You Either Have It or You Don’t: First Year Engineering Students’ Experiences of Belongingness

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You Either Have It or You Don’t: First Year Engineering Students’ Experiences of Belongingness

This research paper investigates first-year engineering students’ perceptions of belongingness in engineering. Interviews with 23 students about their fit, belonging, and similarities in engineering informed our analysis of the ways in which first-year engineering students describe belonging in engineering. We found that students responded to questions about belongingness in three ways: through their personal attributes, interests, and emotions. Additionally, we found that students described these attributes, interests, and emotions as characteristics that they either did or did not have. These fixed characteristics did not allow for student change or growth. Together, our results inform ways that students evaluate their belongingness in engineering, as well as ways in which educators can help their students feel like they belong.

Introduction

Belongingness typically describes a sense of community or affinity towards a certain group, as expressed by an individual. In this article, we use the term to represent an individual’s judgement of whether they feel welcomed and wanted in engineering. Stronger feelings of belongingness result in higher self-efficacy [1], engagement [2], and ability [3]. Conversely, a lack of belongingness has been identified as one of the top reasons that students leave a university [4, 5]. Belongingness is imbued throughout a student’s educational experience, at both the classroom and university levels [1, 2].

In engineering education research, belongingness is often investigated through the experiences of women in science, technology, engineering and mathematics (STEM) majors and careers [6, 7]. Tonso found that “Women belonged only in the social arenas of Greek societies, not as engineers” [8, p. 365]. Women were excluded from the social activities in engineering available to their male peers and thus had decreased perceptions of belonging. In a survey of 288 undergraduate engineering students, Cech and colleagues [9] found that students, especially women, who developed confidence in their fit with the engineering profession were more likely to persist in engineering. Other studies have also shown that creating an alignment between women’s individual characteristics and selves with engineering culture can create strong feeling of belonging in engineering [10, 11]

Additional work on belongingness in engineering education research has shared the powerful, emotional experiences of racial and ethnic minority students in engineering. Foor, Walden, and Trytten [12] told the story of Inez, a student who continually felt excluded from engineering. Although she enjoyed the work and persisted through challenges, Inez’s multiple identities and experiences coalesced into a perception that she was not wanted in engineering. Inez keenly felt a sense of “Us” and “Them,” saying, “I wish I belonged more in this whole engineering group.” The story of Inez and others like her in engineering show that a lack of belonging causes serious distress and concern across a range of demographic profiles and experiences. A significant amount of other research has shown similar trends for other minoritized students [13-15].
Our work focuses on a new way of investigating belongingness within engineering. Rather than focus on where belongingness might occur or the experiences of minoritized groups, we investigate the lived experience of belongingness as reported by first-year engineering students. Individuals in this group are developing their identities as engineers within an engineering community of practice. The particular ways in which they feel that they do and do not belong in engineering can provide evidence for how students start to become more legitimate participants in engineering and begin to take on the role of being an engineer. In this work, we have intentionally left the prompts for asking about student belongingness open to understand the different ways in which students discuss belonging in engineering. Given the demonstrated importance of belongingness in terms of success in academic settings, how students feel they fit in engineering may have drastic effects on their overall experience and persistence in engineering.

The research question guiding this analysis was: How do first-year engineering students describe what it means to belong in engineering?

Methods
The data for this study come from interviews with 23 students in either Spring 2016 or early Fall 2016. Students attended one of four large U.S. research institutions involved in the study: Midwest Primarily White Institution (Midwest PWI), West PWI, South PWI, and South Hispanic Serving Institution (South HSI). Interview participants were recruited from a group of students at the four institutions that took a survey in their first-year engineering programs in Fall 2015. Rationale and mechanisms of recruitment have been discussed in-depth previously (Authors, 2016a). In brief, students were recruited from different attitudinal profiles generated from data gathered from a survey exploring their attitudes and beliefs (e.g., engineering identity, goal orientation, and career outcome expectations). Table 1 contains each participant’s pseudonym, the distribution of participants by institution, their gender, their race/ethnicity, and their major.

The interviews were semi-structured and were conducted face-to-face at the home institution of each student. The semi-structured protocol allowed for a level of consistency across interviews but also allowed for follow-up questions, clarifications, and elaborations. Interviews lasted approximately an hour and students were compensated for their time. Students chose their own pseudonyms. Institutional Review Boards at each institution approved the recruitment and interview processes.

The results in this article are based on student responses to four questions within the interview: (1) Does engineering feel like a good fit for you? (2) Do you feel like you belong in engineering? (3) What characteristics of yourself make you like an engineer? and, (4) What characteristics of yourself make you unlike an engineer? These questions were developed to explore students’ feelings of belongingness within the field of engineering and how they conceptualized their alignment with the role of an engineer in their communities of practice. Due to the semi-structured nature of the interviews, the order of presentation varied and each of these four belongingness questions were not asked in every interview. For this analysis, only the direct responses to these four belongingness questions were investigated.
<table>
<thead>
<tr>
<th>Institution</th>
<th>Pseudonym</th>
<th>Gender</th>
<th>Race/Ethnicity (write-in quoted)</th>
<th>Planned major at time of interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midwest PWI</td>
<td>Aaron</td>
<td>Male</td>
<td>Hispanic, “Honduran American”</td>
<td>Computer Engineering</td>
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<tr>
<td></td>
<td>John Smith</td>
<td>Male</td>
<td>White, “Midwesterner”</td>
<td>Agricultural Engineering</td>
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<td></td>
<td>Kathie</td>
<td>Female</td>
<td>White</td>
<td>Aerospace Engineering</td>
</tr>
<tr>
<td></td>
<td>Keyla</td>
<td>Female</td>
<td>White</td>
<td>Chemical Engineering</td>
</tr>
<tr>
<td></td>
<td>Matt</td>
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<td>White</td>
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</tr>
<tr>
<td></td>
<td>Sean</td>
<td>Male</td>
<td>White, “Irish”</td>
<td>Construction Engineering &amp; Management</td>
</tr>
<tr>
<td></td>
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<td>Asian, “Indian”</td>
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</tr>
<tr>
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<td>Tranlin</td>
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<td>South HSI</td>
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<td>Betty</td>
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<td>Cara Smith</td>
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</tr>
<tr>
<td></td>
<td>Elisa Barr</td>
<td>Female</td>
<td>“Multiracial”</td>
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<td>Pilar</td>
<td>Female</td>
<td>Hispanic, “Colombian”</td>
<td>Biomedical Engineering</td>
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<tr>
<td>South PWI</td>
<td>Buck</td>
<td>Male</td>
<td>White</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
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<td>Candace</td>
<td>Female</td>
<td>White, “German, Polish”</td>
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</tr>
<tr>
<td></td>
<td>Dominic</td>
<td>Male</td>
<td>White, “German”</td>
<td>Biomedical Engineering</td>
</tr>
<tr>
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<td>Eric</td>
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<td>Francis</td>
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<td>Charles</td>
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<tr>
<td></td>
<td>Christian</td>
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</tr>
<tr>
<td></td>
<td>Elizabeth</td>
<td>Female</td>
<td>White, “American”</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td></td>
<td>William</td>
<td>Male</td>
<td>White, “Scottish, White”</td>
<td>Mechanical Engineering</td>
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Research quality was considered throughout the data collection and analysis process, based on the Qualifying Qualitative Research Quality (Q3) framework by Walther, Sochacka, and Kellam [17]. The belongingness responses from each student were coded using in vivo codes [18]. In vivo codes brought richness to the analysis and reflected the exact words used by the students [17]. Multiple coding and theming passes, as well as a constant comparative method, were used across interviews to tightly link the themes to the data [19]. Authors had ongoing conversations about emergent results and addressed borderline cases. Memos were kept throughout the analytical process to document and make apparent the researchers’ perspectives.
The qualitative analysis of responses leveraged a phenomenological lens by seeking to understand the lived experiences of belongingness in engineering [20, 21]. Due to large sample sizes for phenomenological work [21], we integrated thematic data analysis approaches to accelerate the coding process. Specifically, we generated a series of in vivo codes from student transcripts which were arranged thematically to focus on students’ perceptions of themselves in relation to engineering, as opposed to the perceptions of others or outside experiences. Throughout the development of themes, attention was paid to the words students used to describe their feelings of belongingness in engineering. The results focus on students’ word choice and subsequent use in describing belongingness and resulted in the creation of three super-themes, or patterns of responses.

Results
We found two major results. First, we found nine themes of belongingness within student responses. We then grouped these themes into three categories of responses: students’ personal attributes, interests, and emotions. The larger categories were developed using students’ linguistic patterns of “I have/I am,” “I like to do,” and “I feel,” respectively. The nature of the responses within these patterns indicate that students judged belonging in engineering based on an idealized representation of engineering traits.

Second, students made their evaluations of these themes in binary, all-or nothing terms. By this statement, we do not mean to say that students evaluated belongingness as a pass or fail metric. Rather, students discussed their belongingness through multiple traits that were either completely present or not. Students described themselves in fixed terms and did not discuss growth or development of these traits. The multiple trait binaries then formed a spectrum of belongingness in engineering.

Together, these results have implications not only about what students discuss with respect to belonging in engineering, but also about how students evaluate themselves on these traits. A summary of the findings can be seen in Table 2, which includes themes, super themes, and example codes. As a formatting note, ellipses in square brackets indicates editing done by the authors. Unbracketed ellipses within a transcript quote indicates a pause in speech. A more detailed discussion of these findings follows.

Ways of Belonging
There were three general linguistic patterns that students adopted when describing their belongingness in engineering. The patterns were defined by the phrases “I have/I am,” “I like to do,” and “I feel.” These patterns are not mutually exclusive; however, they do represent different ways students describe how they fit into the field of engineering. Nine themes were connected to the three patterns. Within Pattern 1 (“I have/I am”), the themes were: Creative/Innovative, Hard Working/Persevering, and Mindset. Pattern 2 (“I like to do”) contained the themes of Being Social, Certainty, Problem Solving, and How Things Work. Finally, the themes within Pattern 3 (“I feel”) were Comfort and Enjoyment. These themes did not focus on responses about internships, beliefs about engineering, or social networking in which students engaged. Instead, the themes focused on the ways students talked about themselves and their belonging in engineering contexts.
The first pattern contained responses that generally began with “I have” or “I am.” These responses described students’ perceptions of their own attributes and reflect who the students are as people. Students saw themselves as innovative, as having strong work ethics, and as having the mindset required of an engineer. Kathie, John Smith, and Charles each embodied one of these attributes and follow the same linguistic pattern.

I have a very strong sense for innovation. That's why I didn't want to work in finance or anything because you can't innovate in that field. – Kathie

I'd say like the hard work and dedication I have, like if I'm working on a project, I'm not going to give up on the first time if it doesn't work out. – John Smith

<table>
<thead>
<tr>
<th>Super-Themes</th>
<th>Themes</th>
<th>Example Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern 1</td>
<td>Creative/Innovative</td>
<td>“I have the creativity from when I used to dance” (Allison Scott)  [ “I’m very creative and open-minded […] I do like a challenge” (Bradley) ]</td>
</tr>
<tr>
<td></td>
<td>Grit/Work Approach</td>
<td>“The hard work and dedication I have” (John Smith)  [ “Engineers have to have perseverance […] I feel like I have perseverance” (Francis) ]</td>
</tr>
<tr>
<td></td>
<td>Mindset/Brain</td>
<td>“Engineering is very much a personality thing” (Kathie)  [ “It’s just the way my brain works” (Eric) ]</td>
</tr>
<tr>
<td>Pattern 2</td>
<td>Social</td>
<td>“I’m pretty good at communicating” (Dominic)  [ “I like to help people” (Elizabeth) ]</td>
</tr>
<tr>
<td></td>
<td>Certainty</td>
<td>“I like when things have answers” (Keyla)  [ “You have to have an interest in finding the right answers” (Kathie) ]</td>
</tr>
<tr>
<td></td>
<td>Problem Solving</td>
<td>“I like trying to solve problems or think about things in a different way” (Candace)  [ “I like building things, designing and fixing problems” (Eric) ]</td>
</tr>
<tr>
<td></td>
<td>How things work</td>
<td>“I really enjoy taking things apart, not physically but in terms of mathematically or practically” (Tranlin)  [ “I like to understand things” (Keyla) ]</td>
</tr>
<tr>
<td>Pattern 3</td>
<td>Comfort</td>
<td>“It’s just a feeling of being comfortable” (Aaron)  [ “It just kind of feels right” (Elizabeth) ]</td>
</tr>
<tr>
<td></td>
<td>Enjoyment</td>
<td>“I like it. I like what I’m learning” (Buck)  [ “I just enjoy it” (Francis) ]</td>
</tr>
</tbody>
</table>

Table 2—Summary of super-themes, themes, and example codes.
Because I've succeeded at it [engineering] before, because I've had experience with it and I know I have a good mind for it. – Charles

Kathie felt like she possessed a “sense for innovation” that drove her choice to study engineering. John Smith focused on his work ethic and his commitment to work through a problem. While Charles based some of his belongingness on his past engineering experiences, he also said that he knew he had a “good mind for it.” These responses, and the responses of other students, were centered around the students’ perception of themselves and the traits they possessed, in relationship to engineering. Here, belongingness is derived from possessing traits or attitudes that students described being like an engineer.

The second pattern of responses were related to actions that students liked to do. These actions were working with people, finding a single correct answer, engaging in problem solving, and understanding how things worked. Rather than the personal attributes described above, this pattern of responses addressed an embodied sense of belonging by doing actions that engineers do. Elizabeth and Francis described ways in which this type of belongingness is experienced.

I guess I just enjoy it. I enjoy problem solving. I enjoy looking at things a different way. I enjoy seeing how things will work. Just all of that together, I think, kind of adds up ... Something I enjoy. – Francis

It's a good fit, because I like to help people. ... I do this stuff anyway without really thinking about being an engineer. I try to help fix things for people. – Elizabeth

Francis and Elizabeth described different actions and activities related to engineering they like to do that they feel make they like engineers or fit into engineering. Francis focused on the problem solving and understanding how things work, while Elizabeth liked to help other people with her actions. Elizabeth’s intrinsic desire to help others was so strong that she would do so “without really thinking about being an engineer.” Her fit in engineering comes from an alignment of her interests in helping people with the activities expected of an engineer.

The final pattern of responses related to student’s affective attitudes towards engineers and engineering practices. This pattern was distinguished by the phrase “I feel” as well as the word “just.” The use of “just” seemed to reference an innate feeling the student had about their attitudes and beliefs, rather than a specific affinity towards some trait such as creativity or action such as problem solving. Students expressed two kinds of emotional responses to belongingness: comfort and enjoyment. An excerpt from Candace’s interview transcript is an example of students’ comfort towards being in engineering.

Q: Do you feel like you belong in engineering?

Candace: Yes. I don't know, I've just never felt like I wasn't in the right place or I wasn't - I guess I've never felt like I didn't belong, so I don't know why I feel like I do belong, but...

Q: It's okay. I understand.

Candace: Yeah, I feel comfortable in all my classes and all the people in it. I feel like, not feeling like I don't belong, if that makes sense.

Candace’s difficulty in answering the question pointed to her feelings and emotions of belonging in engineering. She did not feel that she did not belong in engineering, but had a difficult time
explaining why, or even if, she felt that she did belong in engineering. Evaluating belongingness goes beyond tallying attributes and affinities to a deeply personal experience.

The intention of describing each group above is not to establish discrete categories of belongingness but instead understand the different aspects of belongingness that students experience in engineering. The potentially overlapping nature of these three patterns is evident in Allison Scott’s description of what makes her like an engineer.

I have the creativity from when I used to dance. It turns out I’m a good problem solver, critical thinking and I like challenges. They make me happy.

Allison Scott used the phrases, “I have,” “I am,” and “I like” within the same thought, and also connected to how she felt like she belonged (emotions). In this case, the happiness Allison Scott described was tied to challenges rather than engineering as a whole. Allison Scott’s perception of her belongingness in engineering was not based in one response pattern, but touched on each grouping of linguistic patterns. As a result, Allison Scott was highly confident in her ability to fit in and do well in engineering.

Binary Evaluations

When addressing fit, belonging, and likeness, students assertively described their attitudes and characteristics in an all-or-none fashion. In binary terms, students described these traits as either “zeros” or “ones.” When a trait was a zero, the student did not perceive themselves as having the trait to any extent (but they might describe needing that trait to be like an engineer). On the other hand, when a trait was a “one,” students discussed the trait as if they possessed it completely and used that characterization of themselves as evidence for why they belonged in engineering. Such a description is shown in Eric’s response to the question, “Do you feel like you belong in engineering?”

Yeah, I think I definitely belong in engineering. I think it's just the way my brain works, my mind works and what my natural interests are aligned to. I think I definitely belong in this major.

Eric was very confident about his overall belongingness in the field of engineering as well as his major of mechanical engineering. He justified this evaluation by citing his mindset and his “natural interests” as aligned with engineering.

Tranlin responded similarly to belonging in engineering. Tranlin based his belongingness in his enjoyment of understanding how things work.

Yeah, I think so. Again, I really enjoy taking things apart, not physically but in terms of mathematically or practically. I like to see how things work, and that being said, it's what engineering is about.

Both Tranlin’s and Eric’s responses to why they did belong in engineering were based in personal attitudes and characteristics they perceive to be innate and potentially unchanging. Eric did not develop his brain and mind to work like an engineer, and Tranlin’s interest in tinkering was similarly fixed. These types of responses reflect student’s perceptions that they “just” had particular attitudes, skills, or traits that made them like an engineer with no gradation or opportunity for development.
The “zero” part of the binary came into effect when students discussed how they were potentially unlike engineers or did not belong in engineering. Many students responded that they sometimes procrastinated. Some students, like Aaron, were more extreme in describing their procrastination by incorporating the trait into their identity.

The procrastinator in me is one of them. I will admit I- I’ve been trying to fight this, too. Procrastination, I know I’m a procrastinator and I know that’s not a very good thing for an engineer or anyone in general to really have.

These characterizations of procrastination as a static trait rather than a behavior speak to the extent to which students incorporated the action into their identity. Avoiding procrastination, as Aaron believes engineers should, involves fighting against who he envisions himself to be.

The act of not embodying a necessarily engineering trait jeopardized some students’ perceptions of belongingness in engineering. Keyla is one example of a student who shared a way she did not feel like she belonged in engineering. The conversation between Keyla and the interviewer is below (emphasis added by authors):

Q: Do you feel like you belong in engineering? If so, how?
Keyla: Yeah, I would say so. I'm still in it so far, and I feel pretty comfortable with it. I'm kind of along for the ride, I guess.

Q: Is there ever a time where you feel as if you don't belong in engineering?
Keyla: Yeah, sometimes. Last semester one of the projects was very heavily design oriented, and I’m not very design-y, I guess. For that one, because it was groups, I just ... One of the other kids was like, "Here. What do you think about this?" Then we're like, "Oh, yeah." It was more of stepping back in that case, I guess, and letting them ... They obviously understood it better.

Keyla felt some belonging in engineering, although she couched her evaluation with the phrases “I’m still in it so far” and “I’m kind of along for the ride.” She did not feel like she belonged in engineering when she was expected to participate in design because she did not perceive herself as possessing the design trait.

Discussion and Implications
We found three patterns that students used to talk about the relationships between engineering and themselves. The first pattern consisted of ways that the students’ attributes—their mindsets, work ethics, and creativity—were like that of engineers. The second pattern of responses address ways that the students’ interests, particularly interests in doing something, were connected to engineering. Students liked solving problems and working for or with other people. The third pattern contained students’ affective judgements of their fit in engineering, using the words “just” and “comfortable.”

The student responses indicate use of idealized traits that an engineer is expected to possess. According to these students, engineers should be innovative, determined, and think a certain way. Engineers should like working with people, finding the right answer, solving problems, and understanding how things work. This final group of responses – that of feel comfortable – most
closely mirrors the belongingness discussed in prior literature. However, we believe that expanding the use of belongingness has powerful applications.

Students responded to questions about fit, belonging, likeness, and unlikeness through binary terms. Students described their belonging in terms of attitudes or characteristics as if they had always possessed those traits that made them an engineer and could not grow or develop them. This way of describing belongingness in engineering is particularly striking and problematic. If students see engineering as a “fated” choice aligned with who they are rather than a discipline that can provide training and enrichment in a broad set of skills, attitudes, and characteristics, the pathways into engineering may seem closed for many students who do not fit the stereotypical or idealized role of an engineer as framed in the university setting or in wider society. Additionally, these attitudes about belonging may privilege particular normative attitudes and ways of knowing and being within engineering. This phenomenon is already documented for engineering culture broadly [22] but this culture may continue to be reified by students’ own definitions of what it means to be and belong in engineering.

Such responses, especially when describing positive engineering traits, align with Dweck’s work on fixed and growth mindsets [23]. In the context of learning and intelligence, individuals with fixed mindsets believe they possess a set amount of intelligence, whereas those with growth mindset believe they have the capability to learn and increase their intelligence. A fixed attitude towards belongingness in engineering can be similarly problematic because students might believe that they cannot increase their fit in engineering. A growth mindset can be fostered by putting emphasis on progress and changing what it means to be successful [23, 24]. If this fixed binary can be overcome, different ways of characterizing belongingness may provide multiple avenues to appeal to students, through their personal attributes, their interests, or their feelings. Educators can create welcoming classroom environments and can potentially disrupt student’s binary preconceptions by helping grow certain skills and interests.

These three themes of belongingness indicate three pathways that educators may target independently or collectively to help students connect their current tasks to the future goals of becoming an engineer. The development of an engineering identity is a social dialectic process [25]. As such, students may be negotiating how they perceive themselves currently and comparing these conceptions into what it means to be an engineer (even if that is a stereotypical definition of what it means to be an engineer). If students are able to connect their current identities with who they want to be in the future they are more likely to persist in academic tasks [26].

Additionally, students’ abilities to take on particular role identities, like being an engineer, is contingent on the congruence of their claimed identities and how they perceive what it means to be an engineer [27]. This connection is evident in students’ descriptions of what it means to belong or fit in engineering. As students enter an engineering community and begin the process of moving from peripheral to legitimate to core participation, each individual norms to community practices. This process of norming, in turn, influences their ability to integrate the role of an engineer into their current self-perceptions [28]. The roles of engineers that are communicated both explicitly and implicitly by the community of practice in which students are integrating affects both their identity formation and their perceived fit [29]. If these roles are
communicated as static or rigid, as indicated by our results, these culturally defined meanings of “an engineer” may be perceived as exclusionary to particular students who do not fit these stereotypical norms. Our results are concerning if students only perceive fit as innate traits that they either do or do not possess that make them like an engineer. Working to expand the definitions of what it means to be an engineer and who can do engineering within engineering education may provide ways in which to help more students, especially minoritized students, belong.

Limitations, Future Work, and Conclusion
We acknowledge that this work comes with several limitations to the quality and transferability of results. The phrasing of the interview questions, particularly asking about like and unlike characteristics, may have influenced students to answer in a binary, all-or-none. However, these binary evaluations were found in the responses to every student’s belongingness dialog. Additionally, the questions about like or unlike characteristics generally came after the other belongingness questions. Another limitation of our work is that, due to the narrow scope of this analysis, discussions of belongingness elsewhere in the interviews were excluded. As we did not press students to exhaust their perception of fit in engineering, the data is made of students’ first reactions to the idea of belongingness.

Future work aims to follow the themes of belongingness from the participants through the longitudinal interviews over the course of two to three years after starting their engineering studies. Following the students in the college career enables not only an understanding of their belongingness trajectory, but also enables rich qualitative data as rapport is built with the students. Subsequent belongingness models will also address students’ professional experiences, social networks, and beliefs about engineering.

This analysis investigated how students responded to four questions exploring their perceptions of belongingness in engineering. We found that students responded in a binary fashion without discussion of growing or changing attitudes and characteristics. We also found patterns of responses relating to students’ attributes, interests, and emotions. When reflecting on their fit in engineering, students may use responses that align with any or none of these patterns. Understanding these types of responses to belongingness can empower educators to find different ways to make their students feel like they can fit in engineering. Additionally, this work emphasizes the need for engineering educators to help students develop healthy, flexible, and growth-orientated ways of seeing themselves in engineering and as belonging in the field.

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