”Being able to hold your own”: Underrepresented engineering students’ perceptions of sense of belonging

Dr. Angela Thompson, University of Louisville

Dr. Angela Thompson is an Associate Professor in the Department of Engineering Fundamentals at the University of Louisville. Dr. Thompson received her PhD in Mechanical Engineering from the University of Louisville. Her research interests are in biomechanics and engineering education, particularly related to first-year students.

Dr. Jessica Buckley

Dr. Buckley is a clinical assistant professor at the University of Louisville.

Dr. Thomas Tretter, University of Louisville

Thomas Tretter is professor of science education and director of the Center for Research in Mathematics & Science Teacher Development (CRIMSTED) at the University of Louisville. His scholarship includes collaborative efforts with science and engineering faculty targeting retention of first-year engineering students as well as other engineering education efforts.

Dr. Brian Scott Robinson, University of Louisville

Brian Robinson is an Associate Professor with the Department of Engineering Fundamentals at the University of Louisville. His primary research focus is in Engineering Education, with highest interest in first-year (and beyond) engineering retention & the effects of value-expectancy theory on student persistence.

Gholam Abbas Sattar-Shamsabadi II, University of Louisville

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Abstract

This Empirical Research Paper (Research Brief) presents perceptions of sense of belonging in engineering among students from underrepresented groups. Sense of belonging has important, positive outcomes for engineering students, especially underrepresented students. Yet, sense of belonging can be interpreted in multiple ways and differentially across contexts. As part of a mixed-methods longitudinal study on student sense of belonging in engineering, we sought to describe students’ own perceptions of what belonging in engineering means. 11 engineering students (7 women, 3 men, and 1 non-binary student; 4 students were white and 7 people of color) participated in semi-structured interviews. This paper focuses on qualitative responses to one question from these interviews, which asked “What do you think belonging means?” Transcripts were inductively coded, and emerging themes were discussed by the authors. Findings highlight 3 important themes: competence, positive learning environments, and positive social engagement. Many students related belonging to their competence or abilities in engineering. Students also highlighted the importance of their experiences in the academic environment (do they enjoy themselves, do they feel comfortable) on their sense of belonging. Lastly, students emphasized the importance of forming connections and fitting in, seeing others like themselves or having shared experiences. These findings are important for educators and practitioners seeking to provide inclusive, equitable learning environments for underrepresented students in engineering.

3-5 keywords: sense of belonging, engineering, qualitative, underrepresented students, minoritized students

Introduction

Sense of belonging has important, positive outcomes for engineering students, especially underrepresented students [1], [2], [3]. Yet, sense of belonging can be interpreted in multiple ways and differentially across contexts. While a common definition concerns “the degree to which an individual feels respected, valued, accepted, and needed by a defined group” ([4], p. 97), Vaccaro and Newman [5] found minoritized students defined belonging as including a sense of safety, unlike other students. Additional scholars have suggested competence may also be necessary for students’ perceptions of belonging in academic contexts [6]. Still others have suggested that sense of belonging requires certain social competencies [7] and is a developmental capacity [8]. While scholars have shown multiple belongingness interpretations exist, few have considered students’ own definitions of belonging in the context of engineering. Given belonging is contextual [4], students definitions of belonging may be unique in academic contexts and can be critical to developing targeted interventions to improve engineering belonging for different groups and outcomes, such as student persistence. Therefore, this study sought to answer the research question: *How do students from underrepresented groups in engineering (by race, ethnicity, and gender) define belonging in engineering?*

Literature Review

The importance of sense of belonging is documented across disciplines [9], [10], [11]. Strayhorn [11] from socio-psychological, and Hammond [10] from a neurological perspective, situate sense

of belonging as a fundamental human need, critical for higher order tasks, such as learning and creative thinking. Scholars have shown the association of sense of belonging broadly in higher education with positive outcomes, such as grades [12], intrinsic motivation [13], persistence, engagement, and mental health [14]. Specifically in engineering, Weaver et al. [3] found increased belonging uncertainty correlated with decreased grades in engineering, while Judson et al. [15] found an increase in retention for engineering students in a longitudinal project designed to support their sense of belonging.

In addition, sense of belonging is especially critical for minoritized students given they ways they experience decreased belonging on many campuses [11] and in STEM disciplines [16]-[19]. Geisinger and Raman [2] found that classroom and academic climate, race, and gender were among factors that influenced attrition in engineering. Rodriguez and Blaney [19] described the negative classed, raced, and gendered experiences Latina women found in STEM, leading them to seek belonging elsewhere. Our previous work [20] has shown decreasing salience of sense of belonging in engineering classrooms or seeking belonging in other contexts may be one way in which minoritized students navigate negative climates. Sense of belonging, therefore, seems critical for student outcomes and especially for providing inclusive, equitable learning environments for minoritized students in engineering.

As noted in the introduction, belonging can be defined differently by different students; yet few examine students' perceptions of what belonging is, especially in in engineering. Quantitative studies often simplify understanding of sense of belonging and may incorrectly assume shared understandings of survey questions. For example, Polmear et al. [21], defined sense of belonging as "perception of acceptance, fit, and inclusion in their academic discipline of engineering" (p. 556). They included the following items to measure academic sense of belonging: "I do not feel a strong sense of 'belonging' to my academic discipline;" and, "I do not feel like 'part of the family' in my academic discipline" (p. 563). While such measures capture important data, students may differentially interpret survey questions and their meanings [22] and such measures fall short of understanding or assessing students' perceptions of what belonging means, leaving interpretations of the data incomplete. Similarly, many qualitative studies assume student perceptions about the meaning of belonging. For example, in the first phase of our longitudinal project, we often asked questions about factors students felt contributed to their belonging without asking about their interpretations of their meanings of belonging [8]. This study, therefore, offers unique insight into the ways in which minoritized engineering students define sense of belonging within the discipline.

Methods

As part of a multi-year, mixed-methods study on sense of belonging in engineering students, we conducted one-hour semi-structured interviews with 11 students in their 3rd year in an engineering degree program at an R1 institution in the Southeast; all students were invited to participate in interviews because of their prior participation in focus groups in 2020 at the beginning of the longitudinal study. Participants included 7 women, 3 men, and 1 non-binary student; 4 students were white and 7 people of color (Table 1). All students were from groups underrepresented in engineering (by race/ethnicity or gender). Ensuring diverse participants was purposeful for the initial design of the study given the importance of identity in student experiences of sense of belonging.

Because of the larger study design, interview questions included the impact of COVID on students' experiences and experiences that impacted students' sense of belonging in engineering. This paper focuses on qualitative responses to one question from these interviews, which asked "What do you think belonging means?"

In much of our research associated with the project [8], [20], definitions of belonging serve as conceptual frameworks for analysis. For this study, we purposefully did not use a specific belonging framework given the nature of the question, which examines students' own defining of belonging. Belonging definitions noted in the introduction served as "sensitizing concepts" rather than "established concepts" that facilitated "operationalizing" elements of the study [23,p.16-17].

Thus, transcripts were coded inductively rather than applying an *a-priori* coding scheme. Authors met regularly throughout the process to discuss coding decisions and questions, resulting in a consensus coding scheme. First round focused coding established emergent categories related to students' definition of belonging and additional theoretical coding narrowed to key, shared themes from students. This study was approved by our Institutional Review Board.

Table 1: Participants and identities

Pseudonym	Race (Self Description)	Gender	Low income*	First Generation
Alexus	Indian American (subcontinent)	Woman	N	N
Aziz	White	Woman	N	N
Breonna	Caucasian	Woman	N	Y
Camila	Black/African American	Woman	N	N
Cole	Thai	Man	Y	N
Isabella	White	Woman	N	N
Jordan	Bi-racial (white/black)	Man	Y	Y
Logan	Black/ African American	Man	N	N
Mia	Black/Afro-Latina	Woman	Y	Y
Olivia	White	Trans-nonbinary	N	N
Pheobe	Black/Pacific Islander	Woman	N	N

*Low income defined by institution as students meeting Pell-eligible status

Results

Students offered varying meanings of sense of belonging, but findings suggested 3 key properties: competence, positive experiences in the environment, and positive social engagement.

Competence

Many of the participants (7 of 11) related sense of belonging to their competence, performance, or abilities as an engineering student. When asked what belonging means to them, students used words like *prove*, *deserve*, *capable*, *doing well* to describe their sense of belonging in engineering. For example, Olivia said "I deserve to be her, I am good enough to be here." Similarly, Mia noted the importance of her capabilities for belonging:

> For me, belonging is being able to hold your own, … having the abilities to–just having knowledge of what the tech industry is and being able to apply everything you've learned, being able to apply the things you've studied. For me, it's …just proving what I know and proving myself. That's how I feel like I belong.

Some students specifically related their competence to their decision to stay in an engineering major. For example, Breonna said "Do I feel like I'm doing well enough to want to stay in this major?" Camila on the other hand focused on her ability to secure a job as an engineer, stating "Do I see myself as an engineer who's capable of getting a job as an engineer?"

Two students emphasized having an important role or making an impact in their community. Phoebe said, "[Belonging] means having the confidence to know you have a place and a role that's important in the field." Logan related belonging in engineering to being part of a team:

> If I'm on a team and I make the team and I'll do anything for the team. If I play basketball but I don't play and I don't help us win, I feel like I don't belong, but if I'm playing and I'm out there playing, getting like 10 points, 5 rebounds or whatever, I can see how I'm helping, so I feel like I belong there.

Positive Learning Environments

Students (6 of 11) also described belonging as having properties related to a positive learning environments, especially enjoyment and comfort in learning. An example of enjoyment, Breonna stated "Do I like it enough to want to stay?" Isabella described belonging as "wanting to be there". Aziz similarly described belonging as "feeling like you enjoy it, having a positive experience."

Similarly, a few students described the importance of feeling comfortable and secure in their environment for their sense of belonging. For example, Cole said:

> I can feel comfortable at being myself. I can see myself just walking around on campus without feeling scared, feeling like I'm gonna get attacked or, like, discriminated in any shape or form, and just find ways to where I can actually call someone a friend, feel like the campus is very friendly, and everyone's provided me with, like, a safe place.

Alexus also described the importance of comfort but in a different context. Alexus described belonging as "being comfortable enough to make mistakes." These examples show ways in which students were concerned with how they are perceived or treated by others, and, thus, their impetus for defining belonging as partly about comfort.

Positive Social Engagement

Finally, 6 of 11 students described belonging as having properties related to positive social engagement, including relationships and shared experience and/or identity.

Forming meaningful relationships with others was often mentioned. Olivia described the importance of "interconnectedness." Logan similarly described belonging as "if you feel like you are connecting with other students." Jordan stated "You feel welcomed. You feel like you're supposed to be here. You feel like everybody wants you to be around."

Finally, it was not only important for students to have relationships with other students but also to see others with shared experiences and identities. Some, like Cole, stated that belonging

means having “someplace that I feel like I can fit in.” Aziz said belonging is “having people who are like you, I think things like that just make you feel like you belong.” Alexus described the importance of seeing others like her successful in engineering: “maybe seeing people that look like you or from where you're from and have done this thing, knowing that you'd be able to do that is important. My sister did it. My mom did it. My cousin did it. I can do it.” Thus, for some students, belonging meant having others with shared identities.

Discussion

This paper highlights the ways that underrepresented students described sense of belonging in engineering. When asked what belonging meant to them in the context of engineering, students offered multiple and varied definitions. Across the definitions, students found that belonging meant having competence, positive experiences in the environment, and positive social engagement. These findings have importance for engineering education specifically as they can support ways to operationalize belonging in an academic context. While many definitions of belonging feature ideas of student support, connection, and feeling valued, students in this study explicitly identified three properties that define belonging in engineering, which move beyond feeling supported broadly into specific features related to learning. The findings provide empirical grounding for ways to build belonging-minded engineering environments.

A unique finding related to belonging in this study was the way students defined competence in engineering as an aspect of belonging. Studies have shown relationships between students’ sense of belonging and feelings of self-efficacy and competence [6], and with academic performance in engineering [3], but this study shows how engineering students directly interpret the meaning of belonging. Many participants related belonging to some expectation of performance. For example, were they performing well enough, able to contribute, deserving of their status as an engineering student? Their responses newly suggest that belonging in academic environments may need to include students’ competence and consider the ways in which environments recognize competence.

Another key theme related to students’ experiences of their environment, such as whether they enjoyed engineering. Several students also mentioned that sense of belonging also meant a sense of comfort. Importantly however, “comfort” was contextualized differently by different students; for example, some students described being comfortable making mistakes while others described having physical comfort, free from discrimination or harm. These findings support those of Vaccaro and Newman [5] who found that minoritized students emphasized security and safety as critical to their sense of belonging. At the same time, this study offers new insight into the importance of learning environment and climate as an element critical to engineering.

The last theme focused on social elements of relationships with peers and finding others with shared experiences and identities. In this case, belonging meant being able to make meaningful connections with others, “be themselves,” “make mistakes,” and know others around them shared similar identities or experiences. Such a finding echoes literature showing the importance of both behavioral and compositional diversity in equitable learning environments [24]. While the role of positive social engagement is perhaps most closely aligned with traditional definitions of belonging, it offers new insights in the context of this study as it suggests the importance of learning environments that extend beyond simply supporting cognitive and content learning to ones that do so with collaborative, engaging pedagogies.

Implications

These findings have important implications for educators and researchers in engineering. Sense of belonging is important for student retention and persistence, and may be particularly important for underrepresented students. Our findings suggest that building student confidence (particularly in an academic context), creating a safe, inclusive environment, and providing opportunities for students to build positive relationships with peers (and perhaps faculty and staff) may be critical components of belonging in engineering. The three properties our findings revealed can help operationalize belonging in engineering; for example, serving as criteria for rubrics that measure belonging in engineering learning environments, standards by which to make belonging-minded pedagogical choices (such as assessments, instructional strategies), or theoretical tools for examining and improving engineering learning environments. Additionally, given the strong correlation in students' minds between perceived competence and belongingness, faculty and institutions should carefully consider the ways in which they may be communicating 'competence' to students. Is it only grades that matter? Or is active engagement in learning by asking questions, forming study groups, and visiting during office hours a recognized aspect of competence in that the students are taking active ownership of their own learning? Faculty may not always be aware of how students perceive 'competence,' and so efforts to be explicit and recognize multiple dimensions and ways to be competent may support a stronger sense of belonging for more students, particularly those underrepresented in engineering.

Findings here mirror prior work suggesting belonging may incorporate feelings of safety and inclusion for underrepresented students [5]. However, findings also offer a unique insight on the importance of competence for belonging in engineering (or perhaps any academic context). Belonging interventions, therefore, may entail not only building positive, equitable, social environments but also environments that allow students from diverse backgrounds to grow in competence that can be recognized in multiple ways beyond simply grades, suggesting many implications for pedagogical practice, such as effective assessment, feedback for growth, and academic encouragement and support.

Limitations

This study is just one part of a longitudinal study of sense of belonging, and analysis was limited to just one question in a broader interview. Additionally, students self-selected to participate in the study twice; therefore, some important voices (e.g., those who may be less likely to volunteer) may be missing from analysis. At the same time, participants provided thoughtful insights into the many ways students define belonging in engineering.

Conclusion

This study described underrepresented students' own perceptions of sense of belonging, highlighting the multiple and varied ways that students describe what belonging in engineering means to them. Responses demonstrated the ways in which students described belonging as meaning (a) having competence, (b) positive experiences in the learning environment, and (c) finding meaningful social connections. These findings, part of a broader mixed-methods study on sense of belonging in engineering students, can inform further research, helping to contextualize student interpretations of belonging and providing strategies to improving learning environments to support student sense of belonging.

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