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Brianna Benedict
Purdue University, benedicb@purdue.edu

Dina Verdín
Purdue University, dverdin@purdue.edu

Allison Godwin
Purdue University, godwina@purdue.edu

Thaddeus Milton
Purdue University

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Brianna Benedict, Dina Verdín, Allison Godwin, & Thaddeus Milton
School of Engineering Education
Purdue University
West Lafayette, Indiana

***Abstract*—This work-in-progress (WIP) research paper investigates contributing factors for how students describe what it means to be an engineer and what particular characteristics enable students to belong in engineering. We answer the research question, "What are the key contributing factors that influence how diverse students feel that they belong in engineering?" We used a semi-structured protocol to interview 12 diverse engineering students during Fall 2016 about their pathways into engineering, identities, and belongingness in engineering. The participants were selected from a pool of students who completed an attitudinal survey during Fall 2015 as a part of a larger study. They were purposefully recruited to maximize the number of women, students of color, first-generation college students, students with visible and non-visible disabilities, and LGBTQ+ students. The interviews were coded inductively to understand the emergent themes of how students described their social and individual identities and how they did or did not fit with what it means to be an engineer. The themes are emergent and this work-in-progress paper will describe our findings to date.**

Keywords—belongingness; latent diversity; identity

I. Introduction

Despite efforts to diversify the pool of engineering students, the historical gender and cultural norms of engineering persist [1]. It is important that the engineering field becomes more diverse to develop solutions that are innovative, feasible, and usable as well as increase the number of knowledgeable persons within society [2]. Heterosexual white males have influenced the cultural and social norms of engineering and what it means to be an engineer which restricts how students may see themselves as the kind of person that can do engineering (i.e., identity) [3]. In engineering, students are expected to navigate the cultural norms and conceptual difficulties of an engineering program while balancing their individual identities. In this paper, we refer to diversity as both students' social identities (e.g., race/ethnicity, gender, sexual orientation) and latent diversity (e.g., underlying attitudes, beliefs, and mindsets unique to the particular student). Research suggests that students who feel that their social identities or latent characteristics may be in conflict with espoused engineering norms or engineering ways of being which can lead to a lack of belongingness [4]–[7]. This misalignment can affect whether a student "fits" in an engineering program and can influence whether they persist in their program. This work-in-progress research paper investigates contributing factors for how students describe what it means to be an engineer and what particular characteristics enable students to belong in engineering.

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II. Theoretical Framework

Establishing a sense of belonging is significant for academic achievement [8] and persistence [9]. Otherwise, a student may be more susceptible to dropping out, partially because of his/her inability to connect with others [10]. Previous studies have concluded that cultures within STEM disciplines such as physics and engineering are problematic when they do not welcome active learning or various learning styles, lack a sense of community, and foster a competitive culture [11]. Strayhorn defined belonging as the student developing a community through their interactions with their peers and faculty to receive support and acceptance [9]. Baumeister and Leary suggested that the need to belong influences motivation and cognition [8].

Diversity has been studied to understand whether students experience a sense of belonging or fit in engineering [4]. Foor, Walden, and Tryten captured the story of a student, Inez—a multi-minority female, persevered through her challenges, despite not feeling welcomed or comfortable in engineering. Another story of Michael revealed that when his personal epistemology (ways of knowing) conflicted with the culture of his engineering discipline, he considered leaving engineering because he did not "intellectually fit" the disciplinary norms and ways of learning in his engineering classroom [12]. These studies demonstrate the role belongingness plays in retention and persistence, but the literature does not examine how diverse students describe what it means to belong in engineering. Therefore, there is a need to understand how students define what it means to be an engineer and factors that contribute to belongingness among diverse students. These inquiries will aid in understanding factors that contribute to having a sense of belonging and insight on how to create an inclusive space for prospective engineering students, despite their differences.

Therefore, we examined the stories of diverse students (i.e., social identities and latent diversity) to understand how they identify with engineering, and how that identification determines if they feel they belong in engineering. In this paper, we answer the following research question, "What are the key contributing factors that influence how diverse students feel that they belong in engineering?"

III. Methods

The participants in this study were selected from a pool of first-year engineering students who completed an attitudinal survey during Fall 2015 as a part of a larger study. The focus of the larger study was to investigate how latently diverse students—students with varied mindsets not readily visible within the classroom—experienced the culture of engineering and negotiated their identities as engineers. We used a semi-structured protocol to interview 12 engineering students during Fall 2016 about their pathways into engineering, identities, and belongingness in engineering. The interviews took place in a large research-intensive institution located in the Midwest region of the U.S. This institution is predominately white with a large international population.

A. Participants

The 12 participants in this study were engineering students in their second semester of college. They were purposefully recruited to maximize the number of women, students of different race/ethnicities, first-generation college students, students with visible and non-visible disabilities, and LGBTQ+ students. These demographics were self-identified by students, and, in this work, we report them in their own words. Six students identified as female and six identified as male. Three students identified as first-generation college students, four were non-first-generation college students, and three did not identify their parents level of education. Two students interviewed had a visible and non-visible disability, respectively. One student identified as part of the LGBTQ+ community. Only one participant was an international student, although a few students had parents or guardian born outside of the U.S. The students were asked if they wanted to create their own pseudonym. Many chose a pseudonym meaningful to them, but some preferred for the researcher to select a pseudonym.

B. Interviews

A one-on-one semi-structured interview protocol was used to guide the exploration of the following interview questions 1) Do you feel like you belong in engineering?; 2) What characteristics make you like an engineer?; and 3) What characteristics make you unlike an engineer? These open-ended questions allowed for the exploration and probing of students' perceptions of belongingness and characteristics that supported or hindered their sense of belonging. Students were interviewed by one member of the research team. The interviews were typically 40 minutes in duration.

C. Analysis

The data were audio recorded, transcribed verbatim, and analyzed using NVivo 11 [13]. The interviews were coded iteratively, first examining each interview and then analyzing results across interviews to ensure complete coder agreement among the four members of the research team. A constant comparative analysis was employed. This method allowed us to compare and contrast data [14]. In the first stage of our constant comparative analysis, we employed an open coding approach. An inductive process was used to understand emergent themes of how students described their social identities and latent diversity in how they did or did not fit with what it means to belong in engineering. This approach allows researchers to read over students' responses to derive concepts or categories [14]. Because we were interested in uncovering different ways students feel they do or do not belong in engineering, inductive analysis allowed for a "goal-free" evaluation [15]. After initial codes were identified, we used axial coding to identify connections between the inductive codes within an interview as well as across interviews.

IV. Results

These resulting themes were based on the responses from questions regarding the characteristics that make someone like and unlike an engineer and whether they felt a sense of belonging. Similar themes emerged across belonging and particular engineering characteristics such as the application of skills, interpersonal skills, work ethic, feelings of recognition, future goals, emotion, and knowledge/competence. Other themes such as intrapersonal skills, creativity, and ways of thinking were identified in the engineering characteristics section. In this paper, we report on five of our emergent themes: future goals, work ethic, knowledge/competence, creativity, and diverse ways of thinking.

We defined *future goals* as the goals students intended to accomplish in engineering as a student or professional. This theme links to how students saw themselves as engineers in their future. Some of the students mentioned that the need to have a positive influence on the world with their engineering skills was an aspect of belongingness and a characteristic of an engineer. Others described their future goals as a particular degree and/or career attainment. Kevin, a mechanical engineering student, was an active student leader of organizations such as Purdue First-Year Engineering Student Advisory Council and Purdue Alumni Student Experience. His sense of belonging was based on his alignment with his description of engineers' roles. Kevin said, "I believe that I belong in engineering because like I said, I want to work on things that will help improve human life and sustain the earth."

The theme *work ethic* includes the effort that the student puts forth to accomplish a task. Intrinsic traits such as perseverance, commitment, hard work, resourceful, driven, and a desire to learn were used to describe characteristics of an engineer and how students defined whether they belonged in engineering. Commitment was a

common sub-theme among the interviews for Jean and Ayida that manifested in different ways. Jean was an international student from China. She chose industrial engineering because she felt that it was a versatile field. Jean did not describe herself as belonging in engineering because she did not have an interest in being an engineer after she graduated. She already had intentions to leave engineering for a career in psychology, marketing, or economics, but she was interested in developing problem solving skills through her engineering degree. She said,

> In the future, I can't imagine myself as an engineer for the rest of my life. I like engineering. I like to have a degree in engineering just because to get problem solving skills. I just can't see myself as an engineer for the rest of my life.

Another student, Ayida, a dual citizen—Caribbean and American—described her belonging as based on her interest in being an engineer. She said, "I belong as long as I want to be there." Ayida solely determined her belongingness in engineering based on her commitment to study engineering rather than other external factors or definitions.

Although Ayida did not rely on others to determine her belonging, other students relied on their peers and performance (i.e., grades). Naomi was an agricultural and biological engineering student who justified her sense of belonging based on her willingness to put in the work necessary to become an engineer. She also received validation by comparing her work ethic to her peers. Naomi said, "I feel like I belong here because I'm putting in the work and I'm doing what everyone else is doing to prove myself." Prior to college, she also described herself as being "smart in school" because she was "good at math and science," but her confidence declined when she failed her physics course in college. Naomi's feelings of belonging in engineering depended mostly on her beliefs about her ability to succeed in engineering coursework.

Multiple students expressed the importance of feeling competent to belong and to be considered an engineer by themselves and others—we define this theme as *knowledge/competence*. Students described competency as being knowledgeable about math and science principles, being able to identify problems, justifying ideas, having technical skills and analytical skills, and applying their skills to solve engineering problems. Several students mentioned the significance of being competent in math and science, whereas other students discussed the need to be analytical and a problem solver. Naomi said, "I like solving problems and I feel really accomplished when I do a job well done. I was good at math and science." Nathan identified as a problem solver as well. He developed his interest in engineering by participating in the Project Lead the Way program. He said, "You need to be able to handle the problems as they come and give those results quickly." Another student, Ashley, who has Chronic Rhinitis which influences her ability to hear, shared that she was an engineer because she was analytical. She said, "I am a very future forward thinker. I am very analytical."

Students described *creativity* as a characteristic that was both like and unlike an engineer. Ayida discussed the importance for engineers to be able to generate ideas and justify them with reason. She said, "I think that's the thing that makes me capable of being an engineer is the fact that I can stick to my ideas and thoughts." Anika, an electrical and computer engineering student who originally intended to become an aeronautical engineer so she could work at NASA someday, also mentioned creativity as a key characteristic of being an engineer. After having some experiences with computer programming, she realized she would prefer to major in electrical engineering. Anika identified not only as an engineer but also as an artist. When she described herself as an engineer, she discussed her entrepreneurial aptitude as related to her art. She sold her paintings to people and was developing a website to display her paintings. Anika also mentioned that being an artist made her unlike an engineer because it separated her from her peers,

> I think it's definitely a benefit to me that I can do art because a lot of engineers aren't really artistic, and so I guess that makes me stand out, which maybe I can help connect to different things that people don't think of.

We define the theme *diverse ways of thinking* as a variation of mindsets in engineering to understand and do engineering work. We asked about this concept to understand better how students might describe their latent diversity in engineering. We found four consistent ways students described their ways of thinking—holistic, introverted, future oriented thinker, and logical—their ways of thinking made them feel like they belonged in engineering. Casey was an industrial engineering student that described her thought processes as holistic,

> I'm just trying to build different experiences and I think that different backgrounds in a technical field and non-technical field. Combinations of those will help me get an idea of the big picture and building on those will help me in the end being able to understand all of the processes and make plans for the businesses.

Casey sought to see a big picture when understanding engineering concepts, which she said made her different from some of her peers. Another student, Mr. Rhee (chosen pseudonym), considered himself a logical thinker. He said, "When I see a problem, I like to work it out systematically, piece by piece, break it down, and get it solved." His decision to pursue electrical engineering was influenced by his father—an electrical engineering graduate of a Midwestern university. He cited his father as a major influence on the ways in which he did engineering.

V. Discussion

The primary goal of this paper was to begin to understand how students described belonging and characteristics that make them like and unlike an engineer.

The analysis revealed several emergent themes for the relationship between belongingness and engineering characteristics—including non-engineering characteristics (as described by students). Some of the students determined their sense of belonging according to the alignment between their personal beliefs and beliefs of engineers which is consistent with prior research [16]. Other students did not describe belonging in engineering because they did not intend on pursuing an engineering career post-graduation. This finding is consistent with Strayhorn's study on sense of belonging and success in STEM [9]. His findings suggested that student's act of affirming their position in STEM strengthens their commitment to degree attainment, and reduced intentions to leave the field. Lichtenstein and colleagues conducted a study to understand career decision making processes that influence whether students decided to enter or leave STEM [16]. Their findings indicated that students were not necessarily committed to entering an engineering career when they completed an engineering degree. Instead, students selected engineering majors to become qualified for various professions since problem solving and technical skills are valued by other professions in addition to engineering [16],[17]. We also found that a few of the students were interested in pursuing engineering because they wanted to use engineering to advance human life and environmental sustainability [17]. This finding is consistent with prior work that demonstrated that women are more likely to choose engineering based on these outcome expectations [18],[19].

Students felt that they belonged in engineering when they saw themselves competent in math and science. Other work has emphasized the importance of feeling confident in one's abilities on engineering tasks or self-efficacy for persistence in engineering [20]–[22]. However, other work showed that performance/competence beliefs alone without interest in the subject and feeling recognized by others as the type of person that can do engineering are not sufficient for a student to see him/herself as an engineer [19].

The students identified attributes of themselves that were aligned with engineering characteristics such as perseverance, commitment, hard work, resourcefulness, drive, and a desire to learn. These characteristics are consistent with prior work that indicates that students describe engineering as "hard" and something that requires effort [23]. The "meritocracy of difficulty" in engineering has been a source of exclusion and attrition for many students [5], [23]. It is interesting that the students in our group, although demographically diverse, all describe similar ways of feeling belonging in engineering.

Tension arose in the creativity theme because many students' perceptions of engineering characteristics included creativity. However, within the same interview one student, Anika, mentioned that being artistic made her unlike an engineer. She perceived being artistic as a creative trait not associated with engineering. This contradiction is interesting considering students are often expected to have spatial reasoning skills which are supported by visual thinking and creativity [24]. Sorby [24] discussed how early engineers were artists but that essence of engineering has declined as a focus on developing analytical skills has dominated.

Finally, we found that students described that they felt a sense of belonging when they *thought* like an engineer. This finding is consistent with The National Academy of Engineers' (NAE) call to develop engineers that seek new approaches to problems in order to overcome the growing engineering challenges of our time [17]. For example, students must not only be able to solve technical problems but also understand and include societal factors in engineering solutions. Other aspirations for engineering graduates outlined by the NAE include knowledge of mathematics, science, humanities, social sciences, and economics to develop innovative technologies [17], [25]. However, students only described commonly accepted ways of thinking and problem solving as ways in which they felt like they could be engineers. This finding raises questions about who becomes an engineer and what kinds of knowledge are privileged in engineering classrooms. Noticeably, the students did not discuss the need to be versed in non-STEM disciplines or open to interdisciplinary opportunities to support the design of innovative solutions. Nevertheless, the students did identify the need to have a desire to learn which is consistent with NAE outcomes of engineering students who are lifelong learners able to adapt to constant change.

VI. Future Work

This study of preliminary results of our interviews is only the beginning of understanding how students with particular attitudes, beliefs, and mindsets (i.e., latent diversity) feel that they do or do not belong in engineering. We asked students about particular reasons they felt that they did or did not belong in engineering. All students described aspects of their underlying characteristics rather than external characteristics often researched in belongingness research like race/ethnicity and gender. We acknowledge that students may not have discussed these topics because they are difficult or uncomfortable or that engineering culture does not emphasize that these aspects are important as long as one can "cut it" [23]. Our work raises questions about how students who may not fit the stereotype of what it means to be an engineer or who can belong in engineering navigate their engineering pathways. These instances raise concerns of whether other students could be uninterested or lacking a sense of belonging because they do not feel their non-technical interests or skills contribute to their ability to be an engineer. Therefore, there is a need to identify various ways students' express creativity and value interdisciplinary knowledge and collaborations. Future work will continue to examine particular characteristics that support engineering development and those that do not. The goal of this future work is to increase the variability of innovative thought in engineering students and create an inclusive space for prospective engineering students, despite their differences.

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