

# LGBTQ+ in ECE: Culture and (Non)Visibility

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**Abstract—Contribution:** This article confirms the continued marginalization of undergraduate LGBTQ+ electrical and computer engineering (ECE) students and describes how they navigate their (non)visibility in engineering. Best practices to increase diversity and inclusion are discussed.

**Background:** LGBTQ+ ECE undergraduate students experience a chilly, sometimes hostile climate in engineering. As a result, they experience lower sense of belonging, worse academic outcomes, and greater mental and emotional stress in their daily lives.

**Research Questions:** How are LGBTQ+ ECE undergraduate students' perceptions of ECE culture, sense of belonging, perceptions of discrimination, and (non)visibility affected by their identities? How do they navigate their (non)visibility in engineering contexts?

**How do LGBTQ+ ECE undergraduate students perceive and navigate engineering culture and their (non)visibility in engineering spaces, potentially integrating LGBTQ+, race, ethnicity, gender, and other identities into their perceptions?**

**Methodology:** A mixed-methods study with a survey and focus groups was conducted at a large southern public university in the United States. Survey participants included 854 undergraduate ECE students, of which 9% were strongly LGBTQ+. Focus group participants included 9 self-selected LGBTQ+ ECE students from the survey sample.

**Findings:** LGBTQ+ ECE undergraduate students face non-inclusive environments, marginalizing experiences, and cis-heteronormativity in engineering as a result of their multiple marginalized identities that intersect with their LGBTQ+ identity.

**Index Terms**—Discrimination, electrical engineering, inclusivity, LGBTQ+, sexual orientation, student diversity, undergraduate, underrepresented students.

## I. INTRODUCTION

DIVERSITY and inclusion are becoming widely recognized as a valuable and necessary part of the engineering workforce [1]. However, one particular group of students that continues to be understudied in engineering diversity/inclusion discourses is lesbian, gay, bisexual, transgender, queer, and other gender/sexuality nonconforming (LGBTQ+) engineering students. LGBTQ+ engineering students consistently report feeling more anxious and stressed, which impact their desire to engage with the engineering profession and

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their academic performance [2]–[4]. In addition, policies and programs intended to serve LGBTQ+ students may still be exclusive to certain populations [5], [6]. LGBTQ+ students continue to face an uphill battle in engineering spaces.

This study contributes to the burgeoning literature on diversity/inclusion by investigating how undergraduate LGBTQ+ electrical and computer engineering (ECE) students experience engineering culture. Through a mixed-methods study, the authors find that LGBTQ+ ECE students are enmeshed in a cis-heteronormative, competitive culture, and they must use various techniques to navigate their (non)visibility from space to space to feel safe. These findings corroborate and extend previous literature on LGBTQ+ engineering students to the ECE field and showcase the continued need for the ECE education institution to support these students.

## II. RELEVANT LITERATURE

Previous work on LGBTQ+ engineering students have utilized terms from LGBTQ+ studies and sociology to analyze LGBTQ+ ECE students' experiences. *Heteronormativity* is defined as the prevailing cultural assumptions that normalize heterosexuality. *Cis-heteronormativity* is an extension of heteronormativity to include the male/female gender binary, highlighting the marginalizing experiences of trans\* and gender-nonconforming people. Cis-heteronormativity also encapsulates the various assumptions of sex, gender, and sexuality that people may make about others, such as using binary gender pronouns (e.g., "him/her" versus "them") and assuming the gender of significant others. Cech and Waidzunas [2] found that heteronormativity contributed to a significant amount of stress and feelings of marginalization for LGB engineering students, which reflected negatively on students' academic and emotional well-being. More recently, Linley *et al.* [7] explored how LGBTQ STEM majors' interactions with (LGBTQ and non-LGBTQ) peers and faculty influenced their experiences in STEM spaces, finding that LGBTQ students felt the most comfortable in interactions with other LGBTQ peers.

LGBTQ+ engineering students may also perceive a culture of silence around LGBTQ+ issues in engineering. In [3], gay men often conducted environmental surveillance to determine who was safe to come out to as a response to their observations of heteronormativity. A *culture of silence* is defined as a climate in which students' LGBTQ+ and other marginalized identities are omitted from discussions of diversity and inclusion. This is potentially exacerbated in engineering because of cultural beliefs that depoliticize engineering work and separate the technical work of engineering from social issues [8]. In addition, *environmental surveillance* is defined as the ways in which LGBTQ+ people constantly assess their

environment for potential stigmas associated with being visible. Environmental surveillance informs LGBTQ+ people of whether it is safe for them to exist in a particular environment and impacts their sense of belonging, particularly in engineering. Cech and Rothwell [4] found that the pressures of heteronormativity and the culture of silence had significant adverse effects on the academic, social, emotional, and mental well-being on LGBTQ+ engineering students. In addition, LGBTQ+ engineering students were more likely to experience marginalization, less comfortable with working with others, and less likely to report that their engineering work is respected.

At the intersection of their LGBTQ+ and engineering identities, LGBTQ+ engineering students face unique experiences of marginalization with respect to their visibility. As [9] discussed, visibility is informed by internal decision-making processes that take into account environmental surveillance and other factors. While many LGBTQ+ activists see visibility as a key goal for diversity and inclusion, LGBTQ+ people may choose to be nonvisible for a variety of personal and/or political reasons, such as concern for their safety, fear of retribution in careers, or simply because they choose to be nonvisible, as the queer women of color did in [10]. LGBTQ+ youth are also known to regulate their (non)visibility in subtle, nonverbal ways, including selective disclosure to specific people [11]. Work done by [12] and [13] illuminate that LGB people utilize visibility management to cope with minority stressors and mental health issues. Strategic disclosure processes often existed in tension with other demands placed on students. In [14], some demands included the desire to build queer community, affirm their identities to others through symbols and maintain positive social relationships. In addition, online spaces present locales for additional visibility management as well as identity exploration for queer students [15]. While this article does not explore online spaces, online interactions present another locale for LGBTQ+ students to navigate identity and (non)visibility issues in both personal and professional contexts. As a result, the term *(non)visibility* is used in this article to highlight the active, ongoing negotiations of visibility that LGBTQ+ students encounter in their daily lives.

### III. METHODS

A mixed-methods study was conducted to explore the experiences of LGBTQ+ undergraduate engineering students. A mixed methods design was chosen because both quantitative and qualitative methods yield important data that can inform understandings gleaned from each other. Qualitative data can contextualize and situate inferences from quantitative trends, and quantitative data can capture large-scale processes to help generalize the unique, individual experiences that qualitative data elicits [16]. By using both qualitative and quantitative methods, a mixed-methods study offers rich potential for exploring complex processes, such as marginalization and inequality [16], [17].

The study was divided into a survey and focus groups. Preliminary results from the survey informed the focus group questions, and the survey invited LGBTQ+ engineering

students to participate in the focus groups through a separate form. It was not possible to tie survey responses to focus group participants. After the survey concluded, one-hour semi-structured focus groups were conducted with LGBTQ+ engineering student volunteers from the survey.

#### A. Study Site

The study site was a large public university in the southern United States. At the institutional level, there are various resources for students of underrepresented backgrounds including a gender and sexuality center, a multicultural center, and various student organizations. Within the engineering school, student organizations surrounding marginalized racial and gender identities also exist. At the time the study was conducted, there were no LGBTQ+-specific student organizations or resources available in the science or engineering schools.

#### B. Phase 1: Survey Methods

An online survey was administered to 854 undergraduate ECE students recruited through a department listserv, roughly 58% of the undergraduate ECE population. The survey used a novel gender identity and sexual orientation inventory to determine a participant's gender identity and sexual orientation. Each item provided a list of terms and asked students to rank on a 5-point Likert scale how they would describe their gender identity and sexual orientation for each term, with 1 = "does not describe at all" and 5 = "describes extremely well." Nine common gender identity terms (e.g., man, woman, transman, transwoman, gender nonbinary) and twelve common sexual orientation terms (e.g., straight, gay, lesbian, bisexual, queer) were provided, and respondents were allowed to enter their own identities on the survey. During the analysis phase, survey responses were parsed into three groups based on the responses to the LGBTQ+-identifying items. Responses with a 5 on any terms that were not "male," "female," or "straight" were classified as "strongly LGBTQ+." Responses without a 5 on any term but without a 1 to all the LGBTQ+ terms were classified as "moderately LGBTQ+." The remaining responses comprised those who did not find any LGBTQ+ term to describe them at all, or non-LGBTQ+-identifying responses. This novel approach to identifying LGBTQ+ individuals recognizes that gender and sexuality both lie on separate spectrums and captures nuances in gender identity and sexual orientation [18], [19].

From the Gender Identity and Sexual Orientation inventory, 79 (9.25%) of survey respondents identified as strongly LGBTQ+, 82 (9.60%) identified as moderately LGBTQ+, and 693 (81.15%) identified as non-LGBTQ+. Other demographic questions revealed that among LGBTQ+ respondents, about 57% of LGBTQ+ respondents (moderate + strong) were assigned male at birth, and 43% were assigned female at birth. This distribution was significantly different from the sample population, where there was a 4:1 ratio between male and females. On race/ethnicity, 44 (26.7%) LGBTQ+ respondents were exclusively white, 18 (11.2%) were East Asian, 15 (9.3%) were South Asian, and 11 (6.8%) were multiracial. Other races/ethnicities represented less than 5% of the LGBTQ+ respondents.

A sense of belonging scale from [20] and a discrimination prevalence item were selected for analysis. The 5-item sense of belonging scale used a 4-point Likert scale with 1 = “strongly disagree” and 4 = “strongly agree.” The mean of the responses to the five items was calculated for each respondent. If a respondent did not answer all items, the mean of the items that the respondent did respond to was calculated. The discrimination item comprised of two multiselect items asking respondents to select any forms of discrimination that they had observed and their sources. Respondents were presented with 17 forms and 7 sources of discrimination. Both items contained an exclusive “I have not experienced discrimination” item and a fill-in-the-blank “other” item. The data was cleaned and analyzed using R version 3.6.2 in RStudio.

### C. Phase 2: Focus Group Methods

Nine LGBTQ+ ECE students who took the Phase 1 survey also voluntarily participated in focus groups. Of the nine participants, two were first-year students, three were second-years, one was a third-year, and three were fourth-years. Five identified as white, two as Asian, one as Hispanic, and one as Asian-Hispanic. Four participants were men, three were women, one was transgender, and two were nonbinary. Three participants identified as gay, one as bisexual, one as lesbian, one as straight, one as asexual, and two as pansexual.

Four hour-long semi-structured focus groups were conducted, one with three people and the other three with two people. Participants were divided into the focus groups based on their availability during the week. While some of the participants in the focus group knew each other, this was not accounted for in the group allotment. Participants were not notified of the other members of their group prior to the focus groups. At the beginning of each focus group, the facilitator [JY] read a prewritten statement that asked participants to consider their multiple identities, such as race, gender, etc. throughout the focus group. The focus groups were audio-recorded and transcribed for analysis.

Focus group items were drawn from preliminary survey data on items related to sense of belonging and discrimination based on LGBTQ+ and other (race, gender, etc.) identities. Questions sought to elicit students’ overall perceptions of their experiences in the ECE department, how their LGBTQ+ and other identities impacted their work and participation in engineering activities, and how different spaces could impact their experiences. In addition, the facilitator asked participants to highlight instances of discrimination or harassment they had witnessed or experienced and how the department could better serve their needs in the future.

The facilitator coded the focus group transcripts using a two-step iterative process [21], [22]. Initial codes were generated from each focus group using both inductive and deductive methods. Out of 31 codes, 26 codes such as “just comes up” were taken from the transcripts [23], while the remaining codes such as “compartmentalization” drew from research literature [2]. Once the codes for each transcript were consolidated, the transcripts were open-coded, and the coder wrote an analytical memo based on initial perceptions of the coding process [22]. Next, categories were formed to generate new

codes for axial coding. After axial coding, the categories were consolidated into themes and cross-checked with the survey data. To ensure validity, the facilitator and a second researcher [MS] discussed the codes after each iteration of coding and writing memos, and the manuscript was sent to the participants for review.

## IV. RESULTS

From the survey, LGBTQ+ ECE students reported lower sense of belonging compared to non-LGBTQ+ students and observed different forms of discrimination than their non-LGBTQ+ counterparts. From the focus groups, LGBTQ+ ECE students described a competitive, cis-heteronormative, and marginalizing culture, especially for students with multiple marginalized identities. As they moved between various spaces in ECE, they often made careful decisions about their (non)visibility based on environmental surveillance, particularly in professional spaces. (Non)visibility practices also differed by race and gender identities.

### A. Survey Results

1) *Sense of Belonging*: A one-way ANOVA test using the afex R package was conducted to determine whether there were any significant differences in mean sense of belonging based on the strength of LGBTQ+ identification. Based on the study design and group sizes, the responses were assumed to be independent, and the data was assumed to satisfy the normality condition. A Bartlett test for equal variances found no significant difference in variances among the three groups ( $K^2 = 1.89, p = 0.39$ ). The ANOVA yielded a statistically significant difference in mean sense of belonging ( $F(2, 803) = 8.16, p < 0.001$ ). A post-hoc Tukey honestly significant differences test using the emmeans package revealed that while there was no statistically significant difference between the moderately LGBTQ+ ( $M = 3.79, SD = 0.66$ ) and strongly LGBTQ+ group ( $M = 3.79, SD = 0.76$ ), there was a statistically significant difference between the two LGBTQ+ groups and the non-LGBTQ+ group ( $M = 4.04, SD = 0.72$ ) ( $p = 0.007$  for both groups).

2) *Discrimination*: Table I shows the frequency of responses for the top three forms and sources of discrimination based on LGBTQ+ status. By far, the most prevalent form of discrimination experienced by students from all three groups was jokes, and the most prevalent source of discrimination was students. About half of moderately LGBTQ+ students and a third of strongly LGBTQ+ students indicated that they did not experience or witness any form of discrimination in the engineering department. Of the discrimination items, strongly LGBTQ+ participants selected “pressure to keep silent” second-most frequently.

### B. Perceptions of ECE Culture

A competitive culture and unwelcoming faculty created non-LGBTQ+-specific negative academic experiences for students. Derogatory comments, misgendering, and a culture of silence were LGBTQ+-specific forms of marginalization where cis-heteronormativity emerged from the ECE culture.

TABLE I  
TOP FORMS AND SOURCES OF DISCRIMINATION OBSERVED BY ECE STUDENTS

	Non-LGBTQ+	Moderate LGBTQ+	Strongly LGBTQ+
Total Respondents	365	34	52
<i>Forms of Discrimination</i>			
1. Jokes	92	14	27
2. Pressure to keep silent	28	3	16
3. Employment/career problems	33	2	5
4. Refusal of friends/colleagues to associate with you	15	3	5
<i>Sources of Discrimination</i>			
1. Students	72	13	26
2. Faculty	20	3	8
3. Companies associated with [department]	9	1	3

While competition is often part of engineering, a competitive culture could cause detrimental effects on LGBTQ+ ECE students. Elliot and Charlie described experiences that highlighted negative aspects of the competitive culture in ECE. Elliot stated, “Some of the people within ECE are more competitive than I am, and that is not really how I operate.” Charlie narrated how the competitive culture led him to feel that he could not compete in the ECE program, leading to imposter syndrome. He stated, “A lot of students would ask challenging questions that they thought would show the professor their intelligence, especially in the first few semesters where everybody’s trying to prove themselves.” Because of his perception of competitive culture, Charlie felt the need to constantly prove himself in the ECE environment. Being enmeshed in this culture led him to “feel like an idiot compared to everybody else” and “not smart enough” despite graduating with a job offer. Elliot and Charlie’s perceptions of a competitive culture reduced their sense of belonging in engineering, highlighting a challenge they faced in trying to adapt to the engineering environment.

Four of the participants described encounters with unwelcoming faculty. Peyton expressed that her engineering experience was “negative [partly because] I had a lot of faculty that were not very nice, and it was a lot of awful weed-out courses.” Charlie relayed a time when a friend was struggling in a class and went to the professor for help. According to Charlie, the professor responded, “Maybe you should not be taking this class right now or maybe this course is too hard for you, you should drop it and take it another semester. If you do take this class, you should do 50 problems every day.” Elliot mentioned that faculty could have a “hard time speaking to people who do not have the same level of understanding of the concepts” and “made me feel dumb for asking the question.” Cameron encountered faculty who often misgendered them or used noninclusive pronouns (e.g., “him/her[”] versus “them”). Unwelcoming faculty sometimes emphasized or enhanced the lack of belonging that some students experienced, particularly if they did not see the student as technically competent.

Focus group participants mentioned only a handful of professors with whom they had positive experiences. These three professors were known by most of the participants for their support. Five participants mentioned one professor who was active in building diversity and inclusion programming in the department as someone who “tr[ied] to foster a lot of community” (Peyton) and “brings you into ECE with the expectation

that ECE is difficult, but... not because of who you are.” Charlie mentioned another professor who “did not feel the need to be hyper-competitive and... took the time to answer questions in a polite and caring way.” Chandler mentioned that her research advisor was accepting of her transition and new pronouns. Aside from these professors, the participants did not mention other professors that they had positive experiences with.

As LGBTQ+ ECE students, participants also experienced various forms of cis-heteronormativity. A general culture of silence around LGBTQ+ issues pervaded the department, which Taylor described as a “sense of vilification” of bringing the topic up. Alexis and Peyton mentioned how some people, particularly “conservative girls,” would “turn away” from them when they came out to their peers, and Taylor and Drew mentioned how their LGBTQ+ identities often were “on the backburner” instead of a direct part of their daily engineering lives. Riley expounded on the culture of silence with his senior design team experience:

*I've learned a lot about [the culture of silence] with my senior design team because they've been my friends for all three years here. Last semester, I mentioned, “Oh, my boyfriend's going in for surgery,” and they were all super supportive. They're like, “Oh, that's great. You should be with him.” They never said anything strange. But at the same time, they'll still all talk about their girlfriends and girl stuff and they never like turn to me and talk about the same kind of personal details. (Riley)*

Riley highlighted how even though his senior design team was supportive of him and his relationship with his significant other, he observed elements of cis-heteronormativity in their conversations that made him feel less included in his group. Riley’s teammates’ lack of engagement with him on personal details compared to other (straight) teammates showcased how the culture of silence could reduce one’s sense of belonging in interactional settings.

With respect to faculty, Cameron expressed how they perceived little likelihood of faculty addressing diversity/inclusion topics in the classroom, stating “They’re not going to stop in the middle of talking about embedded systems and be like *So* (emphasis original).” Cameron and Peyton also contrasted the culture of silence around LGBTQ+ issues in ECE with their experiences in liberal arts classes, where they felt

more welcome to share their identities as part of their coursework, whereas “engineering’s not about you” (Cameron) and “[Engineers] don’t care really what you do or what your identities are because your work is a product of your skillset, and not really your identity” (Peyton). These perceptions of engineering and engineering culture highlight how silence around LGBTQ+ identities permeated through the ECE environment.

Five participants reported experiencing or witnessing derogatory comments that made them feel uncomfortable. Chandler witnessed several students in her classes “talk about everything negative about ‘artsy people,’” implicitly linking LGBTQ+ identities with the “artsy” descriptive. Cameron, who identified as a nonbinary person, noted several instances in which faculty misgendered them with incorrect pronouns. At a large career fair sponsored by the engineering school, Cameron was talking to a recruiter who claimed, “Females are having to fend for themselves and actually get jobs.” Cameron’s response was, “I lose hope. They do not even want to accept straight white rich women.” Derogatory comments were the primary form of outright LGBTQ+ discrimination that participants discussed.

While many of the participants described negative experiences, six of the nine participants described that their overall experience in ECE was positive due to the technical knowledge and opportunities they were able to gain from being an ECE student. At the beginning of his focus group, Elliot stated, “The people that I’ve met in ECE and the classes that I’ve taken have been worthwhile” to his education. Drew also highlighted that while he had some negative personal experiences in ECE, he was able to gain the technical knowledge he needed to be successful in his career. Riley commented that overall, he “didn’t experience any blatant adversity” in achieving his career goals. Experiences with faculty mitigated some of the negative experiences that participants had, as described above, and Chandler highlighted their experiences with faculty as the primary reason her experience was overall positive. This finding provides a counterpoint to many of the negative experiences that LGBTQ+ ECE students reported.

### C. Navigating (Non)Visibility in ECE

(Non)visibility was a complex and nuanced issue that varied from space to space, context to context, and person to person. Sometimes, (non)visibility “just came up” in conversation. Other times, social group interactions and professional spaces heightened (non)visibility concerns. Students with multiple marginalized identities navigated their (non)visibilities differently from others without those identities.

Some focus group participants’ experiences with (non)visibility were simply instances in conversation where it “just came up.” Taylor, Alexis, and Drew described scenarios in which friends, recruiters, or faculty would try to make small talk by asking about their personal lives. When such situations arose, they had to make split-second decisions based on their environment to determine whether to be visible or not. For example, Alexis sometimes corrected people who called her significant other a “boyfriend.” Taylor had an “internal battle” between lying about his and/or his partner’s

identity. Drew would change the topic. The suddenness of the situation forced participants into situations where they had to choose whether to identify or not based on the conversation.

Professional spaces exacerbated challenges of (non)visibility. Taylor related one instance in which he was confronted with a decision about putting a volunteer experience with an LGBTQ+ organization on his resume. Cameron had to decide whether to put their legal name and pronouns on their resume to avoid being misgendered, at the cost of being rejected for being nonbinary. At school-sponsored career fairs, Cameron and Drew were wary of “old white guys” and people from “different [cultural] backgrounds” whom they perceived could be less inclusive based on dominant stereotypes. This environmental surveillance caused them to avoid certain companies. Fears of professional consequences for being visible were exacerbated by the knowledge of the lack of anti-discrimination laws for LGBTQ+ employees. Cameron stated, “[Employers] do not even have to pretend it is something because people still do that for racism. If I do something that makes you not like me, then that job is just gone.” LGBTQ+ ECE students often weighed the cost of being visible in the profession with the benefits of being authentic.

For LGBTQ+ ECE students with multiple marginalized identities, navigating (non)visibility was complicated with other identities, such as race and gender. In nonprofessional spaces, Peyton mentioned that she often found friends through her significant other. She also used environmental surveillance and “general alliances” to determine who could potentially be welcoming of her identities. For example, someone saying something “pro-Trump” was a “strict divisive line” for her. In professional spaces, Peyton stated,

*I worry that if I’m too vocal about being a woman or if I’m too vocal about Latina or if I’m too vocal about any of my other queer identities, then people will question, “Well, did you get that or is it just representation?” And if you’re too open about it, people won’t believe you earned your right to be here, but if you’re not open about it, that’s doing a disservice to yourself and to other people who could view you as a role model. (Peyton)*

Peyton’s internal conflicts and environmental surveillance highlight how LGBTQ+ ECE students with multiple marginalized identities face unique dilemmas in navigating ECE and the professional world. While Peyton was the only participant who discussed issues with multiple marginalized identities in great depth, she was the only queer woman of color participant in the focus groups, and the authors include her narrative here to ensure that her unique perspective on her experiences was represented in the findings.

## V. DISCUSSION

From the survey results and focus group findings, LGBTQ+ ECE students perceived a variety of cultural forces that negatively impact their experiences in ECE. These forces also impacted how they moved through ECE from space to space and person to person, using environmental surveillance and protective heuristics to ensure their safety.

LGBTQ+ ECE students perceived a competitive culture in which they felt the need to “prove themselves as intelligent human beings.” This toxic competition culture may exacerbate stress in students who perceive that they cannot compete, as it “creates... undemocratic power dynamics for learning by creating identities of ‘losers’ and incompetent engineers” [24, p. 206]. Perceiving other students’ competitive natures and his (in)ability to compete with others, Charlie gained an imposter syndrome that led him to believe that he could not be successful in engineering.

The influence of faculty on students’ experience was somewhat mixed. Certain faculty were known by students to be supportive and inclusive, whereas other faculty whom students encountered were discouraging, had unrealistically high expectations, and/or appeared aloof to diversity/inclusion issues in the classroom. Students’ mixed experiences with faculty has also been shown in the literature. While faculty could serve as role models and positive influences for underrepresented students [25], [26], they were often “lone wolves” in a large department [27]. Unwelcoming faculty could “have a ... paralyzing impact on students’ academic and subsequent career goals” [27, p. 200]. Negative experiences with faculty could have a significant impact on students, decreasing their overall sense of belonging.

Focus group participants’ experiences also highlighted a persistent cis-heternormative culture that marginalized their identities and closely paralleled the results from the discrimination items on the survey. Jokes, derogatory comments, and a culture of silence were evident in focus group participants’ experiences in ECE and was the number one form of discrimination reported by all three groups of ECE students in the survey. Jokes and derogatory comments continue to be reported by underrepresented students in STEM [2], [28]. While derogatory humor sometimes functions as a social glue [29], it alienates students who feel uncomfortable with such forms of humor and propagate a noninclusive culture.

An interesting point that Peyton and Cameron raised was the contrast between their experiences in ECE and their experiences in non-ECE classes. While this contrast was not explored as deeply in the focus groups, it corroborates findings from [7], which also noted that non-STEM spaces were perceived as more welcoming and “safe” than STEM spaces to be visible. Linley *et al.* [7] attributed this contrast to different disciplinary cultures, and in particular, Cech [8] and Faulkner [30] described a techno-social divide in engineering in which personal issues are relegated to the back burner that may not exist in nonengineering disciplines. However, more work is needed to understand the role of disciplinary cultures in LGBTQ+ students’ experiences.

The culture of silence linked the “pressure to keep silent” item from the survey discrimination items to the focus group participants’ experiences. Taylor’s description of “vilification” and Riley’s senior design team experience exemplified how cis-heternormative ideals were entrenched into ECE culture. Silence around their identities felt stifling compared to the more open experiences that Peyton, Cameron, and others had in liberal arts classes. These results parallel [2] and [3] and

indicate the persistence of cis-heternormative assumptions in ECE that may cause discrimination against LGBTQ+ students.

(Non)visibility was a significant challenge that LGBTQ+ ECE students had to navigate as part of ECE culture. The fact that LGBTQ+ identities sometimes “just comes up” in conversation placed some participants in uncomfortable situations in which they needed to make split-second decisions about whether to be visible. Some students, like Drew and Taylor, perceived the “just comes up” phenomenon as rife with the potential for conflict and exclusion, but others, like Alexis, leveraged it as a way to remain comfortably nonvisible and only navigate their (non)visibility when it came up. The situations in which participants’ LGBTQ+ identities “just come up” represented an experience not reported before that reinforced the out-of-placeness of being LGBTQ+ in ECE.

Aside from conversation, (non)visibility was most closely tied to environmental surveillance and protective heuristics. The authors coin the term *protective heuristics* to represent the assumptions that LGBTQ+ students made about others to determine whether the other person would be supportive of their LGBTQ+ identity (e.g., “old white guy”). Participants used environmental surveillance and protective heuristics to vet the people they talked to and ensure that they would not face retribution for being visible in certain spaces. In professional spaces, protective heuristics became important at face-to-face events, such as career fairs, in which LGBTQ+ students perceived a greater risk of losing job opportunities because of their identities. These conclusions extend [3]’s findings that environmental surveillance played a significant role in LGBTQ+ ECE students’ choices to be (non)visible in certain spaces.

While the authors were unable to fully explore intersectional experiences in the study due to the limited sample, they were able to capture Peyton’s narrative of navigating (non)visibility from an intersectional perspective. For LGBTQ+ ECE students with multiple marginalized identities, (non)visibility may be complicated by the challenges they face with respect to their other identities. Peyton’s narrative exemplified these challenges, as she worried about how her visibility and advocacy could raise questions about her legitimacy in engineering. These fears underscored her use of protective heuristics to navigate the ECE department, as she wanted to be valued for both her identities and her technical abilities. While there was only one instance of multiple marginalized identities impacting a participant’s LGBTQ+ identity, Peyton’s perspective is corroborated by the previous literature reporting similar experiences of students with multiple marginalized identities [14], [15], [31], [32]. Future research should explore these experiences more comprehensively to unpack how multiple marginalized identities may factor into students’ perceptions of engineering culture as well as LGBTQ+ identities.

It is important to highlight that despite highlighting many negative experiences, a majority of focus group participants in this study mentioned that their experiences in ECE “overall” were positive, since they were able to achieve their technical and career goals. This phenomenon was also observed in [31], where some queer STEM professionals also reported

an overall non-negative perception of their profession but mentioned many negative experiences. This discrepancy may serve as an interesting potential negative case analysis to the negative personal and often interactional experiences presented above [33]. Whereas studies on LGBTQ+ and queer identity may focus on the personal and interpersonal experiences that participants have with others and the institution, they may also minimize how much weight participants give to developing their professional and technical abilities in the field versus feeling like they belong and can thrive. In the case of Elliot, his perception of the competitiveness of ECE did not seem to bear heavily on his perception of his overall experience in the department. Further research should explore this boundary in greater detail.

There are several limitations of this study that provide a generative space for future work. While this study only focuses on one ECE program at one university, future work could include expanding the population to other campuses and exploring other engineering fields to increase its generalizability. Furthermore, the focus group volunteers likely only capture the perspectives of strongly LGBTQ+ students, who may have different experiences from moderately LGBTQ+ students. In the survey, more work needs to be done to understand whether using scale-type items to identify participants' LGBTQ+ status is useful for research or practice. Also, other sense of belonging scales targeted toward college students may be useful in capturing LGBTQ+ college student sense of belonging. These epistemological questions need to be explored further. Other directions for similar studies may also explore how online personal and professional spaces (e.g., social media) impact LGBTQ+ students' identities and (non)visibility in physical engineering spaces [15], as well as dive deeper into the interactional forms of discrimination that LGBTQ+ students face (such as derogatory comments) through discourse analysis.

## VI. RECOMMENDATIONS

Engineering institutions may pioneer programs and events specifically tailored to diversity and inclusion. Previous events at the study site included school-sponsored mental health panels, self-care events, panels for LGBTQ+, and other minorities that brought in LGBTQ+ engineering faculty, and first-year experiences tailored to students' identities. These efforts were welcomed by the focus group participants and can be used to raise awareness of continued discrimination.

In addition, engineering departments should provide more opportunities for faculty, staff, and administrators to interact with students beyond a formal environment. Faculty engagement was a crucial aspect of LGBTQ+ ECE students' positive experiences, as supportive and nonsupportive could make significant differences on LGBTQ+ ECE students. Research has also shown that more frequent and more positive personal interactions with faculty increased student self-efficacy and academic confidence [26], [34]. Regular meetings, coffee chats, and the like may allow students to identify with faculty as role models, therefore increasing their sense of belonging.

Developing communities of practice for students, faculty, staff, and administrators to engage in dialogue about

diversity/inclusion would also aid in driving institutional policy. A *community of practice* is a group of people who share information and learn from each other to achieve a particular practice, in this case, promoting diversity and inclusion in engineering [35]. An example is the American Society for Engineering Education (ASEE) LGBTQ+ Advocacy in STEM virtual community of practice [36]. The virtual community of practice intendeds to "support individual members to take action to advance LGBTQ equality in their departments" through digital means [36, p. 2]. An in-person community of practice may meet regularly to exchange insights and share experiences related to students' underrepresented backgrounds in a safe space. Such interactions may be sites for generative and reflective conversations surrounding departmental and institutional efforts toward diversity and inclusion.

Finally, students, faculty, staff, and administrators should be encouraged to participate in diversity and inclusion training programs to familiarize themselves with the language, best practices, and support techniques for allyship. For example, the ASEE Safe Zone Ally Training Workshops [36] offer not only various levels of diversity and inclusion training open to all stakeholders in engineering education but also organizational and professional certification for training completion. Many U.S. college campuses offer such training as well, and individuals may enroll in these programs on their own.

## VII. CONCLUSION

This study extended the previous knowledge on the challenges that LGBTQ+ ECE students face in engineering spaces. LGBTQ+ ECE students are faced with a complex landscape of cultural forces, cis-heteronormativity, and (non)visibility issues that they must navigate as they progress through the engineering program. They reported discriminatory jokes and derogatory comments and likely lowered their sense of belonging. In addition, a competitive culture and unwelcoming faculty exacerbated lower sense of belonging. (Non)visibility issues forced students to confront questions about their identities through normal conversation, environmental surveillance, and protective heuristics to ensure their and their careers' safety. These experiences demonstrate the significant need for faculty, staff, and administrators to implement policies and programs that serve LGBTQ+ engineering students. As the engineering field becomes more diverse, the onus is on faculty, staff, and administrators to work with students to craft truly inclusive spaces where everyone can feel welcomed, valued, and validated for their authentic selves and contributions to the field.

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