Work-in-Progress: Sense of Belonging Among Underrepresented Voices in ECE

Chelsea Lyles

Chelsea H. Lyles, Ph.D. (she, her, hers) is the Associate Director for Broader Impacts at the Center for Educational Networks and Impacts (CENI) within the Institute for Creativity, Arts, and Technology (ICAT) at Virginia Tech, where she previously served as a postdoctoral associate for outreach, engagement, and evaluation. Her research interests explore the intersections of a) P-12 and higher education policy and finance, b) academic labor, c) graduate education, and d) assessment of student learning. By critically examining these areas, she aims to illuminate adverse, systemic impacts of policies and practices on historically marginalized populations at the organizational level. Current research projects include a scoping review of service learning courses, measuring sense of belonging in electrical and computer engineering, and a qualitative study of boundary-spanning educators. She has contributed to manuscripts about STEM graduate student funding, skill development, and recruitment in the International Journal of STEM Education and the Journal of Higher Education. She has also written education finance policy analyses for the Journal of Education Finance and published a document analysis in the Journal of Education Human Resources. She has more than 15 years of experience in higher education, including academic advising, academic administration, student affairs, assessment and evaluation, and research. She earned a M.B.A. at Lynchburg College and holds a Ph.D. in Higher Education from Virginia Tech. Her dissertation was titled, “The Relationship Between Responsibility Center Management, Faculty Composition, and Faculty Compensation.”

Emily M Burns (Graduate Student)

Thomas Koonce Jr

My name is TJ Koonce and I am a first-year in the Engineering Education PhD program at Virginia Tech. I went to Virginia Tech for my undergraduate degree in Computer Engineering and I worked with the Center for the Enhancement of Engineering Diversity (CEED) as a GTA for my first semester. The following semester, I worked for CENI as a GRA for data analysis on interviews and a sense of belonging as part of the RED Grant. For research, I am interested in collegiate programs for first-generation and low-income engineering students and student perspectives of collegiate support. After the completion of my PhD, I hope to become a professor for first-year engineering and coding courses at the collegiate level.

Lisa McNair

Lisa DuPree McNair is a Professor of Engineering Education at Virginia Tech and Director of the Center for Educational Networks and Impacts (CENI) at ICAT. Her work focuses on building networks between the university and multiple community sectors and supporting evidence-based outreach in science, engineering, arts, and design. She translated a decade of interdisciplinary initiatives into VT’s Innovations Pathway Minor, and has directed 11 PhD dissertations, served on 17 PhD committees, and funded and mentored 6 post-graduate scholars (5 PhD, 1 MFA). Her funded NSF projects include revolutionizing the culture of the VT ECE department, identifying practices in intentionally inclusive Maker spaces, and researching effective modes of co-creation between housing experts and remote Alaska Native communities.

Annie Yong Patrick (Ms.)
Work-in-Progress: Sense of Belonging Among Underrepresented Voices in ECE
Abstract. Sense of belonging is a theoretical framework of inclusion describing tenets that contribute to academic success and are often absent for underrepresented students. We conducted document analysis of interviews with 20 participants who answered questions designed for creating podcasts about diversity in an ECE undergraduate program. Our findings indicate that sense of belonging is greatly impacted by how an individual interacts with their environment. We offer recommendations from our study and the literature on ways that faculty, administrators, and advisors can build more inviting environments that promote sense of belonging for a broader range of students.

Compared to White students, a disproportionate number of Hispanic, Black, Native American and Hawaiian/Pacific Islander students completed a four-year degree in STEM in 2018 (83.6%, 11.4%, 4.2%, 0.3%, and 0.2%, respectively) [1]. As is the case with other STEM disciplines, a consistent challenge within electrical and computer engineering (ECE) is increasing the enrollment and matriculation of people from underserved and underrepresented communities. Though there have been numerous initiatives throughout the years, ECE undergraduate education still struggles with compositional diversity. Part of addressing the challenge of compositional diversity (in addition to equity and inclusion) is understanding the importance of factors such as sense of belonging, identity, and representation of students. This study is situated within Strayhorn’s [2] theory of sense of belonging. Derived from Maslow’s [3] hierarchy of needs framework, belongingness is a human need that explains behavioral motivations. In the college campus environment, belonging is positively associated with academic success.

With the goal of exploring tenets of sense of belonging in an undergraduate program within the ECE department, our research questions were:

1) What evidence do we find of a sense of belonging and its tenets? And

2) What is the relationship between sense of belonging and social identities?

A Brief Review of the Literature on Sense of Belonging among College Students

Belonging, or how students perceive campus support, connection, and being valued, is a key factor in college students’ success. Belonging is positively associated with students’ transitions to college, retention, persistence, and self-efficacy [4], [5]. Additionally, a sense of belonging is key to one connecting with their classmates, their community, and eventually their profession [4]. This sense of belonging is not only invaluable to fostering connection and identity, it is also key to motivation and resilience [6].

Lack of belonging negatively impacts students’ academic performance as well as their engineering identity. Therefore, it is very important for engineering departments to foster a sense of belonging for students to identify with engineering and be successful in college [7]. Among engineering students, belongingness relates to feeling included among their peers [8]. In their mixed methods study of five ECE students from 4 different postsecondary institutions, Rhode et al. [8] found participants determined their level of inclusion in contrast with their classmates and reported they felt more included when they found similarities with their peers [8].
Sense of Belonging and Social Identities in STEM/Engineering

Sense of belonging is especially critical in educational contexts where students feel marginalized, such as students of color and women in STEM contexts where they are underrepresented. Underrepresented students may find they have less in common with peers with whom they do not share social identities and therefore may experience a lower sense of belonging than their majority peer counterparts. Strayhorn [2] found students of color “are prone to feel ‘out of place’ or invisible in STEM classrooms” (p. 94). Sense of belonging influences self-esteem and frequency of peer interaction among racial/ethnic minority STEM students [2]. How students experience belonging may differ by social identities and their intersections.

Less women pursue a degree in engineering or identify as engineers when compared to men [9], [10]. In 2010, only 21% of first-year engineering majors enrolled in U.S. post-secondary institutions were women [9]. Cheryan, et al. [9] conducted an extensive literature review to explore the origins of this gender gap. They proposed educators foster a “social and structural environment that confers a greater sense of belonging and ability to succeed to men than women” (p. 8). Consequently, fewer women enter college intending to pursue a career in engineering because their school personnel most likely did not encourage them to consider engineering. Among those women who major in engineering, they are less likely than men to identify themselves as engineers [10]. Myers et al. [10] found in their quantitative study of 701 engineering majors at a private institution that 12-20% fewer women, across all academic levels, identified as engineers when compared to the men in their study. The higher chance of men identifying as engineers is likely an outcome of the self-perpetuating societal belief that engineers are typically White men.

Intersections of multiple underrepresented social identities and institutional context can also contribute to sense of belonging [11], [12]. For example, Dortch and Patel [11] conducted a phenomenological study of three Black women’s undergraduate experiences while earning bachelor’s degrees in STEM and found all three women reported experiencing microaggressions and subsequently lower sense of belonging after enrollment in their STEM programs. Johnson [12] studied 1,722 survey responses from women currently majoring in engineering at 29 predominately White, postsecondary institutions and found women of color majoring in STEM reported lower feelings of inclusion compared to responses from White women. In contrast, regression analysis revealed that when women of color assessed their overall campus as inclusive and formed relationships with peers in their residence halls, they reported a higher sense of belonging [12].

Fostering strong feelings of inclusion among underrepresented engineering students supported their persistence as engineering majors and cultivated desired engineer characteristics [13], [14], [15], [16]. Tomasko et al. [13] studied the experiences of four cohorts of incoming underrepresented minority, women, and first-generation STEM students (N=188) who participated in a summer transition program and found the program improved student persistence rates across all groups studied. The authors attributed the strong sense of inclusion and community building among participants as a major factor in these improved persistence rates [13]. Banda and Flowers [14] conducted a qualitative study of 11 senior-level, engineering undergraduate Latina students attending a research focused institution who reported joining student organizations to find both social and academic support, receive affirmation of their importance as Latina women in engineering, and meet students from other races [14]. The
relationships these students found in student organizations strengthened their feelings of inclusion and supported their persistence in engineering [14]. Verdín [16] studied 373 undergraduate women majoring in engineering at nine different 4-year postsecondary institutions in the United States and found students’ motivation for studying engineering was the highest predictor of their retention. Polmear et al. [15] studied the development of desired engineering traits by comparing the out of classes experiences of marginalized and overrepresented civil engineering students. Both over- and underrepresented students reported work as a major source for developing engineering traits, but underrepresented students more often identified sports, civil engineering teams, dance, and music activities as additional supports [15].

As indicated in the aforementioned research studies, it is essential for engineering post-secondary administrators to prioritize students’ sense of belonging, rather than initiating underrepresented students into a chilly campus climate [18], [19]. Strayhorn found Black students at a Predominantly White Institution reported feeling that institutional leaders did not treat them in the same warm, welcoming ways as they did White students [18]. In an earlier study, Morris & Daniel [19] found women and non-white students attending a community college and majoring in fields dominated by White men reported experiencing a less welcoming and more exclusionary campus climate than White men in the same majors. Given this persistent finding of students experiencing engineering programs as cold and unwelcoming, it is important for engineering administrators to intentionally cultivate inclusive engineering programs. Therefore, we sought to study the overall reported sense of belonging among undergraduate students and administrators in one ECE department, including the experiences of underrepresented groups.

Theoretical Framework

We used Strayhorn’s [2] Sense of Belonging Theory to guide the design of this study. Strayhorn [2] emphasized seven essential tenets, of a sense of belonging. First, all human beings have an inherent need for inclusion. Therefore, experiencing belonging is an essential requirement for college students to learn and gain new insights in educational environments. For students to reach their full potential, they must first have a consistent support system of people who believe in their importance. Second, one’s desire to belong dictates actions, meaning college students will seek out places where they feel included and significant. Third, the need to belong arises at pivotal times and places in a person’s life, especially for those who are most often excluded by members of society. Thus, college students who experience multiple forms of oppression enter higher education environments with an acute need for inclusion. Students are less likely to learn and grow in college until they find a group of people with whom they belong.

Fourth, one’s assessment of whether others’ believe they are important is an indication of their perceived sense of belonging [2]. Therefore, if a college student believes others around them (e.g. peers, instructors, advisors, etc.) value their presence and contributions, they will report a high sense of belonging. Fifth, Strayhorn [2] posits “social identities intersect and affect college students’ sense of belonging” (p. 37). Thus, when studying college students’ sense of belonging, it is imperative to consider their social identities. Sixth, college students who feel they belong experience numerous benefits including successful course completion, contentment, and meaningful involvement in college activities. Lastly, one’s sense of belonging shifts depending on a given situation or experience. Thus, college students’ sense of belonging may fluctuate based on their interactions with those around them and experiences within institutional cultures.
Methodology and Methods

This study examined the significance of sense of belonging within an Electrical and Computer Engineering (ECE) department at Virginia Tech, a doctoral university in the southeastern United States with very high research activity Carnegie Classification. Of the over 300 ECE undergraduates at this university, 18% of the students were Asian, 3% are Black, and 5% are Hispanic. Women comprised 32.1% of matriculating undergraduates. Therefore, the majority of undergraduate students at the time of our study were White men, meaning it was important for us to consider sense of belonging among underrepresented, marginalized undergraduate students. With the goal of exploring tenets of sense of belonging in this context, our research questions were:

1) What evidence do we find of a sense of belonging and its tenets? And

2) What is the relationship between sense of belonging and social identities?

Data Collection

Our data sources included transcripts from a series of interviews conducted as part of a podcast series, Engineering Visibility (https://icat.vt.edu/projects/red/podcast.html). The podcast was created to highlight the experiences and voices of students, faculty, staff, and administrators within an ECE department that may not have previously been at the forefront of the department. The podcast was planned as a limited series podcast to highlight several identities and concerns within the ECE department from a departmental climate and culture study. Episodes featured students, alumni, academic advisors, and administrative leaders discussing a variety of topics. A description of the episodes from which participants agreed to have their interviews be part of this research study are summarized in Table 1. All episodes were created by a graduate student as part of an NSF-funded study; the episode detailing the experience of the first-generation student was co-created with undergraduate students participating in a service-learning course in the Honors College.

Table 1. Summary of Podcast Episodes

<table>
<thead>
<tr>
<th>Episode</th>
<th>Episode Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invisible Voices in Covid-19</td>
<td>Now that we are all learning and socializing virtually, let’s take time to talk about how COVID-19 has changed the ECE department. What is it like to be a student, faculty member, advisor, and graduate student in a department and a world that will never be the same? In this episode, we hear from the many people of the ECE department, such as students, faculty, and advisors about their experiences of adjusting to COVID-19, how it has changed their lives, and how it affects their future. 4 participants, including 1 administrator, 2 advisors, and 1 graduate student.</td>
</tr>
<tr>
<td>Topic</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Seeing the Non-Traditional Student</td>
<td>The majority of undergraduate students come to ECE along a traditional track from high school senior to undergraduate freshman. However, this is not every student’s experience. Some students are veterans, some are transfer students, and others may have pursued another career before choosing to pursue a career in electrical and computer engineering. In this episode, we hear from these students and alumni and discuss their experience of being a “non-traditional” student. 3 participants, including 1 graduate student and 2 undergraduate students.</td>
</tr>
<tr>
<td>&quot;I'm in ECE for Me&quot;--Being a Woman in ECE</td>
<td>This episode focuses on being a woman in a field traditionally dominated by men. In this episode, we hear from both women alums and current students to discuss the experience of being a woman student in the ECE department and how to maneuver the industry as a woman engineer. 5 participants, including 3 alumni and 2 undergraduate students.</td>
</tr>
<tr>
<td>Extending Grace and Opportunity: The Experiences of Inclusion and Diversity</td>
<td>In the Spring of 2019, of the 354 graduates in ECE, 11 were Black, 20 were Hispanic, 64 were Asian, and none were American Indian or of Native Hawaiian/Pacific Islander descent. Today, the world is in the grips of a tide of social and racial justice, racial acknowledgment, and the words “diversity,” “inclusion,” and “equality” are even more significant. However, what does that mean in the ECE department? Do efforts to address these issues reach students? In this episode, we discuss what all these things mean, not as an initiative, but as a person. 3 participants, all alumni.</td>
</tr>
<tr>
<td>Taking Time to Talk About Teaching in ECE</td>
<td>The ECE department is renowned for the research accomplishments of its faculty. However, this episode is not about their research, this podcast is all about their teaching. The life of a faculty member is multifaceted...today we feature several faculty members who give us a glimpse into what happens when they aren’t in classes, what they want you to know about their approach to teaching, and how your participation contributes to their teaching. 3 participants, all faculty.</td>
</tr>
</tbody>
</table>
## About the First-Generation Student Experience

About 18% of undergraduate students at Virginia Tech are first-generation college students. A first-generation college student is defined as a student in which neither one of their parents nor their guardian earned a bachelor’s degree at a four-year college or university. This very special episode of Engineering Visibility was created by five very talented students from an undergraduate Honors Service Learning class. This episode features four special guests: Mrs. Tamara Cherry Clark, the Assistant Dean of Students for First Generation Student Support, and three first-generation students from the ECE department sharing their experiences of being a first-generation student. 2 participants, both undergraduate students.

### Participants Recruiting

Participants were recruited through two methods to take part in interviews that would be used to create podcasts. First, a recruitment announcement was created and distributed through the departmental and select university program listservs. The announcement, focused mostly on the student population, described a new podcast that was focused on bringing attention to the department’s less popular stakeholders. Interested participants were provided a link to a survey that provided the proposed episodes and a synopsis. Participants could then choose the episodes they were most interested in and provide their contact information. The researcher then followed-up with each participant. Six people responded to the survey and after contacting them, three were chosen. The second recruitment was through word of mouth and snowballing techniques. ECE faculty reached out to current students and alumni who fit the criteria for the podcast. The podcast author contacted each suggested participant individually, explained the project, answered questions, and followed up with the chosen participants. Additionally, participants were asked to suggest names of other ECE alumni and students who might be interested in participating.

Each podcast episode featured a combination of 3-5 people discussing their experience regarding the specific topic. The questions asked in each episode are listed in Appendix A. Each participant was pre-interviewed to address any questions about the podcast and explain the steps for the interview to reduce anxiety. A week prior to the podcast recording, each participant received a list of 8-10 questions to guide the interview and instructions for the recording. Each interview was conducted virtually using the Squadcast recording software. Only audio was recorded for each podcast interview. The interviews averaged approximately 40 minutes. For editing and story-telling, each podcast episode featured an average of ten minutes of conversation from each interview.

As this project began as a public-facing project that would be available to the public through several open streaming platforms, the institution’s IRB deemed individual consent unnecessary at the time. However, recognizing the value of these conversations in relation to belonging, the authors of this paper decided to analyze the interviews for research. Thus, all podcast participants were contacted via email and informed of the desire to incorporate their interviews into a research project. Each participant was provided an IRB-approved information sheet detailing the project, the benefits and risks of participation, and their rights. The information sheet was provided through a Qualtrics link in each individual email. After reviewing the information sheet...
participants had the option to indicate their desire to have their interview withdrawn from the study. All but one of the participants indicated their approval, resulting in 20 participants.

These approved interviews were anonymized using 20 pseudonyms (see Table 2) and organized into a secure Google Drive with access only available to IRB-approved researchers. Since data came from participants’ podcast interviews, they did not provide general demographic information unless relevant to their interview. Audio files were transcribed using Rev.com, a machine transcription service, and reviewed by one member of the research team. Text transcripts were then uploaded to Dedoose, a qualitative analysis software program, for analysis by three IRB-approved members of the research team.

Table 2. Summary of Participants.

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Podcast Episode</th>
<th>ECE Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allie</td>
<td>Invisible Voices in Covid-19</td>
<td>Advisor</td>
</tr>
<tr>
<td>Amber</td>
<td>Taking Time to Talk About Teaching in ECE</td>
<td>Faculty</td>
</tr>
<tr>
<td>Ashley</td>
<td>Invisible Voices in Covid-19</td>
<td>Graduate student</td>
</tr>
<tr>
<td>Barbara</td>
<td>&quot;I'm in ECE for Me&quot;--Being a Woman in ECE</td>
<td>Alumni</td>
</tr>
<tr>
<td>Beth</td>
<td>Invisible Voices in Covid-19</td>
<td>Administrator</td>
</tr>
<tr>
<td>Bob</td>
<td>Extending Grace and Opportunity: The Experiences of Inclusion and Diversity</td>
<td>Alumni</td>
</tr>
<tr>
<td>David</td>
<td>Extending Grace and Opportunity: The Experiences of Inclusion and Diversity</td>
<td>Alumni</td>
</tr>
<tr>
<td>Jess</td>
<td>Seeing the Non-Traditional Student</td>
<td>Undergraduate student</td>
</tr>
<tr>
<td>John</td>
<td>Seeing the Non-Traditional Student</td>
<td>Alumni</td>
</tr>
<tr>
<td>Katie</td>
<td>Invisible Voices in Covid-19</td>
<td>Advisor</td>
</tr>
<tr>
<td>Mary</td>
<td>&quot;I'm in ECE for Me&quot;--Being a Woman in ECE</td>
<td>Undergraduate student</td>
</tr>
<tr>
<td>Mikayla</td>
<td>Pioneer, Problem-Solver, and Purposeful--The First-Generation Student Experience</td>
<td>Undergraduate student</td>
</tr>
<tr>
<td>Nate</td>
<td>Pioneer, Problem-Solver, and Purposeful--The First-Generation Student Experience</td>
<td>Undergraduate student</td>
</tr>
<tr>
<td>Rachel</td>
<td>&quot;I'm in ECE for Me&quot;--Being a Woman in ECE</td>
<td>Undergraduate student</td>
</tr>
</tbody>
</table>
**Data Analysis.**

Interview transcripts were analyzed by members of the research team using document analysis [17], a qualitative research method that combined elements of content analysis and thematic analysis [10]. Content analysis entailed categorizing data based on our research questions and theoretical framework, and thematic analysis entailed categorizing data as themes emerged. Through an iterative process, we used deductive coding based on Strayhorn’s [2] theory of sense of belonging. These deductive codes included: *belonging brings benefits; desire to belong dictates action; social identities intersect with sense of belonging; inherent need for inclusion; needs of belonging arise at pivotal moments in life; own assessment of value; and sense of belonging shifts.* Our team used these deductive codes to work through the transcripts individually, then we came together to explain our reasoning and establish a group understanding and consensus regarding our codes. As we read transcripts, inductive codes emerged from the interview transcripts. The most salient inductive codes were related to engineering identity and mentors fostering belonging. We met regularly as a research team to discuss and negotiate both the deductive and inductive codes to ensure consistency in code application among the members of the research team.

Figure 1 illustrates our iterative data analysis process.
A simplified sample of our working codebook is displayed in Table 3.

Table 3. Simplified Working Codebook

<table>
<thead>
<tr>
<th>Code Name</th>
<th>Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deductive Codes (Drawn from tenets of Strayhorn’s Theory of Sense of Belonging).</td>
<td>Inherent Need for Inclusion: People must establish a sense of belonging to gain new insights and learn in an educational environment.</td>
</tr>
<tr>
<td></td>
<td>Desire to Belong Dictates Actions: People search for places of inclusion and take specific steps to find/create these places.</td>
</tr>
<tr>
<td></td>
<td>Belonging Brings Benefits: When people experience belonging in educational contexts, they benefit in various ways (e.g., successful course completion, contentment, and meaningful involvement in college activities).</td>
</tr>
<tr>
<td>Need of Belonging</td>
<td>If people experiencing major life changes are unable</td>
</tr>
<tr>
<td>Inductive Codes</td>
<td>Arises at Pivotal Moments in Life</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Own Assessment of Value Compared to Others</td>
<td>If people perceive others value their presence and contributions, they feel like they belong.</td>
</tr>
<tr>
<td>Sense of Belonging Shifts</td>
<td>Sense of belonging can alter for people depending on interactions with those around them or situations they experience.</td>
</tr>
<tr>
<td>Social Identities Converge with Sense of Belonging</td>
<td>Marginalized social identities frequently influence and coincide with people’s sense of belonging</td>
</tr>
<tr>
<td>ECE Field is Chilly</td>
<td>Perception that students who struggle to understand course content, do not belong in the ECE field; idea that students must accept criticism and withstand hardship to be successful in the field.</td>
</tr>
<tr>
<td>Engineering Identity Brings Belonging</td>
<td>Characteristics, traits, and qualities related to people’s value and worth as engineers increased their reported feelings of belonging.</td>
</tr>
<tr>
<td>Lack of University Support</td>
<td>Students are unable to find support at program, departmental, or university level.</td>
</tr>
<tr>
<td>Mentoring Fosters Belonging</td>
<td>Having scientists, faculty members, teachers, and/or peers as mentors fosters belonging among students.</td>
</tr>
</tbody>
</table>

**Researchers’ Positionality**

We are five researchers at two public, four-year universities. One researcher identifies as a White, cisgender woman who is an administrative and professional faculty member affiliated with an engineering education department with a background in higher education and student affairs. She has used Strayhorn’s [2] sense of belonging framework in prior research and it has informed her own teaching praxis with the aim of creating affirming and inclusive classroom environments for all students, including students of color. One researcher identifies as a White, cisgender woman, and is a professor in engineering education as well as a center director. Her varied projects focus on increasing diversity and inclusion in settings that include STEM students and professionals. She has a background in social sciences and humanities. One researcher identifies as a White, cisgender man who is a first-year doctoral student in engineering education. He is a first-generation college student who was able to find a community and hopes to foster a sense of belonging for others through this research. One researcher identifies as a White, cisgender, multiply disabled woman completing her doctoral degree in
higher education. Her research focuses on social inclusion of disabled college students, a topic informed by Strayhorn’s [2] Sense of Belonging Theory. One researcher identifies as a Bi-racial cisgender woman with a disciplinary background in science and technology studies whose research focus on invisibility and identity within engineering education.

**Preliminary Findings**

While our analysis is still ongoing, several themes emerged in response to our research questions. When considering the first research question, *What evidence do we find of a sense of belonging and its tenets?*, we found evidence of all tenets of sense of belonging within the ECE departmental podcast interviews. Evidence of a sense of belonging was especially prevalent to four tenets of belonging: Own assessment of value, desire to belong dictates actions, belonging brings benefits, and importance of belonging at pivotal moments. Additionally, the COVID-19 pandemic exacerbated the need for belonging as demonstrated by two tenets of belonging: the importance of belonging at pivotal moments and a shift in sense of belonging.

When considering the second research question, *What is the relationship between sense of belonging and social identities?*, the most prevalent tenet was social identities intersection with belonging. Therefore, we identified three themes: finding belonging through shared social identities; mentoring fosters belonging among those with marginalized identities; and faculty impact belonging.

**Theme One: Evidence of Belonging**

We found evidence of the following tenets of belonging within every podcast episode: *own assessment of value, desire to belong dictates actions, belonging brings benefits, and inherent need for inclusion.*

Evidence of students’ *own assessment of value* appeared in students’ confidence in their abilities and their recognition that other students had the same doubts they did. Imposter syndrome was frequently mentioned, especially among the women featured in the podcasts, as illustrated by “Mikayla”:

> And just knowing that you are good enough and you are smart enough to become an engineer will get you through college and the engineering program itself. Having those doubts of imposter syndrome and all that, just know that everyone goes through it.

“Bob” described how feeling included dictated his actions. He formed a friend group that “kept each other motivated, and called each other out when we weren’t doing what we were supposed to be doing.”

“Bob’s” group of friends supported each other throughout college and pushed one another to put in the work needed to do well in their course work. This accountability gave “Bob” and his friends the support they needed from peers to persist in the ECE program.

Belonging brought its own benefits to interviewees, many of which are related to academic success, in addition to social benefits of developing friend groups. Academic benefits frequently mentioned included finding a community of peers that could relate over common academic and career interests, peers with whom to work on homework and study, and accountability to persist.
provided by mentoring and peer connections. The benefits of belonging appeared to be especially salient to women and racially minoritized people.

“David” described how his desire for inclusion resulted in service to others. Prior to coming to college, he spent time fixing others’ computers, so when he made the connection that he could actually make a career out of this service, he

   Spoke to the advisor [and] said, ‘Hey, I really enjoyed working with computers growing up, in high school. I'd always worked on people's computers. I would fix them for them. And I didn't realize that what the opportunities really were in terms of engineering and working with computers.'

When he understood that he could channel that immediate satisfaction of solving another person’s difficulties with their computers, he declared his major in ECE. His motivation to help others and the resulting feelings of inclusion and purpose fueled his drive to become an engineer.

**Theme Two: The Need for Belonging During Transition**

We found evidence of two tenets of belonging (need for belonging arises at pivotal moments and shifts in sense of belonging shifts) related to important transitional times such as the first year of college (for both traditional first year students and transfer students). The first year (and first week of college) were key transitional moments that highlighted students' need to belong. Students highlighted the importance of finding community in the first year of college. “Bob” explained:

   Had a bunch of guys that we all started together, and to this day we're best friends… We talk almost every other day, but since the beginning of college we've formed this bond that have kept us strong… I would encourage anybody going through any kind of degree program, your first year, find some buddies… moving from college to even career, those friends still are important… the handful of friends I have met freshman year in college is probably the longest standing relationships I've had in my entire lifetime.

The friends “Bob” made during his first year at college have been with him since then and these bonds have brought benefits throughout college and his career.

First year transition programs (for incoming first year and transfer students) were a key source of support. Starting college as a non-traditional student was much easier for “John” due to support from a summer program offered at the institution: “It wasn't a hard transition for me. I got really lucky. [University] has a Summer program for non-traditional students”.

This allowed “John” to integrate with his peers better and have an easier time during his first-year. “Sam” also emphasized the importance of school programs for first-year students:

   That's where I've met a lot of the other first grade engineering male students… There's some other really close friends of mine that I met through this program… if you'd come in as a freshman straight into the program, you have to first be concerned about where do I fit in into this piece first.
Like “Sam”, “Barbara” emphasized how important it is to reach students early, especially in the first week: “the first week is the hardest because, you have to find a spot to sit and you have to figure out where maybe the right crowd is for you or somebody that you can talk to.”

Belonging was crucial to the transition to college for both first-year and transfer students. Students reported various strategies for belonging, including finding programs to help their transition and making connections easier, as well as finding existing communities and making friends among their peers.

**Theme Three: Employee Need for Belonging Exacerbated by the COVID-19 Pandemic**

Departmental employees experienced a difficult transition due to the COVID-19 pandemic. They discussed the difficulty of adjusting to social distancing, realizing how important that social interaction is for their jobs. They also expressed worries for their students, and highlighted some positives that came from adapting. In this context, faculty, staff, and administrators affirmed the importance of belonging by discussing how their interactions with other faculty and students predicated a shift in sense of belonging through the impacts of the COVID-19 pandemic.

“Allie” discussed the change in her mannerisms and the impact this had on her and those close to her:

> For me, it really has changed a lot. I'm a social person, also very close to my family. So for me, the fact of kind of that those types of interactions have changed. The lack of hugging... Sounds crazy. But the lack of that human touch kind of thing, just going for longer periods of time without seeing other people, without seeing friends and family, without seeing coworkers. We are a pretty tight knit team. And so for not being able to see my coworkers and talk with them on a daily basis, it's been rough. It's certainly been challenging on many levels. So I know that a lot of people have struggled from mental health issues, I'm with them on that. So certainly, I think there have been lots of changes. I'm not saying they're all bad, but definitely getting adjusted to a new way of life… Yeah, I think it hit me when we left campus to come home and telework, the plan was, ‘Oh, you'll be gone for a couple weeks and then we'll be back.’ So I think when we got into that third, fourth, fifth week of being here and being at home and teleworking, I think that's when it really hit me a lot.

“Allie” also expressed her concern for the students who are also trying to navigate the pandemic:

> Just trying to navigate that in a world where they are also kind of isolated, some of them have not seen their families since last summer. And they weren't able to go home this summer because of not being able to do flights and things like that. Some of them, also I think a big concern, some of them did go home and they can't get back. So they're trying to navigate taking online classes in a different timezone, with less access to equipment, and the people … Some of the students don't do well on online courses, they need the structure of a class and having to get up and go to class.

These concerns were commonplace across the other employees interviewed. For example, “Katie” mentioned the downside of:
Missing that non-verbal communication, which sometimes is really important if a student is struggling for us to know how to direct them. If you can't see their eyes, sometimes, you just can't see what you need to be able to find them the help they need.

However, “Katie” also noted some positive changes in operations as a result of the COVID-19 pandemic: “I sometimes think I meet more often with students now. Because they don't have to drive to campus, they don't have to find a place to park, they don't have to squeeze us in between classes.”

In this way, “Katie” explained how the new virtual mode of meeting with students has prompted more students to communicate, but there are still some issues of being able to connect with and foster belonging within these students.

To address the second research question (sense of belonging and social identities), our findings are presented through two overarching themes: 1) Finding belonging through shared social identities; and 2) mentoring fosters belonging among those with marginalized identities.

**Theme Four: Finding Belonging Through Shared Social Identities**

We found participants with marginalized and underrepresented social identities had a crucial need to belong, as emphasized in Strayhorn’s [2] tenets of belonging. Participants from all the marginalized social identity podcast episodes (i.e., diversity and inclusion; non-traditional students; women; and first-generation students) described the value of building relationships with those whom they shared similar experiences and backgrounds. “Mary” explained the importance of having another female in her first ECE course:

> Luckily, I had one friend girl coming to the class, so I wasn't necessarily alone, but I was wondering, if I didn't have my friend Claire with me, I don't know if I would even want to continue with ECE because how do you make friends with people who look so different from you? And of course, it's not that I can't make friends with boys…they don't understand half the things that you go through as a woman. And that's the thing, of course, you can still be friends with the opposite gender, but they lack that fundamental understanding of what it's like to be a woman. And you need that female friendship.

Participants who shared marginalized social identities described similar experiences of belonging within the ECE department. Out of the three participants from the non-traditional student podcast episodes, only one interviewee, “Jess”, reported finding inclusion among other transfer students because they had similar experiences “within our little transfer community that I've come across and really have had the pleasure of joining and getting other people to be a part of, we definitely see ourselves as unique because transfer students just see a whole different array of problems when they get here.”

The alumni from the diversity and inclusion episode described how finding a community helped with withstand the chilly engineering environment. Some exposed this unwelcoming environment by stating: “when they tell the first year that ‘Hey, a percentage of you guys will not go through this program,’ it's a real percentage.” These alumni reported building friendships after joining university-sponsored engineering programs. “David” described surviving his first year in the program after his teaching assistant helped him find community among others with common social identities:
I just remembered actually having a TA who was Black. She was a graduate student…and she saw me, saw I was Black engineering student, and she said, ‘Hey, have you heard of NSBE?’… she told me about NSBE… so I was able to actually attend a NSBE meeting, and I got to learn and meet more people. And then once again, just gravitating towards certain people over others. I think that was how I got through my first year.

The undergraduate first-generation students reported feeling unsure of their belonging because of their lack of knowledge about college. “Nate” reported finding support with another first-generation student as well with “a friend that...he's majoring computer science, but neither of his parents did computer science…we both share kind of similar things, like we're doing something that we have no idea that neither our parents are dealing with it, you know?”

Participants from the women in engineering episode reported intentionally building relationships with other women as a foundation for surviving in a field dominated by men. “Rachel” described needing to prove herself to men in the department: “it's a lot of pressure just to make sure you know what you're doing…so then you don't have that conflict where somebody's like, ‘She's a female, she doesn't know what she's talking about.’”

Like participants from the diversity and inclusion podcast, women described how their friendships with other women fostered their belonging. “Barbara” explained:

I was really lucky in the fact that I found out about this female engineering housing program…it was nice that after being in these classes, by yourself, you could come back and hang out with a group of girls that were like you, or at least similar in habits and personalities and stuff to you. So that was a very good support system to have.

These data points in which underrepresented and marginalized participants found belonging among others with social identities similar to their own affirmed Strayhorn’s [2] tenet of social identities influence one’s sense of belonging.

**Theme Five: Mentoring Fosters Belonging Among Those with Marginalized Identities**

Participants with marginalized backgrounds described the positive impact that both formal and informal mentoring relationships with peers, parents, former teachers, university administrators, and ECE professionals had on their sense of belonging. These relationships served as supports for navigating new and challenging environments.

“Jess”, a transfer student from the non-traditional podcast episode, reported experiencing a sense of belonging by serving as a peer mentor for other transfer students: “Honestly, being a transfer student and helping other transfer [students] was something that was close to my heart. I just really wanted to do it and wanted to help out other students.” “John”, an older student, described how his friend who already completed the ECE program affirmed his belonging in the field:

I just decided to go back from my Master's degree. I've been thinking about it for many years and a friend of mine, he's pretty close to me. He was like, ‘Hey, I think you've been thinking about this. I just graduated from it. I think you'd love it. It'd be a really big career boost for you.’
The first-generation students said previous teachers affirmed their belonging in the ECE field by describing experiences in the field of engineering and encouraging students to consider joining the field. “Mikayla” stated:

I was in AP calculus. And my AP calculus teacher saw that I was doing really well in that class and he pulls me to the side and he just says, ‘Mikayla, what do you want to do?’ And at that time I was a junior and I still didn't know what I wanted to do. And I was like, ‘I have no idea.’ And since my AP calc teacher was a mechanical engineer before teaching, he pushed me to look at…engineering itself because he thought I had what it takes to be an engineer. And so just having his little push was extremely helpful and I will always thank him for that.

Women reported mentorship from their parents, grandparents, and ECE professionals developed their feelings of inclusion and importance as students majoring in ECE. “Tina” described the positive experience of gathering with other women at an engineering conference ECE students could attend to connect with mentors:

There is this very big conference for women, which is known as like Grace Hopper Conference. It's like the world’s largest gathering of women in tech…so there's this mentoring group out there, which like, people can approach those mentoring groups. So I would definitely want all the students to take full advantage of the mentoring session.

Alumni from the diversity and inclusion episode described how their formal mentoring relationships with administrators gave them the support needed to continue in the program when it became difficult. This support cultivated their belonging within the ECE department because they had an older adult supporting them when needed. “Bob” explained how seeing professors and faculty is key to making students feel included:

...where you need diversity with the people, and in order to get the people you need diversity. But I think it might start specifically with the professors… I think that to build a better diversity/inclusion atmosphere, specifically starts with teachers, support staff, professors that look more like the students you're trying to recruit.

Students went where they felt belonging, so having peers and professors who outwardly appeared similar to them sparked their feelings of belonging and drew them into spaces with others who shared their common experiences and identities.

In summary, we found evidence of all of the tenets of sense of belonging in the ECE podcast interview transcripts. Belonging was especially salient for racially minoritized students, women students, first generation students, and transfer students, all of whom are historically and consistently underrepresented in ECE and other STEM fields. The importance of belonging was also highlighted for students and employees alike due to the COVID-19 pandemic.

**Discussion and Implications**

Faculty, advisors, and other leaders in ECE undergraduate settings can use the findings from this study to foster a sense of inclusion among students in their programs. From these findings, we see that a sense of belonging is greatly impacted by how an individual interacts with their environment. Based on these insights we offer the following recommendations:
Participants who reported a higher sense of belonging accredited it to actively looking for people and joining places with which they have a connection. Faculty and staff can intentionally foster a sense of belonging to push these proactive responses from students. By designing courses, program activities, and student organizations with an understanding that all students have an inherent need to belong [3], faculty members and administrators can create programs where students feel like they fit in [10]. Just like the students who found belonging by studying together, faculty members can use belonging to motivate students to study and participate during class activities [10].

Faculty members and administrators can intentionally communicate that students are valuable to the field of ECE [11]. By fostering students’ engineering identity, faculty members and program leaders can help all students develop a common social identity [10], [11]. Faculty and staff can intentionally communicate to students that they are valuable to the field of ECE by implementing mentoring and transition programs for underrepresented students, fostering a common engineering identity among students by creating engineering design groups, and encouraging desired engineering characteristics among students.

Additionally, while efforts to promote inclusion and belonging matter, so does the compositional diversity of a department’s faculty and student populations. Seeing people with shared social identities is especially important for underrepresented students and students from historically marginalized backgrounds. Hiring managers can strive to hire more faculty members from underrepresented backgrounds so students interact with leaders with common backgrounds [12]. This should include efforts to understand the impacts of new modes of interaction resulting from the constraints imposed by the recent COVID-19 pandemic and still instituted in various forms.

**Limitations**

Our sample size of 20 participants for these interviews may not fully represent students, alumni, faculty, and administrators within the ECE department and their perceptions of sense of belonging. Another limitation stems from recruitment of study participants. All participants came from one southeastern U.S. public doctoral research university. While participants come from different backgrounds, the study of using only one institution will lack breadth for our study, but gives more depth for this ECE program. As we used an existing data set, interview questions were different for each episode and thus comparisons across groups cannot be made. As data was collected for podcast interviews, a demographic questionnaire was not part of the original protocol.

**Conclusion**

We focused on college students because their entrance into college placed them in a pivotal situation for establishing a sense of belonging. Students who enroll in programs that prioritize fostering inclusion will experience the benefits that come with a high sense of belonging [2], including positive identity formation and increased retention and persistence [10], [11]. When considering podcast participants’ stories, we focused on how their reported actions and perceptions were related to their desire to form a sense of worth and fit in their college environments. We also paid attention to participants’ reported understanding of their value to those around them. We examined podcast participants’ social identities including their racial and ethnic identities, gender, age, and parents’ educational attainment and how their salient identities
influenced their need to belong. We found evidence that like other undergraduate students, ECE students possess an innate need to belong and experience academic and social benefits from belonging. We also discovered belonging shifted over time depending on the context. As students connected with others with shared social identities, especially marginalized and underrepresented identities, they experienced belonging. Finally, participants provided evidence that various types of mentoring experiences (e.g., formal, informal, peer mentoring, etc.) fostered belonging.

Acknowledgement

This work was supported by the National Science Foundation under Grant EEC-1623067. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
References


## Appendix A. Podcast Questions

<table>
<thead>
<tr>
<th>Episode</th>
<th>Episode Questions</th>
</tr>
</thead>
</table>
| Invisible Voices in Covid-19    | 1. Hi, could you please introduce yourself to our listeners?  
2. To begin our conversation, could you please tell me your general thoughts about COVID-19?  
3. Can you tell me how COVID-19 affected you?  
4. How did it feel to have COVID-19?  
5. What would you want others to know from your experience?  
6. What do you miss from the pre-COVID-19 world?  
7. What is something good that has come out of COVID-19?  
8. As a graduate student, what would you want other students to know?  
9. What is your advice to students during this challenging time?  
10. Last thoughts?                                                                  |
| Seeing the Non-Traditional Student | 1. What did you do before coming to the ECE program?  
2. Can you describe what influenced you to study engineering?  
3. Why did you decide to make a career change?  
4. How does your previous experience contribute to being a current ECE student?  
5. Do you feel different from the other students?  
6. What would you want current students to know?  
7. What would you have done differently?  
8. What would you tell anybody listening that may be considering a career change into Engineering?  
9. Last comments?                                                                  |
| "I'm in ECE for Me"--Being a Woman in ECE | 1. Please introduce yourself.  
2. Why did you choose ECE?  
3. Why did you choose [university]?  
4. Please tell me about your experience of being a student at [university].  
5. This podcast focuses on women in engineering (specifically electrical and computer engineering), could you describe your experience of being a female student in the department? For example your experience in classes, design teams, labs, etc. Do you feel different? Left out? Included?  
6. Things to consider: Sense of belonging? Community?  
7. Are there resources for female students (student organizations, etc) and are they helpful?  
8. What advice would you give to female engineering students?  
9. What advice would you give to female high school students that are considering a career in engineering? |
## Extending Grace and Opportunity: The Experiences of Inclusion and Diversity

1. Please tell me a little bit about yourself.  
   a. Your name?  
   b. Your hometown?  
   c. What do you currently do?  
2. Why did you choose to become an engineer?  
3. Why did you choose [university]?  
4. What does inclusion and diversity mean to you?  
5. Do you believe there are issues with inclusion and diversity within engineering? At [university]? In ECE?  
6. Can you please discuss your experience of being an African American Engineering student in the ECE department? At [university]?  
7. What do you think PWIs (like [university]) do not understand about being a person of color?  
8. What do PWIs get right?  
9. Do you think you had a different experience from other students?  
10. Why do you believe diversity is necessary in the field of engineering?  
11. How would you increase diversity in the field of engineering?  
12. Is there anything you would like to discuss that I did not mention?

## Taking Time to Talk About Teaching in ECE

1. Who was your favorite teacher and why?  
2. Could you please describe your career path/journey into higher education, especially as it relates to teaching?  
3. What are the skills or characteristics of a great teacher? Why do you think that is?  
4. What is your pedagogy around teaching or what strategies have you used in your teaching methodology and why?  
5. Has your teaching evolved or changed over the years?  
6. How has your teaching changed due to COVID-19?  
7. What has been your most challenging course to teach and why?  
8. What has been your favorite class to teach and why?  
9. What advice have you received about teaching that has been effective?  
10. What teaching advice did you wish you hadn’t applied?  
11. Have you ever sat in on a class taught by a peer? If yes, what did you learn from that situation?  
12. What advice would you give to a student for making the most of your class?  
13. What advice would you give to new faculty?  
14. What is the best advice a professor ever gave you when you were in college and/or graduate school?
| Pioneer, Problem-Solver, and Purposeful--The First-Generation Student Experience | 1. So, can you just introduce yourself a little bit? Just let me know your name, year, major, and where you're from.
2. So, you're a first generation student, right? So, neither of your parents went to college?
3. So, what does being a first generation student mean to you?
4. What led ultimately to your decision to pursue a college education?
5. So, did you have anybody in particular that was influential in your academic career?
6. Have you ever felt, since coming to college, awkward or out of place maybe as a result of your first generation status?
7. Have you been able to find any sort of support system within the ECE department or in the college for first generation students?
8. Do you feel like you've been able to find anyone who's able to understand the challenges you've been facing as a first generation?
9. Have you been able to find any other first generation students?
10. So, how do you think your challenges are unique as an ECE student, compared to other first generation students?
11. Do you find it harder to connect with family and friends back home who haven't gone to college?
12. So, what do you think could be changed in the ECE department to better support first generation students like yourself?
13. What else has surprised you since coming to college?
14. Have you ever felt at a disadvantage to your peers that are not first generation students?
15. Do you think your perception of college has changed since coming to college? |