate engineering program?

This longitudinal phenomenology study characterizes how students qualify practicing engineers as meaningful and presents a time-oriented description of how students' access to practicing engineers and associated industry recognition beliefs change over time.

2. Theoretical Framework

To answer our research questions about how students feel recognized by engineers in industry, this work leverages recognition as situated within engineering role identity. Engineering role identity considers how students take on the role of an engineer by engaging with specific practices, developing social networks, and taking on the duties, responsibilities, and knowledge associated with the profession [11], [15], [16]. Students see themselves as engineers through a dialogical process of positioning themselves and being positioned by others as engineers or people who can do engineering [17], [18]. Who is recognized for what is racialized and gendered as recognition is underwritten by systems of power and privilege that constrain who one is allowed to be per the norms, rules, and routines of that community [10], [17], [19], [20], [21], [22], [23]. Although this study does not explicitly consider the role of social identities in

recognition, this work sets up a foundation of understanding that can be used to further explore the richness and nuance of recognition across identities.

Broadly, recognition includes students' perceptions of how others see them as engineers [11], [19] and is the most influential element in the development of engineering identities [9], [10]. This work focuses on the conceptualization of *meaningful recognition* to describe recognition that maintains or develops an engineering identity. Meaningful recognition is present "when an individual perceives and internalizes this recognition," and it "counts for identity development [24, p. 99]." Students perceive meaningful recognition coming from *meaningful others* who are people whose recognition, opinions, and acceptance of them as engineers are valued by students [6], [10], [25]. In this work, practicing engineers delineate engineers working in industry as a separate recognition source from often-studied groups, including peers, family, and faculty [11], [12], [13], [14].

This work focuses on meaningfulness as not all recognition is considered *meaningful recognition,* and not all people are considered *meaningful others* [25], [26]. This emphasis on meaningfulness scopes this study towards recognition experiences that may be perceived, interpreted, and internalized toward recognition beliefs and identity development. When interpreting perceived recognition, students qualify the recognition sources as they determine if they can meaningfully see them as engineers [25], [27]. With respect to various recognition sources and meaningful others, students hold *recognition beliefs* that describe how students feel sources of recognition see them as engineers or engineering people [11]. These recognition beliefs are the aspect of recognition experiences that are most often considered in engineering identity work, but little is known about how students develop these beliefs in an engineering context. In this work, industry recognition delineates recognition beliefs that include how students perceive practicing engineers see them as engineers.

3. Methods

This paper reports longitudinal, qualitative results from an NSF-funded mixed-methods study (NSF grant #EHR-1833738) focusing on a four-year-long cohort program designed to support academically talented and socioeconomically disadvantaged undergraduate engineering students. Interpretive phenomenology guided this work using semesterly semi-structured focus groups and an exit interview for 14 participants to develop a nuanced understanding of the phenomenon of industry recognition as it is experienced from multiple perspectives [28], [29]. The data includes participants' recognition experiences across their entire 8-semester undergraduate engineering program to support a change and time-oriented understanding of the phenomenon. Data was analyzed using iterative rounds of content coding, open coding, and thematic analysis toward the distillation into the essence of what the phenomenon looks and feels like [28], [30], [31]. All authors contributed to the running of the cohort program, with the first, second, and fourth authors playing a significant role in this study's data collection and analysis.

3.1 Location and Participants

This study was conducted at a large, western land-grant, R1 university and focused on the lived-experiences of 14 undergraduate engineering students participating in a four-year S-STEM cohort [32], [33], [34], [35]. Participants voluntarily applied to the four-year scholarship-based cohort program before starting their first semester and were selected based on financial need, academic ability, and letters of recommendation. To promote comprehensiveness [36], [37], this study included participants who were with the cohort for at least six of their eight semesters and

omitted data from participants who withdrew enrollment before graduation. Data collection started during the participants' first semester in the Fall of 2019 and ended during their last semester during Spring 2023. Two participants joined the program during its second year and graduated in Fall 2023.

This cohort program was designed to support undergraduate engineering students to graduation by implementing evidence-based practices targeting the participants' sense of belonging, self-efficacy beliefs, goal-oriented motivation, and engineering identities. With respect to engineering identity and recognition, the cohort program aimed to reduce barriers and create access to co-curricular activities including research and internships. Activities included career fair attendance, career panels, resume and networking workshops, and career-oriented mentoring. By graduation, 11 of the 14 participants had worked at least one industry internship. Although this population represents a higher percentage of students who had an internship experience compared to the national average [38], these participants emphasize the value of these experiences when they can access them during an undergraduate program.

As this was an outward-facing program, additional care was taken to obscure identifiable participant information. Participants are assigned a gender-neutral pseudonym, and demographic information including race, ethnicity, and major enrollment are omitted to protect anonymity. The participants represented seven different engineering disciplines, had a proportionally similar representation of women compared to the larger engineering college, and had a larger representation of students who self-identified as Latino/a, Asian, Black, or multi-racial (64% vs 40%). Although social identities are an important feature of recognition and emerged in the data, this was not the unit of analysis for this phenomenological work. The participants were selected to emphasize the homogeneity of their experience to understand the commonalities and to illuminate the depth and complexities of the engineering recognition experiences of students in a cohort [32], [33], [34], [35]. This sample's composition supports the transferability of findings to similar populations enrolled in undergraduate engineering programs but cannot speak to the experiences of populations not included or identified.

3.2 Data Collection

To explore participants' recognition experiences from practicing engineers, this study drew on phenomenology's operationalization of experiences to include the perceptions of an event happening and the related meaning-making as participants interpret recognition beliefs. A longitudinal approach was taken to appropriately capture the breadth of the experiences across an engineering program. In alignment with phenomenology and to best support the exploration of the personal, contextual, and perception-based phenomena of recognition, a semi-structured approach was used when collecting data [39].

For the first seven semesters, focus groups were utilized to facilitate the sharing of group experiences essential to the larger study about the benefits of the cohort, while still allowing for the sharing of individualized recognition experiences enhanced by participants' ability to compare with each other [40]. Focus groups consisted of four to five participants, lasted about one hour, and were conducted at the end of each semester. A guiding research question asked students "Who sees you as an engineer?" which facilitated a present understanding of recognition beliefs. The open-ended nature of the focus groups allowed for follow-up questions including but not limited to asking the participants to explain how they knew they were seen as

engineers, how they valued being seen as an engineer in those experiences, if their recognition beliefs had changed at all from previous semesters, and what events lead to this change. Focus groups during the first semester were held in person. The following six focus groups were held via an online video platform due to the switch to remote learning due to the COVID-19 pandemic.

For the final semester, we conducted semi-structured interviews to address the need for individualized understandings of recognition experiences over time [41], [42]. The questions were similar to those asked in the focus group but included a journey-mapping activity where the participants plotted how they believed different recognition sources saw them as engineers over time. The participants used these journey maps to illustrate the changing strength of their beliefs ranging from low to high and to indicate key changes or experiences. These journey mapping activities served as an elicitation tool to understand industry recognition experiences across the eight semesters and to offer opportunities to compare with data and check understandings from the previous seven semesters [36], [42]-[44]. Interviews lasted about one hour, were conducted in the final weeks of the semester, and were held in person. All focus groups and interviews were audio and video recorded, professionally transcribed by Rev.com, and checked for errors before being uploaded to the coding software NViVO12 (QST International) for future analysis.

3.3 Data Analysis

Transcripts underwent iterative rounds of coding and analysis towards the generation of descriptions of the phenomenon's essence. Memoing was undertaken before data collection began, after each round of data collection, and throughout the multiple rounds of analysis to support the credible refinement of understandings of the phenomenon [45], [46] and to promote iterative reflexivity [37], [47]. Focus group transcripts and interviews underwent a deductive conceptual first coding pass to categorize the data into significant statements pertaining to the concept of recognition [28], [48]. Codes were derived from existing recognition theory to generate broad codes meant to index large quantities of data for future detailed analysis [49]. The transcripts underwent a second round of open coding to break down concept-coded data into discrete parts to make meaning of the data and capture the essence and essential elements of a phenomenon [49]. Codes included the details of participants' recognition experiences with a consideration of change and time points, which were further categorized into core categories to prime the data for phenomenological theming [49].

The data underwent phenomenological theming to move the data from small parts and narrow statements towards the aggregation of the experience into main themes and meaning structures of participants' shared experiences of recognition [36], [50], [51]. Final themes were developed through iterative immersion with the data, abstraction of the data into codes, synthesis of data into themes, the refinement and reporting of potential themes, and discussion with the research team to support clarity and credibility of the new understandings of the phenomenon [45], [46] . These themes were used to craft a general description of the phenomenological themes and the key time points and events into a cohesive piece meant to capture the essence of recognition in the context of industry and with respect to time. This understanding is presented in the following sections as a summary of practicing engineers as meaningful sources of recognition and descriptions of the common trajectory of industry recognition experiences over time.

4. Results

Guided by research questions seeking to deeply understand how undergraduate engineering students experience recognition from practicing engineers, the phenomenon of industry recognition is presented in two parts. First, this work describes how students qualified practicing engineers as meaningful sources of recognition which is followed by a trajectory of how students accessed recognition and held industry recognition beliefs across their undergraduate program.

4.1 Practicing Engineers as Meaningful Others

The participants qualified practicing engineers as meaningful others who were most qualified to see them as engineers due to their employment as engineers in industry, their engineering experience, and their knowledge of engineering. The participants delineated that engineers working in industry were a highly valuable source of recognition whose recognition *"is more validating " (Avery)* compared to those outside of engineering whose views of them were *"not as meaningful (Morgan)."* Feeling seen as an engineer by practicing engineers carried extra weight to the participants as it also signified that they were now part of the community and conveyed that they were being seen as peers. Practicing engineers were often regarded as the most meaningful recognition sources as they embodied the role that the participants were working to become. Morgan described the shared perceptions of the hierarchical valuing of recognition from practicing engineers where the *"final step is industry validation, where somebody actually working as an engineer says, 'Yes, you are a fellow engineer. You're actually doing the work with me.' Just that physical, tangible proof."*

Participants valued that the engineers recognizing them understood engineering and *"knew what the definition of an engineer was and what an engineer does (Sam)."* If the participants felt that those seeing them as engineers were not knowable of engineering or *"there's some basic principles that they just don't know about at all...it makes me kind of respect them less in an engineering sense but still respect them as a colleague (Kai)."* This devaluing of recognition was common coming from coworkers who worked with engineers but were not engineers themselves. How knowledgeable of engineering was how the participants qualified engineers as highly meaningful others who could impact how the participants saw themselves. Avery articulated that recognition from:

> *Someone who is an engineer who sees me as an engineer, that has more credibility behind it. Because they have experienced that coursework, they've applied what they've learned in their major. And if they're in the industry they've been working in that field for a while. So if they see me as being an engineer, that in itself would boost my confidence.*

Part of the value of recognition from engineers was ascribed to the legitimacy of their degree and title as they have *"all been through [college] already (Casey)."* Being seen as engineers by engineers was valuable to students and impacted how they saw themselves. The participants consistently qualified practicing engineers as meaningful others whose recognition validated their engineering identities; when and how the participants accessed this group changed over their undergraduate program.

4.2 Trajectory of Industry Recognition Experiences and Beliefs

Most participants followed a common trajectory in how and when they accessed recognition from practicing engineers and developed industry recognition beliefs. Early on, the participants typically had low to non-existent industry recognition beliefs that aligned with their limited access to industry professionals. During the middle of their program, industry recognition beliefs

emerged as the participants started interviewing for engineering internship positions and perceiving practicing engineers as recognition sources. Later, the participants' beliefs dramatically increased as they were hired for engineering internships and steadily progressed through various internship experiences. Figure 4.1 illustrates this typical trajectory of the participants' industry recognition beliefs over time to illustrate how these beliefs changed in strength over an undergraduate program. This trajectory included the majority of the participants in this study but excluded the few who had internships starting their first year in school or solely opted for undergraduate research experiences rather than industry internships. This section further describes recognition beliefs, focusing on how that recognition was accessed and interpreted for the participants during the early, middle, and later portions of their engineering programs.

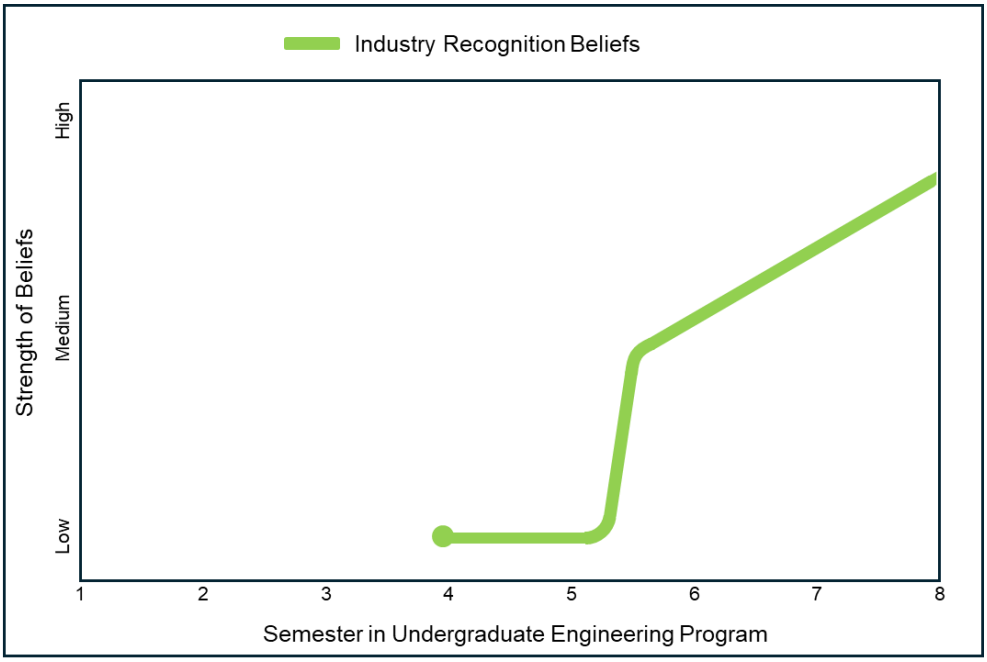

Figure 4.1: Illustration of participants' changing industry recognition beliefs indicating the delayed emergence as they started to apply for internships, the rapid growth as they started to be hired, and the steady growth as they were recognized within industry.

Early Program: Low to non-existent industry recognition beliefs

During the first two to three semesters of their engineering programs, the participants typically held very low or non-existent industry recognition beliefs. The participants did not mention practicing engineers as a recognition source when reflecting on who saw them as engineers; instead, they focused on recognition sources they had regular interactions with, such as family, peers, and faculty. The participants had not yet perceived practicing engineers as a recognition source due to their limited access to or interactions with this group which aligns with the lack of associated industry recognition beliefs.

Middle Program: Emergence of industry recognition beliefs

Practicing engineers as recognition sources and industry recognition typically emerged during the participants' third to fifth semester as they began to search, apply, and interview for engineering internships. When the participants sought industry experiences, they became aware of practicing engineers and began to develop recognition beliefs through interactions at career fairs and interviews. Although some described how they *"kind of felt like an engineer at the*

career fairs when I was talking to people, trying to get an internship (Ellis)," their first industry interviews stood out as key experiences where participants' industry recognition beliefs initiated. These interviews stood as prominent experiences where the participants had direct access to practicing engineers and felt that *"when I'm talking to people for internships, they do kind of see me as an engineer (Jordan)."* Their industry recognition beliefs were fairly low at this time, but they were now described alongside recognition beliefs from other sources.

Middle to Later Program: Grown in industry recognition beliefs

The participants' industry recognition beliefs sharply increased as they started getting hired for and working at engineering internship jobs. This typically happened during the participants' 4th to 6th semesters as they had finished taking enough classes for their discipline and were competitive choices for the positions. Casey described the shared personal value of getting hired after *"going through the five interviews they made me go through and then finally getting it. It was pretty cool. I don't want to say it inflated my ego, but it did for a little bit. I can't lie. It was really cool.* " Being hired as an engineer was confirmation of their abilities in that *"people think I'm intelligent enough to have a job (Drew)*" and were described as validating since *"someone respected where I'm at in school enough to try and put me in a position where I have to do some engineering work (Kai)."* Being hired as an engineering intern was also connected to how they saw themselves *"as more of an engineer now that I've had those internships and have gotten job offers from those. So at least other people see me as an engineer in that way (Ellis)."*

Another key element of this change in recognition beliefs was the change in how the participants accessed practicing engineers. Before starting these new internship positions, the participants' access to practicing engineers was typically limited to brief interactions at career fairs and interviews. In response to the onset of their industry recognition beliefs, Taylor explained how " *the one thing that has changed is my coworkers, but that's just because I put myself in different work settings than I was in two and a half years ago.*" At their new internships, they interacted with practicing engineers almost daily, facilitating many more opportunities to be seen as engineers and develop strong industry recognition beliefs. After the initial increase in recognition beliefs after getting hired, the participants' recognition beliefs maintained steady growth towards graduation as they frequently interacted with practicing engineers and had varied meaningful recognition experiences at their jobs.

5. Discussion

This work explored how undergraduate engineering students experience recognition from practicing engineering in industry. Longitudinal focus groups and interviews illustrated how students saw practicing engineers as meaningful others and that they followed a common trajectory of access to this group. These time-oriented understandings of industry recognition corroborate and enhance understanding of practicing engineers as meaningful others and pushes for their inclusion in recognition research that extends beyond the first year.

5.1 Practicing Engineers as Meaningful Others

This study establishes industry recognition as an important element of engineering recognition that could be explored and supported, especially for students beyond their first year in an undergraduate program. Building off the understanding that not all recognition sources are meaningful others [24]-[26], the results of this work extend our understanding of what makes a source meaningful to students in the context of practicing engineers. The qualification of the recognition sources has been described as a critical step in the interpretation of meaningful

recognition as students evaluate if a recognition source can see them as engineers in ways that matter to them [25]. How recognition sources are qualified as meaningful others is not consistent across groups, although engineering students tend to focus on the sources' knowledge of engineering and the validity and legitimacy of their recognition (i.e., how accurately can that person see them as an engineer)[27]. When qualifying practicing engineers as meaningful others, the participants emphasized the engineers' education and industry experiences in addition to their professional job titles. These findings illustrates the delineation between recognition sources based on engineering knowledge and describes a hierarchy of meaningfulness as the participants qualified practicing engineers as the most meaningful sources of recognition, above engineering faculty and engineering peers.

5.2 The Inclusion of Industry Recognition

Existing work on engineering identity emphasizes the important role of the source in engineering recognition, which is reflected in current survey tools that explore recognition as a construct derived from students' beliefs of how different recognition sources see them. Although some work in engineering education has acknowledged industry recognition [52], this group is missing from most recognition research that instead focuses on three common recognition sources: peers, family, and faculty. The absence of industry recognition is explainable given the theoretical history of disciplinary role identity in engineering education. Current engineering identity models are derived from work in the physics and mathematical education space [11], [14] that only include peers, family, and faculty and conceptualize recognition with respect to a particular subject rather than recognition of a professional role such as engineering. In that work, a student being seen as a math or physics person is not the equivalent of being seen as a mathematician or physicist but rather someone who has the capacity to do that subject well. There is less emphasis on being seen as that specific role by someone who has that role already.

While useful in understanding identity and recognition for early engineering students, these identity models were established with populations that do not reflect students' experiences across a full undergraduate program. Engineering identity scales were derived from math and physics instruments [7], [52]-[54] that were designed and validated for high school and first-year students. Work that does not specifically explore the recognition experiences of students beyond their first years is likely to miss practicing engineers as meaningful recognition sources altogether, as they do not emerge until later in an undergraduate program. A key finding of this work was the participants' delayed access to practicing engineers as a recognition source, reflected by the trajectory of students' engineering recognition beliefs that did not start until their second year. It is not that they had low recognition beliefs; this work illustrates a complete absence of these beliefs as this recognition source was not accessed or perceived by the participants. Work that did not specifically include recognition experiences for students as they started to apply for, interview, and work at internships could inadvertently omit this group as a recognition source entirely. This work highlights the importance of practicing engineers as meaningful others and proposes that industry recognition is included in identity research that extends beyond the first year.

6. Implications

An understanding that practicing engineers are meaningful others that students tend to access later in their programs provides insights for researchers and educators. Engineering identity researchers could consider the importance of time-in-program for their populations and include industry recognition when understanding learning from students beyond their first year.

Engineering identity development and its supporting constructs are dynamic processes as what supports an identity for first-year students is not the same as they persist in their undergraduate programs. While the inclusion of industry recognition may not be appropriate for early program students, engineering recognition work that looks at the middle years and beyond could intentionally include recognition from practicing engineers. Engineering programs are predominantly designed to prepare students for a clearly defined engineering role and identity work that seeks to understand how students see themselves taking on that role could consider how students feel they are integrating and being seen as engineers by those in that community.

Engineering educators could strive to help their students access practicing engineers as many do not begin to access industry recognition sources until the middle of their programs and students may be limited in their access due to a variety of factors including GPA, social networks, and other factors beyond the instructor's control. Instructors can strive to bring industry members into the classroom by including them as project mentors or working to include industry client projects. Faculty can also encourage students to access practicing engineers outside the classroom by attending career fairs and career panels or joining project-based teams with an industry sponsor or industry conference (e.g. design competitions for ASME or ASCE). While these experiences may not be as impactful as internships as being recognized at an engineering internship, they begin to promote access to a hard-to-access group. Engineering programs could seek to include industry in smaller ways such as supporting career fairs, panels, clubs, and mentorship programs. They can also consider larger structural support by implementing co-op programs like those at Drexel University, Northeastern, and Rochester Institute of Technology to name a few. Ultimately, the goal is to make practicing engineers an accessible group to engineering students in ways that allow for more students to have the opportunity to be recognized as engineers.

7. Limitations and Future Work

Although this work exploring industry recognition experience over time has valuable findings for research and education, some limitations must be made explicit to clarify its transferability. The participants in the study were engaged in a four-year-long cohort that included features that encouraged and supported students in seeking, applying, and interviewing for internships. Eleven of the 14 participants had worked at least one engineering internship before graduating. Future work could seek to understand longitudinal recognition experiences of engineering students who had different education paths, such as those who pursued research experiences, were unsuccessful in obtaining an internship, or had career goals outside of engineering (e.g., medical school or law school).

Although the participants in this study represented varied demographic backgrounds, these social identities were not considered in relation to recognition from practicing engineers. It is understood that recognition is underwritten by systems of power and privilege as who gets recognized and for what practices can be heavily influenced by bias. While the participants in this study described experiences of recognition that intersected with their social identities, the purpose of this study was to understand shared experiences, and it was not designed to explore recognition and its intersections with their various social identities. Future work could specifically explore recognition from industry with considerations of how bias may influence recognition experiences in professional settings.

Future work could revisit existing identity surveys to include practicing engineers as part of recognition constructs. This is particularly relevant for surveys intended to understand engineering identities beyond the first year. Additionally, future work could seek to add nuance to what meaningful industry recognition looks like. This work illustrated the role of practicing engineers as late-access meaningful others but does not speak to what recognition in professional contexts can look like. Although meaningful recognition has been identified as important, there is still much room to understand its mechanism better so it can be intentionally supported.

8. Conclusion

This longitudinal phenomenological study explored how engineering students experienced industry recognition throughout a four-year undergraduate program. The concept of meaningful recognition was used to delineate recognition that was supportive of engineering identities and to understand the value of recognition from practicing engineers. Practicing engineers were characterized as meaningful others who were among the most valued recognition sources. However, students typically accessed this group later in their program as they began to apply for internships. This work corroborates existing work on the importance of meaningful others and extends existing literature to better understand what makes meaningful others meaningful.

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