Engineering Students' Perceptions of Belongingness in Civil Engineering

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Abstract

This research paper reports on a study conducted in a civil engineering department that is undergoing both curricular and cultural changes as part of an NSF-funded project. The focus of this paper is on students' sense of belonging within their engineering major and at their university, and how those perceptions differ based on student demographics and year in the program.

Survey data was collected to assess students' motivation, attitudes and beliefs about their courses, department, and university. The survey included eight constructs: sense of community, time-oriented motivation, goal orientation, career outcome expectations, grit, identity, agency beliefs and personality traits. Subscales for students' sense of community (which is the focus of this paper) were sense of community within engineering and the university. Of the 364 undergraduate civil engineering students enrolled in the 2017-2018 academic year, 306 (84.1%) completed the survey; 82.2% of the respondents reported their race as White and 76.8% reported their gender as male, which is consistent with the enrollment data (86% white and 80% male). Quantitative data analyses included descriptive statistics and inferential statistics to compare survey factor means by gender, race and year in the program.

Interviews were conducted with a subset of the survey participants (n=9) from a range of classes and demographics during the last two weeks of the academic year. Responses to interview questions pertaining to students' perceptions of belongingness were analyzed using descriptive coding, with patterns of codes organized into categories and themes.

Quantitative results showed that mean scores for the belongingness sub-constructs increase as students' time in the program increases (i.e., from sophomore year to senior year), with the exception of juniors having the highest score for sense of belonging at the university level. The largest increases in sense of belonging at the college and university levels were between sophomore and junior year. There was a significant negative change in sense of belongingness from the first year of the project to the second. Qualitative analyses revealed that students' perceptions of belongingness were affected by positive learning experiences and connecting with other engineering students in different contexts. Perceptions of not belonging were affected by students selecting this major to fulfill others' expectations and experiencing "in groups" and "out groups." Another insight is that students conveyed the sense that although engineering is open to anyone, certain traits and attributes were beneficial for student success.

Introduction and Background Literature

Prior research has shown that engineering students with low feelings of belongingness tend to switch to non-technical majors (Seymour and Hewitt, 1997; Foor, Walden and Trytten, 2007). With the understanding that aspects of student motivation, identity, and personality, as well as their academic performance, affect their sense of community in engineering (Rohde, Benson, Potvin, Kirn and Godwin, 2018; Satterfield, Rohde, Rodriguez, Ma, Doyle, Godwin, Potvin, Benson and Kirn, 2018), we are tracking these student attributes over time, from their first year in a civil engineering (CE) program through graduation. These data will be used for program design, program evaluation and to gain an in-depth understanding of how student attributes change and develop during their experiences in a curriculum that is drastically different from the status quo.

Departmental Curricular and Cultural Transformation

Curriculum transformation efforts that commence with industry and alumni feedback often involve curriculum changes that increase project-based experiences (Kolmos and Holgaard, 2010). Compared with traditional lecture-based courses, project-based courses are often touted with improving long-term knowledge retention (Strobel and van Barneveld, 2009), as well as for their appeal to female and underrepresented students who are motivated by social context and collaboration (Vaz, Quinn, Heinricher, and Rissmiller, 2013; Bielefeldt, et. al., 2009). While faculty attempts to create an inclusive environment around these experiences are often well intentioned, they may not fully understand the perspectives of students who do not have a strong sense of belonging (Aguilar, Walton, and Wieman, 2014).

Numerous researchers have shown that diversity within teaming structures can increase the creativity and innovation outcomes - assuming the team can participate in both divergent idea generation as well as convergent implementation planning (Kurtzberg, 2005; Kolmos and Holgaard, 2010). However, alongside increases in creativity, diverse team membership may also generate conflict among team members; thus, creating a complex situation (van Knippenberg and Schippers, 2007; Williams and O'Reilly, 1998). Prior research has shown that more conflict and less cohesion may arise in groups with one or more salient differences between members. In team formation, cliques and exclusionary practices can illuminate low sense of belonging among students (especially for females and underrepresented minority students), and cause disparities in learning gains. A survey of nearly 700 students from multiple higher education institutions revealed that 85% of engineering students had experienced issues during participation in group projects within the last year (Wolfe, Powell, Schlisserman, and Kirshon, 2016). The most commonly reported issues included non-participating or "slacker" teammates, followed assignments to less technical areas of the project, and finally being overrun by domineering teammates. The latter two problems were reported more so by women than men, and even more frequently by minority students than all others.

Research has shown that females and underrepresented minority students exit STEM programs more often if they have a low sense of belonging (Corbett and Hill, 2015; Rainey, Dancy, Mickelson, Stearns, and Moller, 2018). According to this research, the most noted reason for low sense of belonging is the lack of interpersonal relationships, followed by identity, interest, and lastly competence. Therefore, curriculum transformations involving significant engagement and teamwork must place value on diversity and inclusion, and should seek to enhance sense of belonging for underrepresented students (including females). When equity is not at play, research has shown that "women and students of color experience higher rates of having their ideas ignored or shut down, having their voices silenced, being assigned work tasks deemed less valuable, having to deal with a domineering teammate, and having their work go unacknowledged or credit stolen by another teammate" (Pfeifer and Stoddard, 2018).

Establishing Mentoring Structures

Another approach to mitigate students' sense of isolation is to provide role models and mentors; this is particularly needed for female undergraduates in a male-dominated discipline (Matsui, Liu and Kane, 2003). Various studies describe positive outcomes of peer mentoring programs that pair new students with more senior students (Matsui, Liu and Kane, 2003; Nicklow, Kowalchuk, Gupta, Tezcan and

Mathias, 2009), including benefits for the mentored students as well as the mentors themselves (Ikuma, Steele, Dann, Adio, Waggenspack, 2019). Ikuma et al. (2019) report that a peer mentoring program for STEM students, in combination with other initiatives, significantly increased participants' persistence in engineering majors, in STEM majors, and at the university level compared to non-participating STEM students.

Research Objectives

Several initiatives were undertaken to achieve departmental transformation and curricular revolution, including curricular change that is underway at the sophomore, junior and senior levels to include cross-disciplinary project-based experiential learning; launching a departmental peer mentoring program; instituting a departmental student advisory council; conducting faculty retreat and discomfort zone sessions to explore how to best meet student and industry needs; and organizing departmental events to increase sense of community and connections to industry. Research on student outcomes from this departmental transformation is examining relationships between student attributes (for example, motivation, sense of belonging, and identity) and changes in those attributes over time (from first year in the civil engineering program through graduation) for various groups of students. Students' attributes and perspectives in turn provide input on initiatives aimed at increasing students' sense of belonging.

For this paper, the guiding research question is: What are civil engineering undergraduate students' sense of belongingness in their major and at the university level? This paper reports on the analysis of quantitative data to examine differences in students' sense of belonging based on student demographics and year in the program, and qualitative data to reveal what factors affect students' sense of belonging. Specific questions we are examining include:

- What differences exist between students' sense of belonging based on academic and social demographics their academic level (year in college, gender and race/ethnicity)?
- What differences exist for two student cohorts, sophomores and juniors, from Year 1 to Year 2 in the project?
- What is the nature of students' experiences in CE that affect their sense of belongingness in engineering?

Methods

Study Context

In 2017, a CE department at a southeastern land grant institution was awarded a National Science Foundation (NSF) Revolutionizing Engineering and Computer Science Departments (RED) grant, which aims to achieve "significant sustainable changes necessary to overcome long-standing issues in…undergraduate programs and educate inclusive communities of engineering and computer science students prepared to solve 21st century challenges" (National Science Foundation, 2018). The goal of the funded project is to institute curricular, community, and cultural change within the department at faculty, undergraduate, and staff level. Underpinning these change initiatives is the desire to increase diversity and inclusion within the student population. The guiding factors of this transformation were founded in industry, alumni, student and faculty feedback on the professional and technical readiness of graduating CE undergraduate students. The significant issues identified by stakeholders through this process include professional formation of students in terms of team work, project management and communication; experiential learning that aligns with professional practice; and building a sense of community.

Table 1 presents the department's undergraduate demographics of race and gender since receiving NSF RED grant in 2017. (Total number of students in each category were not included in Table 1 because student demographics are reported for separate semesters and students could complete the survey in multiple semesters, therefore summation would not be relevant.)

Table 1. Demographics by Gender and Race of Undergraduate Students in Civil Engineering by Semester, Fall 2017 - Fall 2018

	Gender		Race	
Term	Male	Female	White	Non-White
Fall 2017 (*n*= 364)	291 (80%)	73 (20%)	312 (86%)	52 (14%)
Spring 2018 (*n*=372)	294 (79%)	78 (21%)	317 (85%)	55 (15%)
Fall 2018 (*n*=391)	310 (79%)	81 (21%)	331 (85%)	60 (15%)

Survey Background and Constructs

We gathered data from current sophomores, juniors and seniors using a survey and interview protocol adapted from a prior NSF-funded project (EEC Award # 1428523, "Intersectionality of Non-normative Identities in the Cultures of Engineering, InIce") that examined the cultures and student identities within engineering (Fernandez, Godwin, Verdín, Kirn, Boone, Potvin, Doyle and Benson, 2016; Kirn, Godwin, Benson, Potvin, Doyle, Boone and Verdín, 2016). The survey constructs include sense of community, motivation, career outcome expectations, grit, identity, agency beliefs and general psychological characteristics. Psychometric tests on the survey with a nationally-representative sample of first-year engineering students (n=2916) demonstrated acceptable levels of validity and reliability for survey responses from the first year engineering student population (Kirn et al., 2016; Boone and Kirn, 2016).

The survey included eight constructs: sense of community, time-oriented motivation, goal orientation, career outcome expectations, grit, identity, agency beliefs and Big 5 personality traits. Time-oriented motivation constructs draw from the Future Time Perspective theory: the student's perceptions of their future in engineering (Perceptions of Future), the student's perceptions of how useful their courses are for reaching their future goals in engineering (Perceived Instrumentality), the student's perceptions of how the future affects their actions and decision in the present (Future on Present), expectations of success in their courses (Expectancy), the value a student places on thinking about the future (Value) and their tendency to make cognitive connections between the present and the future (Connectedness). Goal orientation constructs relevant to engineering students include those factors that describe their goals when completing academic tasks: the tendency to work toward outward indicators of success, such as grades (Performance Approach), working towards learning and understanding (Mastery Approach), and the preference for working on academic tasks that can be completed in a short amount of time (Work Avoid). Career outcome expectations describe general attributes of a future career. Grit describes the tendency to persevere through challenges on tasks. Identity has three sub-constructs: Physics Identity, Math Identity and Engineering Identity; these identities pertain to the students' perceptions of themselves as a "physics person," "math person," or "engineer," respectively. Agency beliefs pertain to a student's beliefs about

how a career in engineering could make a positive impact in the world. The "Big 5" personality traits of intellect/imagination (also called openness to experience), conscientiousness (related to grit), extraversion, agreeableness and emotional stability (also called neuroticism, or the tendency to have negative emotions) have been shown to be reliable and valid to describe the general psychological traits of individuals.

Demographic questions were asked in a way that holistically represents students' multiple social identities; for example, choices for students' gender identities go beyond binary choices of "male" or "female" (Fernandez et al., 2016). The survey allowed students to choose one or more of the following:

- Female
- Male
- Genderqueer
- Agender
- Transgender
- Cisgender
- A gender not listed: _____

Choices for race and ethnicity on the survey are based on Fernandez et al.(2016) as well, with the following choices:

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic, Latino or Spanish origin
- Middle Eastern or North African
- Native Hawaiian or Other Pacific Islander
- White
- Another race or ethnicity not listed above: _____
- Please print your specific ethnicities in the space below. Examples of ethnicities include (for example): German, Korean, Midwesterner (American), Mexican American, Navajo Nation, Samoan, Puerto Rican, Southerner (American), Chinese, etc. Note, you may report more than one group. Ethnicity: _____

Quantitative Data Collection and Participants

Surveys were distributed among students enrolled in CE labs at the sophomore, junior, and senior levels that were are a corequisite for required CE courses in the current curriculum, with enrollment restricted to CE students. About a month before the end of each of three semesters, research team members attended each lab section to introduce the survey and answer questions. Graduate teaching assistants for the labs were provided with the survey link ahead of time, which they made available to students prior to their lab through the course management platform.

The survey response rate overall for the 2017/2018 academic year was 92%; response rate for the 2018/2019 academic year cannot be reported because survey data analysis is not complete at this point in time. Response rates by academic level are reported in Table 2; academic level (year in the program) and demographics for participants are reported in Table 3 using labels from the survey (Fernandez et al., 2015). There were too few participants who identified as non-White to disaggregate, so these were combined as "non-White."

Table 2. Undergraduate Enrollment, Lab Enrollment and Response Rates for Participants in Civil Engineering, Fall 2017, Spring 2018 and Fall 2018.

Term	Lab	Total Lab Enrollment	Survey Responses	Response Rate
Fall 2017 (n =364)	Sophomore course	83	69	83.1%
	Junior course	83	75	90.3%
	Senior course	43	21	48.8%
Spring 2018 (n = 372)	Sophomore course	67	53	79.1%
	Junior course	41	33	80.5%
	Senior course	71	44	61.9%
Fall 2018 (n = 391)	Sophomore course	95	90	94.7%
	Junior course	94	88	93.6%
	Senior course	36	24	66.6%

Table 3. Demographics (Gender and Race) by Academic Level for Participants from Civil Engineering, Fall 2017, Spring 2018 and Fall 2018

	Gender*						Race	
Course	Male	Female	Genderqueer	Multiple Gender Identities**	Gender Not Listed	Prefer not to respond or did not respond	White	Non-White or prefer not to answer
Sophomore course	F17: 35 S18: 33 F18: 58	F17: 15 S18: 16 F18: 25	F17: 0 S18: 1 F18: 0	F17: 1 S18: 0 F18: 1	F17: 0 S18: 0 F18: 1	F17: 19 S18: 3 F18: 5	F17: 43 S18: 62 F18: 18	F17: 19 S18: 4 F18: 7
Totals***	96	56	1	2	1	27	123	30
Junior course	F17: 67 S18: 21 F18: 58	F17: 9 S18: 9 F18: 21	F17: 0 S18: 0 F18: 0	F17: 0 S18: 3 F18: 0	F17: 0 S18: 0 F18: 0	F17: 9 S18: 4 F18: 3	F17: 37 S18: 21 F18: 36	F17: 10 S18: 4 F18: 5
Totals***	146	39	0	3	0	16	94	19
Senior course	F17: 15 S18: 32 F18: 20	F17: 3 S18: 8 F18: 4	F17: 0 S18: 0 F18: 0	F17: 1 S18: 0 F18: 0	F17: 0 S18: 0 F18: 0	F17: 4 S18: 3 F18: 0	F17: 69 S18: 72 F18: 17	F17: 4 S18: 4 F18: 0
Totals***	67	15	0	1	0	7	158	8

*Gender attributes with no responses were removed from table. **Some participants selected multiple descriptions for their gender identity, these students are only counted here. *** The totals are smaller than the total number of respondents because not everyone reported their demographic data.

Quantitative Data Analysis

After the survey was distributed, all data were cleaned to remove any identifying information and any participants who did not consent for their information to be used in the study. All data analysis was completed in R statistical software (R Core Team, 2016). Because this is a well-established survey which

has been tested for validity and reliability on a similar population, the internal consistency reliability was tested using Cronbach's alphas for the constructs being analyzed. Cronbach's alpha may be sensitive to the distribution of the items (Curran, West and Finch, 1996). The normality of the belongingness items were checked to ensure that the data did not severely violate assumptions about normality (|skew|>2 and kurtosis>7) (Johnson, Tietjen, and Beckmand, 1980). Any items that did not fit these requirements were removed from further analysis (Lee, Godwin, and Hermundstad, 2018). As part of a larger study, a Confirmatory Factor Analysis will be done to confirm that the model of factors from the entire survey behaves in the manner expected, which requires an assumption of a normal distribution (DeVellis, 2012).

Once the validity and reliability of the instrument was tested, quantitative analysis began for answering the research question. A MANOVA, or multivariate analysis of variance, was used to test if there was a significant difference in the means for the two belongingness factors (university and engineering) for sophomores, juniors, and seniors. MANOVAs test for the differences in means between two or more groups. Because the samples at each time point (Fall 2017, Spring 2018, and Fall 2018) are not independent, separate MANOVAs were run for each semester. Hotelling's T2 test was run to determine if there were any significant differences in belongingness across social demographics (gender and race). Welch's two-sample t-tests were run to compare the belongingness factors between sophomores in Fall 2017 and sophomores in Fall 2018, and to test for significant differences between sophomores in Fall 2017 and juniors in Fall 2018, with the assumption that the majority of these students were in the same cohort (i.e., testing for changes in perceptions of belongingness over time for one group of students in the CE program). These t-tests were adjusted for Type 1 error using a Bonferroni correction for multiple simultaneous statistical tests (Cudeck and O'Dell, 1994).

Interview Protocol and Participants

At the end of the survey, students were asked to provide their email addresses if they were interested in participating in a follow up interview, with the incentive of a $20 Amazon gift card. Overall, 219 respondents out of the 306 total respondents provided their email addresses for potential interviews (82 emails from the sophomore class, 91 emails from the junior class, and 46 from the senior class). The emails were divided according to class level, and ranked the students according to each individual's average scores in the engineering belongingness factor. Interview participants were invited through emails, first sent to those in the top 30% and bottom 30% of the engineering belongingness scores, along with all students identifying as female or as non-White. The junior participant slots were filled after the first round of invitations, so the second and third rounds of invitations were sent to all sophomores and seniors who provided email addresses. Nine students were interviewed in total: one sophomore, six juniors and two seniors. Five of the participants identified as females and four as males. Six participants identified themselves as White, two as Black, and one as Asian.

Table 4. Interview Participants' Demographics and Academic Level (Year in Civil Engineering Program)

Pseudonym	Class	Race	Gender
Noah	Junior	White	Male
Logan	Senior	White	Male
Sarah	Junior	White	Female
Patrick	Junior	White	Male
Cindy	Senior	White	Female
Steph	Junior	Asian	Male
CP	Junior	Black	Female
Sue	Junior	Black	Female
Hermione	Sophomore	White	Female

Semi-structured interviews were conducted using a protocol adopted from a previous study (Kirn et al., 2016). Eight of the nine interviews were conducted face-to-face, and one interview was conducted via teleconference with an interviewee who was off campus for the semester. The flow of the interview started with asking the participants about their "story" (for example, "How did you get into engineering?"), followed by reflecting on their engineering identity, sense of belongingness in engineering for themselves and for other students, and their present and future activities and plans in CE. Interviews were conducted by two members of the research team and were approximately one hour long.

Qualitative Data Analysis

Interviews were professionally transcribed, and transcripts were reviewed by the interviewers to correct errors. Initial qualitative analysis was conducted using descriptive coding (Miles and Huberman, 1994); responses to questions about belongingness were coded with the intention of capturing how participants described their sense of belongingness in CE, and factors that contributed to or detract from that perception. Patterns within these descriptive codes were interpreted to categorize participants' descriptions and themes were identified from those categories. Qualitative analysis was conducted by two team members, one of whom conducted the interviewers and one who had experience coding similar data from a related project. Codes were developed initially by one coder; the second coder read through transcripts and codes, identifying additional codes or questions. The two coders met to resolve comments and questions until they were both in agreement about the codes, then developed the categories and themes through iterative readings of the coded transcripts.

Results

Quantitative Analysis of Survey Data

The normality assumptions for all but two of the items were met. The belongingness in university items: "I enjoy going to school here" and "I wish I were at a different school (reverse coded)" were both left skewed and removed from further analysis. The Cronbach's alpha for each of the factors in the survey were above the acceptable range ($\alpha > 0.7$). This paper presents on the belongingness factors, Belongingness in University ($\alpha = 0.86$) and Belongingness in Engineering ($\alpha = 0.72$). The alphas indicate an acceptable internal consistency reliability, or how highly correlated the items within each factor are, suggesting that the items are measuring one underlying latent variable (DeVellis, 2012).

The results from the MANOVA indicate that in the Fall 2017 semester the participants in the junior course have a significantly higher (p=0.012) Belongingness in the University (6.2 out of 7) than the sophomores (5.8). The t-tests across semesters indicate that the participants in the sophomore course in Fall 2017 have a significantly higher (p=0.010) belongingness in engineering (4.98 out of 7) than the sophomores in Fall 2018 (4.64). No other results were significant; the average belongingness scores for each course are shown in Table 5.

Table 5. Average Belongingness Scores for Participants by Academic Level in Civil Engineering, Fall 2017, Spring 2018 and Fall 2018

		Fall 2017	Spring 2018	Fall 2018
University	Sophomore	5.85	5.95	5.88
	Junior	6.20	5.85	6.03
	Senior	6.16	6.25	5.83
Engineering	Sophomore	4.98	5.05	4.64
	Junior	5.05	5.00	5.15
	Senior	5.11	5.25	5.07

Hotelling's T2 test for differences in belongingness between white and non-white in Fall 2018 was non-significant (p=0.07), and male (and cis-male) vs. non-male was also non-significant (p=0.068). Differences by gender and race in the Fall 2017-2018 year (Fall 2017/Spring 2018 combined) were also non-significant (p=0.8027 and p=0.5137, respectively). Therefore, no further tests were completed. The results of the Hotelling's T2 tests are shown below in Table 6.

Table 6. Average Belongingness Scores by Race and Gender

		Average Belongingness		Hotelling's T2 p-value
Semester/Year	Race/Gender	University	Engineering	
Fall 2017-Spring 2018	White	6.119	5.088	0.803
	Non-White	5.827	4.944	
	Male	6.067	5.039	0.514
	Non-Male	6.072	5.139	
Fall 2018	White	6.011	5.067	0.074
	Non-White	5.782	4.941	
	Male	5.990	5.039	0.068
	Non-Male	5.910	5.083	

Qualitative Analysis of Interview Data

In response to questions like "Do you feel like you belong in civil engineering? In what ways?," students described factors that both contributed to and detracted from their feelings of belongingness. In general,

students were able to describe both; there were no students that felt only that they did not belong in CE, but rather there were ways that they felt they both did and did not belong. Additional insights were gained through patterns of responses related to who belongs in CE.

Feelings of Belongingness

Through our qualitative analysis, we identified two common factors that students described as contributing to their feelings of belongingness in engineering: positive learning experiences and opportunities for interactions with other students outside the classroom.

Positive learning experiences

Students reporting high belongingness often described being interested by their coursework, feeling confident in their mathematics or physics abilities, and enjoying engineering coursework before beginning their postsecondary education.

> I am naturally fairly good at it, but I also really enjoy it. A lot of the classes that I notice people complain about are classes that I really enjoy doing the homework for. That sounds really nerdy and weird, but I genuinely enjoy all of the stuff that I've been learning. Even if I get tired of it sometimes, I still really find everything that I'm learning interesting, and I'm good at it, so I feel like the two together work out pretty well and make me feel pretty confident in my choice. (Hermione)

> My high school was really what set me into place to pursue engineering. We had [a local high school] with a technical college attached to it. As a student you can take courses from either, the high school or the technical college. I took drafting design, AutoCAD, Solidworks. I completed architectural design. There was an engineer, he actually got his Bachelor's from [a four-year institution in the state], but he was a mechanical [engineer]. He taught a course where we designed airplanes, and we would fly them. We built the electric sequences and all that, and we'd fly 'em. That got me really curious into just engineering and seeing the design go from a drawing to actually implementing it. That was what really got me interested. I went there [to the technical college], and then I've been trying to pursue engineering ever since. (Noah)

Interaction with other civil engineers outside of the classroom

Students reporting a high sense of belonging in the interviews also frequently reported involvement in engineering internships, fraternities, student organizations and other extracurricular activities. These activities helped direct their paths in civil engineering or confirmed their sense of belonging in the major.

> I'm part of [the departmental mentoring program], which is the mentor/mentee program which we just started, which I think is a great thing... I think that's been really cool to see how we all fit together and how people, sophomores or juniors, one has this other mentor, but they recognize me from the ceremony they've had at the beginning of the year. They'll come up and ask me a question. That's really cool. (Cindy)

> *Personal connections*

> Students feel greater belongingness when they are able to establish meaningful connections with individuals on a personal basis.

>> I think I've made a lot of friends throughout my four years here in civil engineering and engineering in general. I know a lot of people I don't have classes with together all the time ... there's definitely a handful of people in every class that I can go to and ask like, "I need some help on this homework," or stuff like that...I definitely had friends in every

> class, so that was nice, knowing that there were people there...I don't think I've ever ran into anyone who was like, "No, I'm not gonna help you out." (Logan)
>
> Here's one thing that did make me feel like I belong in civil engineering. I was invited by one of the graduate students, she was a TA in one of my labs, to come join this civil engineering organization. (Patrick)

Camaraderie through similarity

Some students felt belongingness through noting similarities with their fellow civil engineering majors, like similar backgrounds or shared experiences.

> I think I belong because of the people I've met here... and seen a lot of similarities with people that I've met and that I'm friends with, students-wise...having peers who supported me and who I could talk to and who were very similar to me made me fit in and feel like this is the right path for me. (Logan)
>
> I think no matter how bad general engineering was, I didn't want to be one of those people that got weeded out. I wanted to push through. I had really good support system...I lived with a [living and learning] community and my roommate was civil engineering and people in the hall were other types of engineering. We were really good at motivating each other. You didn't really want to study for a test or whatever but there was 10 people downstairs studying for it. I went down there and studied with them. I think that was really good for motivating me because we're all like, "Look at the bigger picture. Next year you won't have to do any of this. You're going to be in your specific major hopefully enjoying the classes that you're talking." (Cindy)

Feelings of Not Belonging

Not every student interviewed felt a strong sense of belongingness. Participants gave several reasons for why they, or other students, might not feel like they belong, and these fell into two general themes: not being intrinsically motivated or passionate for engineering, or not feeling supported by educators and peers in their department (i.e., not fitting into the "academics box").

Lack of Intrinsic Motivation

Students described how some of their peers might feel less motivated or feel like like they belong in CE based on meeting others' expectations or doing it for external rewards.

> I think one of the biggest issues for not having a sense of belonging in it is people who enter into it solely out of maybe parents' expectations for them to do it...still trying to do what they think their parents want. But I don't believe civil engineering is what they truly want for themselves, so I think that hurts their sense of belonging and their desire to do it, because it's not really what they want, they just haven't ever tried to find what they want to do. (Hermione)
>
> A lot of times, the more successful in the academic engineers I've seen, they really don't enjoy... a lot of the higher GPA group I've seen pursue it for money. Pursue it for financial success, and it always seems to fall short for them. (Noah)

Not fitting in the "academics box"

The expectation of academic success contributed to a lack of belongingness in some students as they perceived a competitive environment where students could not express the difficulties they were experiencing in attaining high grades and difficulty socializing with students who performed well. This was described by two juniors: CP, a Black female and Noah, a male first-generation college student:

> The curriculum is very challenging and then a lot of times people don't feel like they have anyone to talk to. It's sometimes the rhetoric from other students... (CP)
>
> In the academics, I wouldn't say I feel as welcomed. I wouldn't necessarily say I feel a part of any group.... I definitely feel if you do not follow a certain way to solve a problem, especially if you don't fit the academics box of how to solve a problem, I think that can make you feel like you're not almost worthy of being in engineering because you don't do it the same way as students that are able to pick up on say, the method the teacher shows you, and do it that way. (Noah)

Who Belongs in Civil Engineering?

It is interesting to note that in response to questions about others pursuing CE such as "Who can do civil engineering?," all the students interviewed perceived CE as a field open to everyone, but identified several traits that would help students succeed. These traits were dedication to engineering, strong mathematics and physics ability, detail orientation, the desire to solve problems, the ability to work with others and strong communication skills. Students hypothesized that their peers who left engineering had lower intrinsic motivation (for example, lower interest in the field or a lower sense of satisfaction from their course work), a reduced work ethic compared to others, or were unable to meet academic expectations imposed by themselves or their parents, peers or instructors.

Discussion

Our quantitative results related to belongingness indicate that, early in the implementation of our curricular and programmatic changes, students on average have a relatively high sense of belonging at both the major and university levels, although that sense of belonging was lower for sophomores in the second year of the project than in the first year. This finding may reflect students' resistance to discussing diversity and inclusivity, as reported in prior research (Gillespie, Ashbaugh and DeFiore, 2002; Denevi and Pastan, 2006; Henry, Cobb-Roberts, Dorn, Exum, Keller and Shircliffe, 2007; Mthethwa-Sommers, 2010; Thorington Springer, 2014; Tharp, 2015; Vianden, 2018). Diversity and inclusivity were major themes of the RED project and were discussed with increasing frequency over the course of the first year of the project.

It is interesting that there were few significant differences between levels (sophomore, junior, and senior) and no significant differences between male/non-male, and white/non-white. This finding is counter to prior research that indicates females and underrepresented minorities typically have lower sense of belonging than the majority (white/male) (Corbett and Hill, 2015; Rainey, Dancy, Mickelson, Stearns, and Moller, 2018). While the quantitative analysis did not result in significant differences, the interview responses indicate that these individuals perceive a lower sense of belongingness, for a variety of reasons. The average metric used in the quantitative analysis does not show the spread of responses, nor consistency in individual student response, so there are likely individual students that consistently rate low and others that consistently rate high. Additional analysis of groups of students in the upper and lower thirds or quartiles will be conducted in the future as part of our ongoing studies. Similarly, in a study that clustered engineering students based on quantitative measure of non-cognitive factors, including engineering identity and belongingness, over 40% of the participants did not fit into clusters (Scheidt, Senkpeil, Chen, Godwin, and Berger, 2018). In Scheidt et al.'s study, engineering identity and belongingness were 2 of just 5 factors (out of about 20 total factors analyzed) that drew distinctions between clusters; in other words, engineering identity and belongingness are two of the most varied

affective attributes of students. While engineering faculty and administrators tend to think of our students as primarily possessing a "typical" student profile, the majority of our students are not typical.
Our results related to a first-generation student in our interviews provide valuable insight into this growing but under-studied population. First-generation students have been shown to have an affinity for careers in which they will be “inventing/designing things, developing new knowledge and skills, applying math and science, and supervising others when compared to continuing-generation college students (Verdín and Godwin, 2016); they are a valuable population of engineering students. Belongingness, in addition to engineering identity, were found to have a positive direct effect on persistence of effort for a nationally-representative population of first year engineering students (Verdín, Godwin, Kirn, Benson and Potvin, 2018). Our findings that a first-generation student felt a lack of belongingness is in contrast to earlier findings from a quantitative study of first-generation college students’ motivation and belongingness, in which first-generation students were more likely to feel a sense of belongingness in their engineering classes and in their major than continuing-generation students (Boone and Kirn, 2016). However, this study was conducted at an institution with a high percentage of first-generation college students, which may have provided these students with a sense of community with peers from similar backgrounds. This presents opportunities for undergraduate engineering programs such as the one in this study to focus on the experiences of first-generation students, and helping them build a sense of community with students from a variety of backgrounds and demographics. Regardless, the comments of this student that described “in groups” and “out groups” are similar to those described by Cech and Sherick (2015) in terms of the meritocracy in engineering. Specifically, our participant described the ways in which other students solved problems and communicated those solutions that resonated and were acknowledged by their instructors; there was a sense that as the “in group,” other students had skills and knowledge that Noah did not have access to. Cech and Sherick (2015) describe the power and value associated with skill or ability to the extent that other factors such as race/ethnicity, gender, and socio-economic status may be overlooked. While students may not be overtly creating in and out groups based on visible characteristics such as race and gender, they may be excluding groups based on “invisible” diversity traits, such as ways of thinking, first-generation status, and prior life experiences. (Note that Noah transferred to the university from a technical college.) This could lead to overlooking challenges faced by students from diverse backgrounds as they strive to join the engineering community.

Conclusions and Implications for Practice

Data collected from the first three semesters of the project gives us a snapshot of the diversity of the current student body prior to fully implementing programmatic changes that are planned as part of the RED project. We plan to collect data each year to assess how well our goals of increasing diversity, creating a culture of inclusivity, and increasing the persistence of diverse types of students in the program are being met. This information will inform the design of other activities such as a mentoring program, capstone design, and supporting mid-year content courses and sophomore “springer” courses. Insights revealed in interviews have identified evaluation components for these courses, addressing specific issues of bias, faculty feedback, inclusive teamwork practices and professional skills. Future work includes interviewing students who have left the program and examining their survey data to determine what aspects of the program contributed to their decisions to leave.

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