

BELONGING AMONG QUEER & TRANS UNDERGRADUATE ENGINEERS: AN
EXAMINATION OF DEPARTMENTAL SENSE OF BELONGING, PLANNED
INVOLVEMENT, CAMPUS CLIMATE, ENGINEERING CLIMATE, AND STEM
IDENTITY

by

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(Under the Direction of Katie Koo)

ABSTRACT

By 2031, Science, Technology, Engineering, and Mathematic (STEM) fields are projected to grow by almost 11% (Krutsch & Roderick, 2022). To meet this demand the enrollment and retention in STEM degree programs must be increased, particularly among student populations that are underrepresented in these fields. Despite growing identification with lesbian, gay, bisexual, transgender, queer, questioning, intersexual, asexual, and/or aromantic (QT) identities these students are still underrepresented in STEM disciplines (Hughes, 2017) and their experiences are largely missing from research on STEM environments (Cech & Waidzun, 2011; Hughes, 2018; Strayhorn, 2019). Existing literature highlights the barriers that underrepresented students experience in STEM environments (Baumeister & Leary, 2005; Linley et al., 2018; Rainey et al., 2018).

The purpose of this quantitative study is to examine the relationship between collegiate experiences of perceptions of departmental sense of belonging, planned involvement, STEM

identity, and perceived campus and engineering climates among undergraduate QT engineering majors. The data for this study was collected via an online survey. Participant perceptions of departmental sense of belonging, involvement, climate, and STEM identity were measured through previously created instruments, the Departmental Sense of Belonging & Involvement Scale (Knekta et al., 2020), the LGBTQ College Campus Climate Scale (Syzmanski & Bissonette, 2020), a modified LGBTQ College Campus Climate Scale to assess engineering climate, and the STEM Professional Identity Overlap (McDonald et al., 2019). Demographic information was also collected. Significant predictors of departmental sense of belonging were found to be engineering climate, involvement, and STEM identity. Additionally, significant between-group differences were found in the perceptions of departmental sense of belonging and engineering climate and rates of involvement reported in this study. This study contributes to the growing body of research on the experiences of QT undergraduate engineers and highlights the saliency of QT identity to the experiences of undergraduate students who navigate engineering environments.

INDEX WORDS: campus climate, engineering, engineering climate, involvement, LGBTQIA, QT, queer, sense of belonging, science identity, STEM identity, STEM, trans, transgender

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December 2024

DEDICATION

I dedicate this dissertation to the QT students and QT communities who have made me, and this study, what it is today.

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CHAPTER 1

INTRODUCTION

Background

As of 2021, nationally there are over 10 million workers in science, technology, engineering, and math (STEM) occupations (Krutsch & Roderick, 2022). The Bureau of Labor Statistics defines STEM occupations as (a) computer and mathematical, (b) architectural, (c) engineering, (d) life and physical science, (e) managerial and postsecondary teaching occupations, and (f) sales occupations that require scientific or technical knowledge at a postsecondary level (Krutsch & Roderick, 2022). By 2031, the STEM field is projected to grow by almost 11% which is more than twice the growth of other industries (Krutsch & Roderick, 2022). To meet this demand, enrollment and retention in STEM degree programs must be increased. The need for increased enrollment and retention is impacted by the current state of STEM environments, both academic and professional, which have been found to be challenging to individuals who are underrepresented in these fields. Specifically, research has shown that women and people of color (Carlone & Johnson, 2007; Dortch & Patel, 2017; Rainey et al., 2018; Seymour & Hewitt, 1997; Strayhorn, 2019; Walton & Cohen, 2007) are negatively impacted by the climate and culture of STEM environments and experience lessened sense of belonging when compared to their white, men peers.

Lesbian, gay, bisexual, transgender, queer, questioning, intersex, asexual, and/or aromantic identities are also underrepresented in these disciplines (Hughes, 2017) and are similarly impacted by the current state of STEM environments. Specifically, Bilimoria and

Stewart (2009) found that the emotional toll of being an LGBTQ engineer, whether out or closeted, is so great that it threatens to drive LGBTQ engineers out of the field. Research with individuals who are lesbian, gay, bisexual, transgender, queer, questioning, intersex, asexual, and/or aromantic and their experiences are largely missing from research on STEM workers and educational programs (Cech & Waidzunas, 2011; Hughes, 2018; Strayhorn, 2019). Research on women often fails to address gender marginalization beyond a gender binary and typically excludes transgender and nonbinary experiences through the comparisons of females to their male peers (Carlone & Johnson, 2007; Chen et al., 2020; Hazri et al., 2013; Lucas & Spina, 2022; Puente et al., 2021; Robinson et al., 2018; Victorino et al., 2022).

In this study, QT utilized the umbrella terms of queer and trans to refer, in short, to a large population of students with diverse genders and sexualities. Although queer can refer to both gender and sexual orientations, trans was included in the study's initialism to highlight inclusion of transgender, nonbinary, genderqueer, and other gender expansive participants. Additionally, the use of QT can "acknowledge and represent the fluidity of sexual and gender identities so that individuals across the spectra of QT identities can see themselves reflected" (Shaheen et al., 2023, p. 20) in the work. QT student experience in STEM environments is a critical area of research because of the significant barriers that limit their success in these majors. Additionally, given that in 2022 there was an almost 20% LGBT identification among adults aged 18-25 (Jones, 2023), QT individuals are becoming more represented on college campuses and in STEM majors. While limited, STEM research on QT student experience highlights similar challenges to those identified in research on women and people of color (Cech et al., 2017; Cech & Waidzunas, 2011; Hughes, 2018; Strayhorn, 2019).

Feeling a sense of belonging is one of those challenges. Specifically, sense of belonging has been found to be lessened for those who are underrepresented in STEM fields (Baumeister & Leary, 2005; Linley et al., 2018; Rainey et al., 2018; Strayhorn, 2012; Strayhorn, 2019; Walton & Cohen, 2007). Higher education research has found that a lower sense of belonging among QT individuals is associated with being closeted (Strayhorn, 2019), hearing offensive jokes and comments (Strayhorn, 2019), and holding negative perceptions of campus climate (Parker, 2021; Strayhorn, 2019). Sense of belonging among QT students is enhanced by affirming peer networks (Strayhorn, 2019; Vaccaro & Newman, 2017), positive perceptions of campus climate (Duran et al., 2022; Parker, 2021), and engagement in QT affirming spaces (Duran et al., 2022; Strayhorn, 2019). Increased sense of belonging leads to academic success and retention (Duran et al., 2022; Stout & Wright, 2016; Strayhorn, 2019; Vaccaro & Newman, 2016) which has implications for the diversification of STEM industries and the retention of qualified QT scientists in STEM fields.

Students must persist and be retained through post-secondary STEM degree programs if they are to be employed in a STEM occupation. Interventions to support student retention in STEM programs are therefore necessary to diversify STEM fields (Bernard, 2021; Reggiani et al., 2023). To diversify STEM fields for QT individuals, a more nuanced understanding of the experiences of QT students in STEM environments is needed. Specifically, research that explores transgender and nonbinary populations (Casper et al., 2022), within-group differences among STEM students (BrckaLorenz et al., 2021; Duran et al., 2022), studies that explores STEM or science identity, and studies that look more deeply at the role of institutional type are needed (Hughes, 2018). The resulting literature will assist student affairs practitioners in their

work with STEM communities and STEM departments in identifying ways to build inclusive practices to increase the sense of belonging of QT students in STEM environments.

Problem Statement

Research on QT students, especially in STEM environments, highlights their negative perceptions of campus climate (Cech & Waidzunus, 2011; Miller & Downey, 2020; Strayhorn, 2019) and lessened sense of belonging (Rainey et al., 2018; Seymour & Hewitt, 1997; Strayhorn, 2019; Walton & Cohen, 2007). STEM identity, a key factor in STEM retention, is understudied within QT populations. In addition to being understudied with QT students in STEM environments, a lack of studies exist that examine the links between sense of belonging, involvement or planned involvement, campus climate, engineering climate, and STEM identity. When it comes to QT students, research highlights that QT students experience marginalization and oppression in STEM majors, especially engineering (Butterfield et al., 2018; Trenshaw et al., 2013). Research on QT students in engineering, and other STEM programs, highlights the barriers that these students experience in academic settings (Hughes, 2018; Miller et al., 2020; Miller & Downey, 2020; Strayhorn, 2019). A limitation of current research is that QT student experience has not been conducted with consideration of the effects of involvement, campus climate, engineering climate, and STEM identity on departmental sense of belonging. The purpose of this quantitative study is to examine the relationship between collegiate experiences of perceptions of departmental sense of belonging, planned involvement, STEM identity, and perceived campus and engineering climates among undergraduate QT engineering majors. While there are many definitions for sense of belonging, this study will utilize Vaccaro and Newman's (2016) definition where comfort, fitting in, safety, authenticity, and respect are terms used by

minoritized students to define sense of belonging through factors like the environment, social relationships, and involvement.

Engineering programs, rather than another STEM major, were selected because engineering climate has been found to be particularly challenging for QT individuals (Cech et al., 2016; Cech & Waidzunas, 2011; Hughes, 2017; Miller et al., 2021; Trenshaw et al., 2018; Yang et al., 2021) and serve as a proxy for overall STEM environment in this study. Additionally, studies have been conducted that link campus climate to a sense of belonging and science/STEM identity to a sense of belonging, but this study will uniquely look at how campus climate, engineering climate, planned involvement, and STEM identity predict a departmental sense of belonging among QT undergraduate engineering students. Engineering was selected because “among all STEM fields, women are least represented within engineering” (Hughes, 2017, p. 385) which is likely to contribute to a heteronormative, masculine climate that would be a barrier to QT student sense of belonging (Hughes, 2018). Furthermore, a normalized belief in engineering is that LGBT identities and experiences are irrelevant to the field and that the persistent invisibility of sexual minorities results from the climate of engineering (Hughes, 2017). This study’s focus on engineering participants provides key insight on how to better support QT scientists in their persistence in STEM disciplines.

Purpose of the Study

The purpose of this quantitative study is to examine the relationship between collegiate experiences of perceptions of departmental sense of belonging, planned involvement, STEM identity, and perceived campus and engineering climates among undergraduate QT engineering majors. Five research questions guide this study:

1. What are the characteristics of QT undergraduate engineering students and what are their experiences of departmental sense of belonging, planned involvement, campus climate, engineering climate, and STEM identity?
2. How are departmental sense of belonging, planned involvement, campus climate, engineering climate, and STEM identity correlated to one another among QT engineering students?
3. After controlling for students' demographic characteristics, what are predictors of departmental sense of belonging among QT engineering students?
4. Does STEM identity or planned involvement mediate the relationship between climate and departmental sense of belonging for QT undergraduate engineering students?
5. How are departmental sense of belonging, planned involvement, campus climate, engineering climate, and STEM identity experienced differently across students' identities.

Research Paradigm

The post-positivist paradigm typically holds a “determinist philosophy in which causes (probably) determine effects or outcomes” (Creswell, 2014, p. 7). In this study with undergraduate QT students in engineering programs; campus climate, engineering climate, involvement, and STEM identity were believed to have an effect and determine the outcomes of departmental sense of belonging. I anticipated that as students reported negative perceptions of campus and engineering climates that a direct, negative impact would result in their perceptions of departmental sense of belonging. I also anticipated that a strong sense of STEM identity and reports of higher anticipated involvement would have a positive impact on perceptions of

departmental sense of belonging and could even mediate the influence of negative perceptions of campus or engineering climates. According to Creswell and Poth (2016), a post-positivist paradigm, in comparison to positivism, recognizes that we cannot be positive about our claims of knowledge when studying the behavior and actions of humans and challenges the traditional notion of the absolute truth of knowledge found in a positivist worldview. While I believed that this study would shed light on the sense of belonging among undergraduate QT engineering students, it would not illuminate a “universal truth” or objective reality for QT undergraduate engineers that would be adopted with a positivist viewpoint.

Theoretical Framework

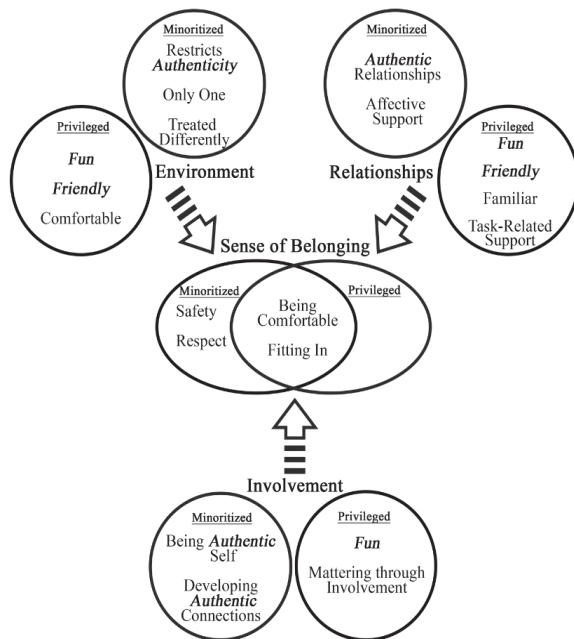
Sense of Belonging for Privileged and Minoritized Students

In this study, Vaccaro and Newmans’ (2016) Sense of Belonging for Privileged and Minoritized Students Model was applied to conceptualize the relationship among campus climate, engineering climate, STEM identity, planned involvement, and departmental sense of belonging among QT students. The model identified that for all students (both privileged and minoritized students), their environment, relationships, and involvement were key factors contributing to their sense of belonging (Parker, 2021; Vaccaro & Newman, 2016). In their reflections on the college environment, minoritized students “required an environment where students could be their authentic selves” (Vaccaro & Newman, 2016, p. 933) to feel belonging. Authenticity was also important to minoritized students in their relationships and involvement. Students identified that “relationships in which they could be their authentic selves” (Vaccaro & Newman, 2016, p. 934) enhanced feelings of belonging as well as “if they could be their authentic selves and develop authentic connections in clubs and student centers” (p. 935).

The model's specific focus on minority students' sense of belonging and the interconnectedness of relationships, involvement, and environment (Parker, 2021; Vaccaro & Newman, 2016) solidified this theory as the conceptual framework for this study over other theories on sense of belonging. A visualization of this model is presented in Figure 1.

Figure 1

Model of Belonging for Privileged and Minoritized Students



Note: Reprinted from “Development of a Sense of Belonging for Privileged and Minoritized Students: An Emergent Model,” by A. Vaccaro and B. M. Newman, 2016, *Journal of College Student Development*, 57(8), p. 936 (<https://doi.org/10.1353/csd.2016.0091>).

These factors aligned with the selected independent variables for this study with campus climate and engineering climate representing different environments that QT students navigate. STEM identity and planned involvement, two additional independent variables, are associated with relationships and involvement, respectively. Students with a strong sense of STEM identity see themselves as members of a community of scientists and are more involved members of their

scientific community (Carlone & Johnson, 2007). When applied to this study, the theory holds that I expected my independent variable(s) campus climate, engineering climate, planned involvement, and STEM identity to influence or explain the dependent variable departmental sense of belonging (Creswell & Creswell, 2017) because key predictors of sense of belonging like safety, respect, being comfortable are effective measures of campus climate and engineering climate. Additionally, fitting in and authentic relationships, two additional key predictors of sense of belonging, can be measured by proxy through the phenomenon of STEM identity and planned involvement. Science or STEM identity or the extent to which a participant sees themselves, and is seen by others, as a science person (Carlone & Johnson, 2007) is enhanced when students see themselves as a part of a scientific community. In other words, if QT engineering students experience campus and engineering climates that provide safety, respect, and allow for authenticity while developing a strong sense of STEM identity through the formation of authentic relationships and fitting in with a community through their involvement they will experience an enhanced departmental sense of belonging.

Key Definitions

This section provides definitions of key terms used in this study.

Campus Climate: Adopting Rankin's (2005) definition of campus climate and defines it as the "cumulative attitudes, behaviors, and standards of employees and students concerning access for, inclusion of, and level of respect for individual and group needs, abilities, and potential (p. 17). This study will address campus climate through student perception rather than direct experiences with bias or discrimination.

Engineering Climate: This term was utilized to refer to the specific climate of the engineering department as reported by QT undergraduate engineering majors who participated in this study.

Engineering Majors – For the purpose of this study, *engineering majors* is any student who is enrolled in a degree program that falls within the scope of a College/School of Engineering at any institution of higher education. Students may hold individual majors across any of the engineering disciplines including (a) aerospace, (b) biomedical, (c) chemical and biomolecular, (d) civil and environmental, (e) electrical and computer, (f) industrial and systems, and (g) materials science and mechanical.

QT- *Queer and Trans* (QT) was utilized in this study to refer to individuals who hold marginalized genders, sexual and/or romantic orientations. QT was selected because it “acknowledges and represents the fluidity of sexual and gender identities so that individuals across the spectra of QT identities can see themselves reflected” (Shaheen et al, 2023, p. 20). While trans individuals hold marginalized gender identities not all people of marginalized genders were included in this study. Specifically, cisgender heterosexual heteroromantic women who do not also identify as members of the QT community were excluded from participation. Utilization of other initialisms (LGBTQIA, LGBTQ, LGBQ, etc.) or terminology (queer-spectrum, lesbian, etc.) occurred when citing direct findings from past literature.

Departmental Sense of Belonging – Adopting Vaccaro and Newman’s (2016) definition for sense of belonging, it was defined by minoritized students as feeling comfortable, fitting in, being part of a community, feeling safe, and feeling respected in their environments, involvement, and relationships. It is measured in this study utilizing the Departmental Sense of Belonging Scale (Knekta et al., 2020).

STEM Identity – For the purpose of this study, science or STEM identity is the extent to which a participant sees themselves, and is seen by others, as a science person (Carlone & Johnson, 2007). It is assessed by the individual, and others, through factors of recognition, competence,

and scientific performance (Carlone & Johnson, 2007). McDonald et al. (2019) utilized the term “STEM identity” rather than “Science identity” in the creation of the Professional STEM Identity Overlap – 4 Scale, which was used in this study.

Planned Involvement –As defined by Vaccaro & Newman (2016) involvement is defined by minoritized individuals as *Being Authentic Self* and *Developing Authentic Connections*. It is measured in this study utilizing the Involvement subscale in the Departmental Sense of Belonging & Involvement Scale (Knekta et al., 2020) through responses related to planned outside the class engagement with department faculty, staff, and peers during this academic year.

STEM – STEM as a reference to Science, Technology, Engineering, and Mathematics was utilized when referencing the larger academic discipline for which engineering is a part of. Additionally, STEM was utilized in this study when referencing past literature that specifically looked at STEM environments, belonging, or climate.

Assumptions and Limitations of the Study

Although this study was novel in its examination of departmental sense of belonging for undergraduate QT engineering students through predictor factors like campus climate, engineering climate, planned involvement, and STEM identity, the study had several identified limitations. First, data was only collected for each participant at a single point in time which limited my ability to draw conclusions that are stronger in a longitudinal study. Additionally, this study examined the experiences and perceptions of current undergraduate students majoring in engineering and failed to consider the experiences of QT students who change majors because of negative perceptions of climate or academic isolation.

Another limitation in this study is the impact of precollege experiences, which have been found to strengthen science identity among STEM students (Carlone & Johnson, 2007). The

diversity among colleges attending, as reported by participants, suggests that precollege experiences with STEM are likely to be great. Over ninety campuses were contacted with recruitment information about this study, representing a wide variety of institutional types and engineering programs (See Appendix A). Additionally, although this study looked at student experience and perception of campus climate, engineering climate, planned involvement, and STEM identity, it failed to address structural processes that lead to the marginalization of QT students in engineering programs at these institutions.

Factors in the study related to QT identity and experience also exist as a limitation. This study did not look at the saliency of a queer or trans identity or QT identity disclosure. Outness refers to the extent to which students disclose their marginalized sexual and/or gender identities (Garvey et al., 2018). Despite research supporting an association between level of outness with perceptions of campus climate (Garvey & Rankin, 2015a; Garvey & Rankin, 2015b; Garvey et al., 2018) outness, along with QT identity concealment, while important avenues for future research on QT engineer experience, were outside the scope of this study.

Significance of the Study

This study adds to the field of growing higher education research on the experiences of QT students in STEM disciplines. Specifically, this study aimed to provide additional insight into the undergraduate experiences of QT engineering students and adds to the growing field of STEM research on this student population. Current research demonstrates the significant barriers that QT STEM students face.

This study has many implications and findings that will assist in identifying additional barriers and opportunities for QT students who wish to major in a STEM discipline. Findings have the capacity to inform student affairs practice across functional areas. For instance, Career

Services staff will be better informed to provide STEM-focused career readiness and preparation programming for QT students. Diversity affairs staff will gain insight into the campus climate experiences of QT students that impact sense of belonging in both institutional and departmental contexts. Finally, practice implications exist for individual faculty and academic units who wish to provide better support and resources for QT students in STEM disciplines. This study also had implications for higher education research. Findings highlighted key experiences that enhance departmental sense of belonging among QT scientists and assist in identifying future research topics for exploring the intersections of QT experiences in the STEM field.

The study's examination of departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity, despite its limitations, addressed a gap in STEM research on QT populations and explored sense of belonging in a unique way. Given that students' perceptions and unique experiences with campus climate and department climate can vary, the inclusion of both types of climates provide insight on how to best support STEM students and whether intervention strategies must occur at the departmental, institutional, or both levels. Additionally, it provided additional insight into the impact of STEM climate on QT sense of belonging, perception of campus climate, perception of engineering climate, planned involvement, and STEM identity.

Conclusion

Student enrollment and retention in STEM disciplines is important to meet worker demand and for the betterment of the field. Research has shown the ways in which STEM fields, especially engineering, reinforce hostile climates that prevent the full engagement of individuals who belong to groups historically underrepresented in these fields. These barriers create challenges to the academic success of women, students of color, and QT people. This study took

a novel approach to understanding how campus climate, department climate, planned involvement, and STEM identity impact departmental sense of belonging for QT undergraduate engineering students. Literature on belonging, science/STEM identity, department climate, and campus climate and their interconnectedness for STEM students informed this study.

CHAPTER 2

LITERATURE REVIEW

The following chapter outlines research that explored sense of belonging, campus climate, engineering climate and STEM identity. Specifically, a closer examination of sense of belonging among QT students, sense of belonging among STEM students, and sense of belonging among QT STEM students was provided. Additionally, a deeper understanding of campus climate for QT students and campus climate for STEM majors was offered. The chapter ended with an overview of STEM identity and associated literature.

Sense of Belonging

Sense of belonging is defined in higher education literature in a variety of ways. Strayhorn (2019) defined sense of belonging for college students as “a student’s perceived social support on campus, a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the campus community or others on campus such as faculty, staff, and peers” (p. 28). Hurtado and Carter (1997) described sense of belonging as a phenomenon that “captures the individual’s view of whether he or she feels included in the college community” (p. 327). It has also been defined by Hausmann et al. (2007) as “the psychological sense that one is a valued member of the college community” (p. 804). This study used a definition for belonging that was developed by privileged and minoritized participants in Vaccaro and Newman's (2016) study entitled *Development of a Sense of Belonging for Privileged and Minoritized Students: An Emergent Model*. In their study,

privileged students were those who held identities among socially dominant groups and did not hold at least one minoritized identity (Vaccaro & Newman, 2016).

In interviews with students, all students talked about their “perceptions of the college environment, social relationships, and campus involvement” (Vaccaro & Newman, 2016, p. 931) as factors that contributed to their sense of belonging. Across all participants, privileged or minoritized, belonging was defined as “feelings of comfort with others and in one’s surroundings” (p. 931) and “fitting in or feeling like they were part of the campus community” (p. 931). Additionally, safety and respect were identified by minoritized students as additional terms to describe sense of belonging (Vaccaro & Newman, 2016). A limitation of the Vaccaro and Newman (2016) study is a lack of attention to gender, especially given the importance of safety for minoritized student belonging and the violence that transgender students experience.

The literature that formed the basis of this study centers around sense of belonging research, QT perceptions or experiences with campus climate, QT perceptions and experiences with STEM climate, and STEM identity. Since research on QT experience with sense of belonging in higher education or sense of belonging in STEM disciplines is limited, we explored sense of belonging research in STEM environments for women and students of color. According to Strayhorn (2019), “there has been a fairly consistent line of research that points out how difficult it is for women and ethnic minorities to “see themselves” in STEM fields without role models who look like them” (p. 89), lack of role models is an experience shared by QT students. Finally, in addition to QT students being among the participants in studies on women and students of color, this body of literature provided insight into marginalized students’ experience in STEM or engineering fields and will inform our understanding of QT experience in STEM

programs. As we move into belonging research, we looked at sense of belonging research among all QT students in higher education contexts.

Sense of Belonging among QT Students

Research on sense of belonging for QT college students is a growing field and relatively new in higher education research. The first major study on sense of belonging with this population was conducted with gay college men (Strayhorn, 2012). Since then, additional studies have found that heterosexist climates of higher education have hindered the sense of belonging experienced by this community (Evans et al., 2017, Vaccaro & Newman, 2017). Additional barriers to QT sense of belonging include being closeted, offensive jokes and comments, and negative beliefs and perceptions held by others (Strayhorn, 2019). Strayhorn (2019) in his study on sense of belonging found that gay men of color experienced displacement from the community as they continued to hide their gay identity and experienced offensive jokes and comments. Their sense of belonging was hindered by the negative beliefs and perceptions that peers, faculty, and staff held for gays and lesbians which left participants in the study feeling unsafe and uncomfortable (Strayhorn, 2019). While peers, faculty, and staff can hinder a sense of belonging for QT students, they can also positively impact it.

In their literature review on LGBT and Queer research, Lange et al. (2019) found that studies on sense of belonging “underscore the importance of benefiting from peer networks that consist of people who affirm students’ queer identities (and other marginalized identities), having connections to student organizations, and building relationships with faculty and staff” (p. 517). Peer networks, especially LGBT groups, were found to enhance a sense of belonging among first-year students in a study conducted by Vaccaro and Newman (2017). Strayhorn’s (2012) study on belonging also emphasized the importance of spiritual and relational connections

with accepting others. Vaccaro and Newman (2017) in their grounded theory study with first-year students found that belonging for LGBQ students occurred at the university, group, and through authentic friendships. University belonging, in contrast to the studies previously mentioned, did not require “deep interpersonal connection or communication but encounters with respectful and cordial students and employees” (Vaccaro & Newman, 2017, p. 143).

Additional belonging research on QT populations highlights within-group experiences, for instance when compared to the average student, LGBQ+ Asian students reported a higher sense of belonging than LGBQ+ White students (BrckaLorenz et al., 2021). BrckaLorenz et al., (2021) also found that bisexual students, when compared to other sexual orientations reported a more than average sense of belonging. Duran et al. (2022) in their critical quantitative study with LGBQ+ students of color (SOC) found that gay SOC reported a more positive sense of belonging. Belonging among all LGBQ+ SOC was found to be enhanced by campus experiences like participating in seminars/lectures, playing an active role in the community, living on campus, and having positive perceptions of LGBQ+ campus climate (Duran et al., 2022). Positive racial climates were found to enhance LGBQ+ SOC sense of belonging but that impact was not as significant for bisexual SOC (Duran et al., 2022). Additional activities that have been found to enhance sense of belonging for gay men of color were (a) attending gay pride events, (b) prayer, (c) joining ethnic student organizations, and (d) finding fictive kin (Strayhorn, 2019). “Gay men of color who reported a higher sense of belonging were more likely to be high achievers, involved student leaders, and highly likely to “intend to stay” in college (Strayhorn, 2019, p. 70) further emphasizing the importance of sense of belonging for QT college students. A general sense of belonging is important, but a focus on sense of belonging among STEM

students and within STEM disciplines was an essential area of research for this study and helped to fill the gaps in sense of belonging research for QT populations.

Sense of Belonging Among STEM Students

Baumeister and Leary (2005) found that sense of belonging is closely tied to social group membership or social identity and Strayhorn's (2019) work in STEM environments supports this notion and takes it a step further in finding that "social identities intersect and affect student's experiences and their subsequent belongingness evaluation in STEM" (p. 93). Due to the importance of social identity and underrepresentation, STEM sense of belonging research has primarily focused on the experiences of women and students of color. These populations have been found to have a lessened sense of belonging in STEM environments (Rainey et al., 2018; Seymour & Hewitt, 1997; Strayhorn, 2019; Walton & Cohen, 2007). Elements that have been found to negatively impact underrepresented student belonging in STEM fields are the absence of peers and role models (Lewis et al., 2017, Strayhorn, 2019), individual experiences or interactions (Dortch & Patel, 2017; Strayhorn, 2012), microaggressions (Dortch & Patel, 2017), and greater campus climate or institutional culture (Dortch & Patel, 2017). Dortch and Patel (2017) in their study with Black undergraduate women found that microaggressions felt in STEM environments had a direct impact on participant sense of belonging.

Underrepresented students have been found to derive a sense of belonging in STEM environments from co-curricular/extracurricular involvement (Litzler & Samuelson, 2013), peer support (Litzler & Samuelson, 2013; Rainey et al., 2018), faculty and department support (Litzler & Samuelson, 2013), and residence programs (Litzler & Samuelson, 2013). Litzler & Samuelson (2013) through their qualitative study using semi-structured interviews with African American, Latino, and American Indian students in undergraduate engineering programs at 11

US universities found that participants identified supportive community in curricular and co-curricular activities and peers as key to their experiences of belonging. Within this study, faculty interactions were found to be essential to a student's identification and affiliation with their department (Litzler & Samuelson, 2013). Rainey et al. (2018) identified three additional factors as essential to a sense of belonging for STEM or previous STEM majors. These factors include perceived competence, personal interest, and the development of a science identity (Rainey et al., 2018).

Sense of belonging within STEM environments is an important field of research as past research has shown that sense of belonging has been associated with academic engagement (Wilson et al., 2015), motivation, success, and persistence (Lewis et al., 2017; Rainey et al., 2018; Strayhorn, 2019; Tate & Linn, 2005; Wilson et al., 2005). Lewis et al. (2017) found that among women in undergraduate physics majors and graduate women in computing programs participants reported a lower sense of belonging and that sense of belonging was more strongly linked to intentions to persist. In a quantitative study with 1,507 undergraduate students, Wilson et al. (2015) found that "it is important to attend to belonging issues and classroom experiences when striving to engage and retain students in STEM fields" (p. 766). Sense of belonging was also identified as a vital component element to STEM leavers. Strayhorn (2019) found that STEM leavers shared the importance of sense of belonging when discussing reasons for changing majors, changing institutions, or leaving higher education altogether.

The body of literature on underrepresented students in STEM is growing; however, there are limitations. Research on women and students of color in these academic disciplines is often conducted from a singular identity lens with few studies looking at the intersection of these identities (Dortch & Patel, 2017; Ong, 2005; Rainey et al., 2018). Binary assumptions of gender

are prevalent in the STEM field. For instance, the field of engineering is dominated by cisgender men with subfields gaining the distinction of “gender diverse” when 20% of enrolled students are women (Casad et al., 2018). Initiatives to diversify STEM fields, along gender lines, and the research driving these initiatives often follow binary assumptions. Additionally, most studies, on these student populations, fail to consider sexual orientation among in-group differences despite the underrepresentation that sexual minorities experience in STEM environments. As “there is a general tendency for feelings of belonging to follow patterns of representation” (Rainey et al., 2018, p. 7), studies on QT sense of belonging, like this one, are essential given QT underrepresentation and invisibility in STEM environments. This study, like the literature below, expands understanding of QT experience in STEM environments and their associated belonging in these spaces.

QT Sense of Belonging in STEM Environments

“I want to know [engineers are] ok with it because even though it doesn’t define me, it’s part of who I am” (Trenshaw et al., 2013, p. 2). As previously determined in research on women and students of color in STEM, “*who you are* determines, in part, *what it* takes to feel and find a sense of belonging” (Strayhorn, 2019, p. 99). Despite knowing this, research on STEM success for minoritized populations rarely includes QT individuals (Vaccaro et al., 2015) or the intersection of QT identities. Since “factors that create a chilly climate for women in STEM also affect sexual minority students because of the relationship between gender stereotypes and sexual orientation (Hughes, 2018, pp. 21-22), it is essential that more is known about the experiences of these students. Research has shown that they are less likely to be retained than their heterosexual peers (Hughes, 2018) and experience a lower sense of belonging (Linley et al., 2018). Furthermore, Bilimoria and Stewart (2009) found that the emotional toll of being an

LGBTQ engineer, whether out or closeted, is so great that it threatens to drive LGBTQ engineers out of the field.

Specifically, the climate of engineering has been found to be particularly challenging for QT individuals (Cech et al., 2016; Cech & Waidzunus, 2011; Hughes, 2017; Miller et al., 2021; Trenshaw et al., 2018; Yang et al., 2021). Engineering climate has been labeled heteronormative, masculine-focused, and toxically competitive (Cech et al., 2016; Cech & Waidzunus, 2011). In addition to STEM climate, QT student sense of belonging has also been found to be negatively impacted by sex (Hughes, 2018) and sexual minority status (Cech & Waidzunus, 2009; Hughes, 2017; Hughes, 2018). Hughes (2018) in their national, longitudinal study with 4,162 STEM aspiring college students across 78 institutions found that sexual minority students were 8% less likely to be retained than their heterosexual peers. Additionally, Cech and Waidzunus (2009) in their qualitative study to understand how students made sense of the intersections between their sexual orientation and engineering identity found that sexual minority status created unique barriers and challenges for engineering students, impeded their academic success, participation in professional networks, and ability to integrate their sexual orientation with their emerging professional identity. Cech et al. (2017) in a survey of over 1700 students at eight engineering colleges found that LGBTQ students faced “greater marginalization, devaluation, and personal consequences (e.g., exhaustion, stress, depression) relative to their peers” (p. 2). Trenshaw et al. (2013) found that “STEM disciplines, specifically engineering, are technical spaces where sharing personal stories is not desired or valued within the normative expectations of heterosexual engineers which negatively impacts LGBTQ student sense of belonging” (p. 2).

Factors that have been found to increase sense of belonging or persistence in STEM among QT students are involvement in LGBTQ STEM clubs/student organizations (Forsyth et

al., 2023; Hughes, 2017) and friendships with other engineering students (Hughes, 2017). Forsyth et al. (2023) grounded theory study with 56 participants found that QT engagement in identity-specific STEM organizations/clubs was a negotiated process for students with minoritized identities of sexuality and/or gender (MioSG). Through interviews, participants shared that they felt forced to engage in identity-specific organizations because the larger, more general ones were unwelcoming or hostile to their MioSG identity (Forsyth et al., 2023). Some participants reported making the choice to not engage in the identity-specific group for fear of being professionally outed (Forsyth et al., 2023). Regardless of student choice to engage in organizations like Out in STEM (oSTEM) students on campus that had identity-specific STEM organizations reported feeling supported and welcomed (Forsyth et al., 2023) which is likely to have a positive effect on campus climate. This study adds to the field of research on QT sense of belonging in STEM disciplines by explicitly examining campus climate, engineering climate, involvement, and STEM identity. Additionally, as engineering disciplines have been found to be the most challenging for QT STEM students, this study's focus on undergraduate engineering students who are QT provides additional insight into the challenges experienced by this student population.

Campus Climate

Campus Climate for QT Students

Campus climate for QT students has been extensively studied in higher education research and is identified by Garvey et al. (2017) as the main source of data concerning the experiences of QT students at colleges and universities. Campus climate is described by Rankin (2005) as the “cumulative attitudes, behaviors, and standards of employees and students concerning access for, inclusion of, and level of respect for individual and group needs, abilities,

and potential” (p. 17). The campus climate for QT students has been found to be challenging, especially for transgender and nonbinary members of the community. Specifically, 24% of trans people who were out or perceived to be transgender in college or vocational school experienced verbal, physical, or sexual harassment (James et al., 2016 as cited in Lange et al., 2019, p. 512). Intersecting identities, such as being part of an underrepresented racial or ethnic group alongside a QT identity, can uniquely shape experiences of campus climate. Strayhorn (2019) found that participants who were gay men of color identified “several campus settings in which they experienced feelings of isolation or alienation, often due to explicit and implicit forms of anti-gay discrimination, homophobia, and/or racism” (p. 66). The experiences shared by the participants occurred across campus and involved physical threats or name-calling (explicit actions) and offensive signs and symbols to racist or homophobic jokes (implicit actions) (Strayhorn, 2019). QT students of color, specifically Black undergraduate women, in a 2017 study by Dortch and Patel found that that microaggressions felt outside of STEM contexts also impacted belonging as students were surrounded by Whiteness everywhere they go on campus.

Academic experiences and outcomes for QT students have been found to be directly impacted by campus climate (Gortmaker & Brown, 2006; Hill & Grace, 2009; Sue, 2010). Garvey et al. (2017) found that “students who participated in more academic-related activities (e.g., professional clubs, honors program, study abroad) had more negative campus climate perceptions” (p. 806). Alternatively, “the physical presence (or lack) of STEM organizations impacted students’ perceptions of the campus climate, whether or not those students actually participated in the organizations themselves” (Forsyth et al., 2023, p. 36).

Campus climate research for QT students has primarily focused on students with marginalized sexualities rather than those who are transgender or nonbinary. This study sought to

recruit and inclusively consider the experiences of transgender and nonbinary identities on experiences with climate. Additionally, this study also considered climate differences that students perceive between a campus and engineering context which is a novel approach to looking at QT perceptions of climate. While campus climate is important and has been found to be connected to retention (Hughes, 2018), literature on engineering climate is also important to consider for QT engineering students.

Campus Climate in STEM Majors

While limited, research on QT students in STEM (science, technology, engineering, math) is important because of the societal push towards these degree programs in both secondary and higher education. In 2011, the first study on LGBT engineering students was conducted, this qualitative study utilized interviews and found that students felt “tolerated” rather than seeing engineering as tolerant or accepting of their LGBT identities (Cech & Waidzun, 2011). More recent research has shown that STEM majors have been identified as queer-free (Forbes, 2020) and that LGBTQ students lack a sense of belonging in these fields (Strayhorn, 2019). Like findings from 2011, STEM environments have continually been found to not have an inclusive climate for students who differ in their gender or sexuality (Miller & Downey, 2020) from heterosexual, cisgender men. Specifically, LGBTQ people hesitate to disclose their identities and have identified a lack of role models and allies for LGBTQ students in STEM (Miller & Downey, 2020). These exclusive environments have lasting impacts on QT student success. Vaccaro et al (2021) found that “STEM students with MIOG (Minority Identity of Sexuality or Gender) limit their undergraduate, graduate, and career opportunities in ways that students without MIOG do not have to” (p. 308).

Heteronormative Culture

Heteronormativity is the assumption that everyone is heterosexual and establishes heterosexuality as normal and privileged” (Bowman, 2018). Participants from a 2013 study specifically identified the heteronormative environment of engineering as often leaving LGBT students to feel excluded from full engagement in their field (Trenshaw et al., 2013). In a literature review, Butterfield et al. (2018) found that engineering departments struggle with change more than most other disciplines and that LGBTQ+ engineering students encounter unwelcoming and sometimes hostile heteronormative environments. Across STEM disciplines this climate is so pervasive that, when interviewed, participants in a qualitative study by Miller et al. (2020) found that only those who could pass as heterosexual, cisgender men were able to fully participate in their STEM discipline. Approaches to the curriculum are also impacted by a heteronormative culture in STEM. Exclusionary curricular approaches were highlighted in one study when a participant shared how their professor used heterosexual attraction to teach charges of atoms (Trenshaw et al., 2013). These heteronormative environments have lasting impacts on QT students. In a quantitative study using longitudinal data sets from 4,162 aspiring college students across 78 different institutions, Hughes (2018) found that 71% of heterosexual students and 64% of sexual minorities were retained in a STEM major to senior year. Findings suggest that non-academic factors, like fit in terms of climate and culture, are driving forces for students to leave STEM (Hughes, 2018). Additionally, the study found that QT students in STEM majors are experiencing exclusionary behavior to overt discrimination (Hughes, 2018).

Experiences of Bias and Discrimination

Utilizing Cech and Waidzun's (2011) interview protocol, Trenshaw et al. (2013) found that, among their 16 participants. LGBT students experience more situations of exclusion within

engineering than in other areas of their campus. 29% of LGBTQ students and faculty in STEM experienced discrimination and harassment (Butterfield et al., 2018). In the same study, almost 33% of LGBTQIA students in a study by Butterfield et al. (2018) were not comfortable in the classroom. Miller et al. (2020) found, through interviews, that bro culture in STEM often included anti-LGBTQIA jokes, being treated as inferior to peers who are heterosexual cisgender men, and the sexualization of both heterosexual and queer women. Additionally, participants felt that their gender identity, gender expression, or sexual identity limited their full participation in bro-STEM culture even if they had the ability to pass as straight and/or cisgender. The exclusionary behavior and overt discrimination that QT students experience in STEM majors is directly connected to the heterosexist culture found to be present in STEM disciplines (Butterfield et al., 2018; Hughes, 2018; Miller et al., 2020; Miller & Downey, 2020; Trenshaw et al., 2013).

Lack of QT Visibility

The male-centered heteronormative learning environments found in STEM disciplines make invisible the identities and experiences of LGBTQ students (Miller & Downey, 2020). Vaccaro et al. (2021), in their qualitative study with 56 participants, found that nondisclosure or selective disclosure of MIOG seemed to be the norm as participants navigated STEM environments. A practice employed by science and engineering faculty has been to disclose their sexual minority status to serve as identifiable resources and mentors to LGB students (Bilimoria & Stewart, 2009). Participants in the Trenshaw et al. (2013) study noted that engineering buildings often lack visibility for LGBT organizations or events. There is also a lack of LGBTQIA topics in STEM settings (Mattheis et al., 2019). QT topics are not discussed by students, nor are they traditionally incorporated into STEM curriculum by faculty. The lack of

inclusion of QT topics in STEM means that students look elsewhere for the expression of this identity or engagement with this community. Friedensen et al. (2021) found that their participants engaged in conversations about their queer identities in contexts that are “outside of STEM.” Forbes's (2020) qualitative study with 20 queer college students found that majors such as those found in the STEM field were designated by students as queer-free. Queer-free majors are those where even discussions of QT content are not welcome or accepted.

Despite growing cultural acceptance and inclusion of QT people, higher education research demonstrates that not much has changed in STEM programs regarding the inclusion of this population. The research conducted assists in having a clear understanding of the barriers impacting QT STEM students and how pervasive heteronormativity is in these disciplines. Themes from the research include the heteronormative culture of STEM disciplines, experiences of exclusionary behavior to overt discrimination, and a lack of QT visibility in STEM. These are significant barriers that limit the success of this student population in these majors. Strengths of current research include both the availability of qualitative and quantitative data and research that looks at major-specific and cross-major experience. Despite the challenges QT students experience in engineering disciplines, the majority of campus climate research on STEM majors is not specific to the field of engineering. This study, which focused on undergraduate engineering majors, seeks to address this gap while exploring STEM identity.

STEM Identity

STEM or science identity development is influenced by shared science experiences with peers and educators who recognize and reinforce scientific identity work (Lucas & Spina, 2022). Science identity can be defined as “the sense of who students are, what they believe they are capable of, and what they want to do and become in regard to science” (Aschbacher et al., 2010,

p. 566). Alternatively, Xavier Hall et al. (2022) defined science identity as how people define themselves and self-present as scientists. Science identity can be developed by engaging in research or other academic opportunities like poster sessions (Lucas & Spina, 2022) and is further influenced by shared science experiences with peers and educators who recognize and reinforce scientific identity work (Lucas & Spina, 2022).

Carlone and Johnson's (2007) science identity model which is "based on the assumption that one's gender, racial, and ethnic identities affect one's science identity" (p. 1191) is especially useful when thinking about science identity development among QT engineering students. Carlone & Johnson (2007) developed this model in their work with Black women who were successful in their STEM fields. The researchers state that a "science identity is accessible when, as a result of an individual's competence and performance, she is recognized by meaningful others, people whose acceptance of her matters to her, as a science person" (Carlone & Johnson, 2007, p. 1192). An individual with a strong science identity would rank themselves high, and be ranked highly by others, within the three dimensions, recognition, performance, and competence, of this model (Carlone & Johnson, 2007).

Rainey et al. (2008) in a study on science identity and belonging found that "participants who expressed belonging based on having a positive science identity describe their major as an integral part of their life and who they are" (p. 8). Researchers in this study also found that the absence of a science identity is greater among underrepresented student groups (Rainey et al., 2008) and those who leave a STEM major. Research by Hughes (2018) emphasized the importance of science identity in their quantitative study on sexual minorities in STEM when they found that a STEM identity was the strongest predictor of retention in STEM to a fourth year. This study, unlike previous research, sought to study STEM identity along with

involvement, campus climate and engineering climate as a predictive factor of departmental sense of belonging for QT students. While these variables are often associated, few studies explicitly examine STEM identity, involvement, campus climate, engineering climate, and departmental sense of belonging. Past literature on STEM identity primarily compares marginalized student experiences across binary sex and racial identities (Carlone & Johnson, 2007; Chen et al., 2020; Hazri et al., 2013; Lucas & Spina, 2022; Nuttall et al., 2018; Puente et al., 2021; Victorino et al., 2022) to their white or male peers. Current science identity literature on QT populations ignores trans or nonbinary students (Hughes, 2018) which is a limitation that will be addressed in this study. Finally, perceptions of campus and engineering climates were a novel way of studying STEM identity among this population of students as context or environment are important considerations for the development of science identity (Kim & Sinatra, 2018). The gap in literature on STEM identity among QT, especially trans, students is an essential contribution of this study to the field of STEM identity research.

Summary

Sense of belonging for QT students is an important aspect to their retention in STEM programs. Barriers to a sense of belonging for QT students, inside and outside of STEM, include STEM climate (Cech et al., 2016; Cech & Waidzunus, 2011; Hughes, 2017; Miller et al., 2021; Trenshaw et al., 2018; Yang et al., 2021), sex (Hughes, 2018) and sexual minority status (Cech & Waidzunus, 2009; Hughes, 2017; Hughes, 2018). Campus climate, especially negative perceptions of campus climate, also negatively impacts sense of belonging and STEM identity. Negative experiences with campus climate include bias and discrimination (James et al., 2016 as cited in Lange et al., 2019, p. 512), intersecting identities like race (Strayhorn, 2019), heteronormative culture (Trenshaw et al., 2018), and lack of visibility (Cech & Waidzunus,

2009; Cech & Waidzunas, 2011). Overwhelmingly, research highlights the role of authentic relationships, affirming communities, and role models have on QT experiences in STEM programs and their sense of belonging. The similarities in factors that contribute to a higher sense of belonging, positive perceptions of campus climate, higher rates of involvement, and a developed STEM identity established each of them as variables in this study and informed my hypothesis.

While these constructs often appear in studies alongside each other, limited research exists that explicitly explores the relationships between perceived sense of departmental belonging, perceived campus climate, engineering climate, involvement, and STEM identity which was the focus of this study. Strayhorn's (2019) study on ethnic gay men is a close approximation but is limited given the population studied. This study sought to connect these areas of research while focusing on the broader QT community in engineering programs. Research has shown that women and QT students are less represented in engineering programs and that engineering culture is specially built upon heteronormative, masculine values (Cech et al., 2016; Cech & Waidzunas, 2011) that hinder marginalized student success. The climate and barriers to QT student success in engineering programs led to the selection of QT undergraduate engineering majors as participants for this study.

CHAPTER 3

METHODS

The purpose of this study is to examine the relationship between collegiate experiences of perceptions of departmental sense of belonging, planned involvement, STEM identity, and perceived campus and engineering climates among undergraduate QT engineering majors. The five research questions that guided this study are

1. What are the characteristics of QT undergraduate engineering students and what are their experiences of departmental sense of belonging, planned involvement, campus climate, engineering climate, and STEM identity?
2. How are departmental sense of belonging, planned involvement, campus climate, engineering climate, and STEM identity correlated to one another among QT engineering students?
3. After controlling for students' demographic characteristics, what are predictors of departmental sense of belonging among QT engineering students?
4. Does STEM identity or planned involvement mediate the relationship between climate and departmental sense of belonging for QT undergraduate engineering students?
5. How are departmental sense of belonging, planned involvement, campus climate, engineering climate, and STEM identity experienced differently across students' identities.

A quantitative, nonexperimental design was used to understand QT undergraduates engineering experience with the main variables of this study (Biddix, 2018). The remaining portions of

chapter three provide an overview of the site, participants, instrument, procedure, data collection, and data analysis.

Methodology

As previously mentioned, this study was a quantitative study which utilized a post positive paradigm. Quantitative methodology tests objective theories by examining the relationship among variables (Creswell, 2014). For this study, I tested the hypothesis as previously stated and will examine predictors of departmental sense of belonging and its relationship with campus climate, engineering climate, involvement, and STEM identity. Creswell (2014) provided the rationale for why quantitative methodology was selected to conduct this study. Creswell (2014) stated that the (a) nature of the research problem, (b) researcher personal experience, and (c) audiences for the study are all considerations in decision making. For this study, the nature of the research problem and audience for the study were key factors for my selection. “When conducting quantitative research, the research problem calls for the identification of factors that influence an outcome’ (Creswell, 2014, p. 20). For this study, the outcome of departmental sense of belonging is under review with variables such as campus climate, engineering climate, involvement, and STEM identity. Additionally, Creswell (2014) stated that “researchers write for audiences that will accept their research” (p. 21). This study was not only conducted to inform student affairs practice, but it is also meant to be directed towards STEM disciplines where there are still barriers to the acceptability of qualitative research (Douglas et al., 2010, Godwin et al., 2021). My personal experience also factored in the selection of quantitative methodology. Prior to this study, I had utilized qualitative methodology to complete original research, the selection of quantitative methods to complete the dissertation

requirements of this doctoral program provided an opportunity for personal growth and development that I was interested in engaging with.

Research Sites

Recruitment was initiated through email to engineering colleges/schools and professional organizations that center their membership around engineering or STEM. In total 95 individual institutions and 22 professional organizations were contacted and received a letter of recruitment and a digital copy of the recruitment flyer. Contact information, which was publicly available on departmental/organizational websites, for engineering departments, identity-based cultural centers, and professional organizations were utilized in these recruitment requests. Individuals contacted determined whether they would share information about the study with their undergraduate community or organizational members. Of the 95 institutions that were contacted with recruitment requests, 28 institutions responded in the affirmative and/or had representation among participants of the study. Among the national organizations contacted, two responded that they would share the information about the study with their membership (See Appendix B).

Sample

Self-identification with the QT community was needed for participation in the study. Examples of gender identities that participants may report are woman, agender, nonbinary, genderqueer, transman, gender fluid, etc. while sexualities may include, but are not limited to, lesbian, gay, queer, bisexual, asexual, etc. Additionally, criteria for participation also included a declared undergraduate engineering major. A screening question confirming QT identification was located at the beginning of the survey instrument. Participants were eligible if they satisfied each of these criteria. To clarify, to participate in this study a student met the following criteria:

- Identified as members of the QT community

- Were an enrolled undergraduate student
- Majoring in engineering

Since many institutions do not record or report student data relating to gender and/or sexuality, the exact population size of QT undergraduate engineering students is unknown. A range of sampling and recruitment measures will be employed to reach eligible students to participate in this study. Participants for this study will be identified using criterion (based on specific criteria), snowball (selected based on recommendations) and convenience sampling (Biddix, 2018; Creswell, 2014).

Participant Recruitment

Participants were recruited on-campus through their undergraduate engineering departments, campus-affiliated student organizations, and identity-based resource centers (e.g., LGBTQ+, multicultural). Additionally, off-campus recruitment occurred through national professional organizations like Out in STEM (oSTEM), Society for Women Engineers (SWE), and the National Society of Black Engineers.

Departmental Emails

College/School of Engineering

Staff or faculty members from the College/School of Engineering at potential research sites were contacted via email and asked to share recruitment materials to inform students of the study, conditions of participation, physical flyer, and a link to the survey instrument (See Appendix C). As QT identification is an often-ignored demographic data set for college students, employees in engineering departments were asked to share recruitment materials with all undergraduate engineering majors with an invitation for members of the QT community to take part in the study. Employees were able to request recruitment materials in different formats

(digital signage, Instagram Post, Instagram Story, etc.) for additional ways to share the call for participants with their campus community. After a week with no response, a follow up email was sent (See Appendix D).

Identity-Based Resource Centers

Recruitment materials were provided to offices whose work centers around resources, advocacy, and support for QT community. Specifically, offices represented included departments like LGBTQ+ Services, Center's for Diversity & Inclusion, Gender & Sexuality Center's, Multicultural Centers, and Pride Centers. Email communications requested that the study be disseminated through associated newsletters or listservs (See Appendix E) and included a digital version of the physical flyer. Staff were able to request recruitment materials in different formats (digital signage, Instagram Post, Instagram Story, etc.) for additional ways to share the call for participants with their campus community.

Physical Flyers

Each College/School of Engineering and campus identity-based resource centers were provided with a digital copy of a recruitment flyer for posting in their respective buildings/physical spaces (See Appendix F). These flyers were posted at authorized research sites at the discretion of the department/office. In addition to pertinent study information the flyer contained a QR Code which directed students to the survey and consent form.

Professional Organizations

Professional organizations that served engineering communities and QT individuals in STEM were sent recruitment emails at publicly available email addresses (See Appendix G). Contact forms were submitted on national websites for organizations that utilized this method for communication in leu of a general email address. The national office was contacted for many

professional organizations; however, chapter (National Society of Black Engineers) and regional (Society of Hispanic Professional Engineers) contact information was utilized as it was publicly available and located on the national website.

Social Media

Social media, specifically Facebook, Instagram, and LinkedIn, were also utilized to share recruitment materials (see Appendix H). Recruitment information shared on social media platforms were sent from my personal accounts, and I refrained from sharing recruitment content to other research sites from communication platforms that I manage at the LGBTQIA Resource Center at the Georgia Institute of Technology.

As stated, all external to Georgia Tech recruitment communications were sent from the researcher's student and/or personal accounts. As the researcher has a connection to Georgia Tech, it was important to recognize the impact of my professional relationship with the students at that institution. Specifically, direct in-person requests were avoided at Georgia Tech. This was done to maintain participant confidentiality and to lessen the pressure that students would have experienced to participate in this study. Additionally, individual students were not emailed at Georgia Tech to avoid additional pressure to participate. Recruitment materials included a reminder that to be a participant in this study a student must meet the following criteria:

- They must identify as members of the QT community.
- They must be an enrolled undergraduate student.
- They must be majoring in an engineering degree program.

Procedures

A quantitative survey relying on responses from students was delivered using Qualtrics software. Survey instruments used in this study include the Departmental Sense of Belonging

and Involvement (DeSBI) questionnaire (Knekta et al., 2020) to measure departmental sense of belonging and planned involvement, LGBTQ College Campus Climate Scale (Szymanski & Bissonette, 2020), and STEM Professional Identity Overlap – 4 (STEM PIO-4; McDonald et al., 2019) for STEM identity; demographic information was also collected. A modified version of the LGBTQ College Campus Climate Scale was created to understand participant perceptions of engineering climate (See Appendix I). IRB approval was received from the University of Georgia. Data was collected and analyzed related to QT undergraduate engineering perceptions on departmental sense of belonging, campus climate, engineering climate, involvement, and STEM identity. Employing Vaccaro and Newman’s (2016) Sense of Belonging for Privileged and Minoritized Students framework the following variables were identified as dependent and independent variables.

Variables

Dependent Variable

Departmental Sense of Belonging. The dependent variable in this study was departmental sense of belonging. Departmental sense of belonging was self-reported and measured by the Departmental Sense of Belonging Scale (Knekta et al., 2020). The Departmental Sense of Belonging Scale, a 16-item sub-scale on the Departmental Sense of Belonging and Involvement Scale, was specifically designed to assess sense of belonging at the department level. Participants responded to the scale using a six-point Likert-type scale from strongly disagree to strongly agree (1=strongly disagree, 2 = disagree, 3= slightly disagree, 4= slightly agree, 5 = agree, and 6 = strongly agree) and will be provided the option to “prefer not to respond”. The scale included items like “People in the engineering department notice when I’m good at something,” “faculty and staff in the engineering department value my opinions,” and

“other students in the engineering department take my opinions seriously.” Cronbach’s alpha from this study was $\alpha = .925$.

Independent Variables

Campus Climate. To measure the environment factor in the Model of Sense of Belonging for Privileged and Minoritized Students (Vaccaro & Newman, 2016) this study looked at campus climate. Campus climate was assessed using the LGBTQ College Campus Climate Scale (Szymanski & Bissonette, 2020). Participants responded to the six-items using a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*). Lower numbers indicate more positive perceptions of campus climate while higher numbers indicate a more hostile climate perceived by QT participants in this study. Items include “heterosexism, homophobia, biphobia, transphobia, and cissexism are visible on my university/institute campus,” “negative attitudes toward QT persons are openly expressed on my university/institute campus,” “my university/institute is unresponsive to the needs of QT students,” “QT students are harassed on my university/institute campus,” and “my university/institute is cold and uncaring toward QT students and issues.” One question, “my university/institute provides a support environment for QT students” was reverse coded with higher scales indicating a more negative perception of the campus climate (Szymanski & Bissonette, 2020). Cronbach’s alpha was reported on the LGBTQ College Campus Climate Scale as .85 (Szymanski & Bissonette, 2020). Cronbach’s alpha for this study was $\alpha = .883$.

Engineering Climate. Another variable for environment included in the list of independent variables is engineering climate. Engineering climate was assessed through a modified version of the LGBTQ College Campus Climate Scale (Szymanski & Bissonette, 2020) (See Appendix J). Participants responded to the six-items using a 7-point Likert scale from 1

(*strongly disagree*) to 7 (*strongly agree*). Similarly to campus climate, the higher the number on this scale indicated more negative perceptions of engineering climate among the participants of this study. Items include “heterosexism, homophobia, biphobia, transphobia, and cissexism are visible in my engineering department,” “negative attitudes toward QT persons are openly expressed in my engineering department,” “my engineering department is unresponsive to the needs of QT students,” “QT students are harassed in my engineering department,” and “my engineering department is cold and uncaring toward QT students and issues.” One question, “my engineering department provides a support environment for QT students” will be reverse coded with higher scales indicating a more negative perception of the campus climate (Szymanski & Bissonette, 2020). Cronbach’s alpha was reported on the LGBTQ College Campus Climate Scale as .85 (Szymanski & Bissonette, 2020). (See Appendix H). Cronbach’s alpha for this study was $\alpha = .928$.

STEM Identity. The independent variable, STEM identity, was measured through the four-item STEM Professional Identity Overlap measure (STEM-PIO-4) as developed by McDonald et al. (2019). The STEM-PIO-4 provided participants an opportunity to pick an image that best describes the current image of the overlap they have of themselves and their image of what a STEM professional is (McDonald et al., 2019). The four instrument items are

1. (Overall) Select the picture that best describes the current overlap of the image you have of yourself and your image of what a STEM professional is.
2. (Competence) Select the picture that best describes the extent to which your knowledge of STEM concepts matches that of a STEM professional.
3. (Performance) Select the picture that best describes the extent to which your capacity to use STEM skills in a public setting matches that of a STEM professional.

4. (Recognition) Select the picture that best describes the extent to which you think others (such as your STEM professors) see your identity as overlapping with a STEM professional.

McDonald et al. (2019) found STEM-PIO-4 to be a reliable and valid measure of STEM identity with an inter-item reliability of $\alpha = .87$ and average inter-item correlation of $r = 0.62$ (McDonald et al., 2019). Cronbach's alpha for this study was $\alpha = .737$.

Planned Involvement. Planned involvement was self-reported and measured by the involvement sub-scale on the Departmental Sense of Belonging and Involvement (DeSBI) questionnaire (Knekta et al., 2020). The DeSBI includes a 12-item involvement sub-scale that was specifically designed to assess students plans for involvement within this academic year at the department level. Participants responded to the scale using a six-point Likert-type scale from strongly disagree to strongly agree (1=strongly disagree, 2 = disagree, 3= slightly disagree, 4= slightly agree, 5 = agree, and 6 = strongly agree) and were provided the option to “prefer not to respond”. The involvement sub-scale asked participants if during this academic year they will “participate in undergraduate research, interact closely with engineering faculty, discuss course topics outside of class, etc.” Cronbach's alpha from this study was $\alpha = .925$.

Demographic Information. Demographic information such as gender, sexuality, trans-identification, race/ethnicity, grade point average and grade level were additional independent variables in this study. As this study was specifically focused on QT students, demographic questions related to gender and sexuality followed current best data collection practices (Bauer et al., 2017; Brenner & Bulgar-Medina, 2018; Chen & Gardner, 2022; Lussenhop, 2018). Specifically, three questions were utilized for participants to record a QT identity. Participants responded to the following questions:

- Do you identify as transgender?
- What is your gender?
- What is your sexual orientation?

A question on sex assigned at birth was unnecessary in this study.

Data Collection Methods

Data collection for this cross-sectional study was performed via an online survey using Qualtrics. Survey design was selected because it provides a quantitative description “of trends, attitudes, or opinions of a population by studying a sample of that population” (Creswell, 2014, p. 155). This study was conducted with QT undergraduate engineering students across a variety of institutions/colleges which would be challenging or ineffective with other data collection methods. The cost and time savings associated with surveys (Fowler, 2009) make them an ideal data collection method for this study.

The survey was distributed to a total of 95 colleges that provide an undergraduate engineering major to undergraduate students. U.S. based professional organizations whose primary audience is engineering or marginalized communities in engineering/STEM were contacted via publicly available email addresses. Follow-up emails were sent to each potential research site after a week of no response. A link to the survey was included in all electronic recruitment materials. Digital versions of the physical flyers which contained a QR code that directed participants to the survey and study information were also included in each email.

The survey started with an online IRB approved informed consent letter (See Appendix K). Participants consented to take part in the study by clicking on a button to indicate that they read, understood, and agreed to the terms of the study. To gain access to the survey questions, students also had to answer in the affirmative that they identified as a member of the QT

community. Additionally, students were informed that they could stop their participation at any time. IP addresses, the only identifying information collected in the survey data, were deleted in the data cleaning process prior to data analysis.

Instruments Used

The survey instrument used in this study was developed from the Departmental Sense of Belonging and Involvement (DeSBI) questionnaire, the LGBTQ College Campus Climate Scale, and the STEM PIO-4.

Departmental Sense of Belonging and Involvement (DeSBI)

The DeSBI Questionnaire is one of two sense of belonging instruments that are applicable at the departmental level. The Sense of Social Fit Scale (SSF), a 17-item measure of college belonging, was created from a review of literature on school belonging and motivation (Maghsoodi et al., 2023; Walton & Cohen, 2007). Despite the advantages of the SSF, I selected the DeSBI because of its inclusion of a section on involvement and a section on sense of belonging which both align with the theoretical framework. The belonging section included subsections on social acceptance and valued competence which align more strongly with this study's theoretical framework. Specifically, the two factors of sense of belonging were more strongly associated with a) competence or being valued and b) feeling accepted or included (Knekta et al., 2020) which are closely aligned with sense of belonging as defined in this study (Vaccaro and Newman, 2016). Additionally, the creation of this scale within the field of biology lessened the adaptation needed to utilize the questionnaire within an engineering context, the focus of this study. The DeSBI was developed and evaluated through factor analysis which indicated a three-factor solution (Knekta et al., 2020). Version three of the instrument, as defined

by Knekta et al. (2002), was used in its entirety for this study and was modified to focus on engineering departments at participant institutions (See Appendix L).

LGBTQ College Campus Climate

The LGBTQ College Campus Climate Scale was developed to assess views of the university/college campus climate concerning LGBTQ students and issues (Szymanski & Bissonette, 2020). The 6-item scale consists of two sub-scales: College Response to LGBTQ Students and LGBTQ Stigma. This scale highlights perceptions of LGBTQ climate, not actual experiences of bias or discrimination which aligns with the theoretical framework. Additionally, this scale, having been developed more recently, did not require an update on language/terminology and was inclusive of transgender people, a limitation of many older campus climate assessments. This scale was utilized to assess the variable of *overall campus climate* and the variable *engineering climate* in this study. Adjustments were made to the language of the scale items to switch the focus from college/school to engineering department (see Appendix J). The scale was found to be structurally valid (via exploratory and confirmatory factor analyses) and reliable (Szymanski & Bissonette, 2020). Additionally, the full scale and subscales were positively correlated with experiences of LGBTQ victimization on campus, anxiety, and depression and negatively correlated with satisfaction and intention to persist in college (Szymanski & Bissonette, 2020) which furthers their validity.

STEM Professional Identity Overlap (STEM PIO-4)

The final measure adopted in this study was the STEM Professional Identity Overlap (STEM PIO-4) to assess participants' STEM identity. This scale was developed using the same science identity framework (Carlone & Johnson, 2007) that was adopted in this study. While a study performed by McDonald et al. (2019) validated a single-item measure of assessing STEM

identity, researchers suggested that future literature continue to utilize the STEM PIO-4 four questions to understand STEM identity among participants. The STEM PIO-4 uses overlapping circles to allow participants to select an image that best represents how they see the image they have of themselves relating to the image they have of a STEM professional. (see Appendix M).

Data Analysis

Overall, descriptive, and inferential statistics to ascertain how QT undergraduate engineering students perceive their campus climate, engineering climate, planned involvement, STEM identity, departmental sense of belonging, and the relationship between these variables. Descriptive statistics were performed to examine responses on each scale, and correlation, multiple regression, hierarchical regression, one-way ANOVA, and independent sample t-tests will be performed to answer the research questions.

Descriptive Statistics

Prior belonging research on minoritized populations has shown that within group differences exist (Duran et al., 2022), descriptive statistics will be the first stage of data analysis. Frequency distributions were reported for all demographics collected. Additionally, descriptive analysis was utilized to examine the perceptions of STEM identity, campus climate, engineering climate, planned involvement, and departmental sense of belonging among the participants of this study. Analysis that was inclusive of participant race/ethnicity, was important as Rainey et al. (2018) found that that lower sense of belonging was reported more frequently among students of color with women of color reporting the lowest feelings of a sense of belonging. While data analysis was not able to be conducted within different racial/ethnic groups, analysis compared participants who held underrepresented racial/ethnic identities to their White participants. Understanding the unique experiences of QT students who are also students of color is important

to this study as these students are likely to experience an intersectional marginalization at the crossroads of sexuality, racial/ethnic identity, or gender identity (Strayhorn, 2019). Adopting a critical analysis that includes an intersectional approach is key to understanding the QT undergraduate engineering experiences among those who live at the greatest margins (López et al., 2018).

To conduct inferential statistics participant scores were averaged for each scale of the survey. These sections included (a) departmental sense of belonging, (b) planned involvement, (c) campus climate, (d) engineering climate, and (e) STEM identity. Higher scores on the two sections of the DeSBI are associated with a higher sense of belonging and anticipations of involvement, higher scores on the climate scales indicated a more negative perception of campus and engineering climates, and higher scores on the STEM PIO-4 indicated more solidified STEM identity. To answer the proposed research questions, analyses were performed as outlined below:

Research Question 1

The first research question “What are the characteristics of QT undergraduate engineering students and what are their experiences of departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity?” was analyzed using frequencies and descriptive statistics.

Research Question 2

The second research question “How are departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity correlated to one another among QT engineering students” was analyzed using correlation statistics. Correlation provided evidence for the strength and direction of the relationship between the variables studied with each other (Christopher, 2017).

Research Question 3

Research question three “After controlling for students’ demographic characteristics, what are predictors of sense of belonging among QT engineering students?” was analyzed using multiple linear regression. Departmental sense of belonging was entered as the dependent variable and campus climate, engineering climate, planned involvement, and science identity were entered as independent variables for all participants.

Research Question 4

Research question four “Does STEM identity or planned involvement mediate the relationship between climate and departmental sense of belonging for QT undergraduate engineering students?” was analyzed using mediation analysis. This method provided greater insight into the relationship between sense of belonging and climate through the mediating influence of STEM identity or planned involvement.

Research Question 5

Research question five “How departmental sense of belonging, planned involvement, campus climate engineering climate, and STEM identity are experienced differently across students’ identities” was analyzed using one-way ANOVA and independent sample t-tests. This method provided the ability to review between group differences in perceptions to the four main variables across each demographic category under review.

Protection of Subjects

An advantage of quantitative research via survey is that the data can be collected anonymously (Mertens, 2021). Students did not report any identifying information in the data associated with the study. Additionally, participants were informed of the limited risk associated with participation in this study in the informed consent information. The risk associated with this

study was the possible experience of discomfort that can arise when reflecting on instances of bias and discrimination.

Positionality

There are several ways in which I approached this research project as an insider. Firstly, I am a queer, nonbinary person who uses they/them pronouns. My gender specifically guides my approach and the biases and assumptions I carry as a student affairs professional. I also carry my own undergraduate experience as a STEM major. Specifically, I hold a Bachelor of Science in biology with a minor in biochemistry from the University of Nebraska-Lincoln. While I did not navigate the entirety of my undergraduate experience as an QT student, I navigated academic spaces as a first-generation, low-income, Latinx student. I understand the experience of learning in academic spaces where you do not experience a sense of belonging and the impact that can have on a student's ability to see themselves as successful in their major.

As a student affairs professional whose roles have been directly supportive of QT students, I also found myself considering my insider status from a professional perspective. I began my student affairs career at small, private, liberal arts institutions and now work at Georgia Tech. In each of these institutional types, I have worked in positions that had primary responsibility to serving and supporting QT students. Although many of my students at past institutions studied in the social sciences, there were many who majored in STEM disciplines. My intimate knowledge and experience with the context and students being studied influences the biases and preconceptions that I entered this work with. My planned dissertation, along with my current professional practice, have led me to studies that highlight the hostile environment that QT students experience in STEM, specifically engineering majors, and it led me to

questioning the relationships between perceived departmental sense of belonging, perceived campus and engineering climates, planned involvement, and STEM identity.

Validity & Reliability

One method which added validity to the study was the use of existing instruments that have themselves been validated and published through a peer-review process. Sense of belonging and campus climate are constructs that have been extensively studied in higher education research. Selecting a survey instrument that has been previously evaluated strengthened my confidence in the reliability and validity of this study (Christopher, 2017). While new, the creation and evaluation of the DeSBI highlighted its effectiveness in utilizing it as an instrument to measure students' sense of belonging to and planned involvement in their academic department (Knekta et al., 2019). McDonald et al. (2019) conducted research to evaluate the effectiveness of a one-item measure of science identity. While their STEM PIO-1 was found effective, the STEM PIO-4 was identified as having more strengths and nuance to understanding science identity (McDonald et al., 2019). Reliability was also strengthened through the reporting of Cronbach's alpha for each variable as explained in the instruments section and through my own reliability testing with the data obtained in this study.

This study was also strengthened by construct validity or the extent to which a higher-order construct is accurately reflected in the planned study (Johnson & Christensen, 2014). Construct validity exists when the scale used to measure a construct accurately measures the construct for which it is measuring. To ensure construct validity of variables, factor analysis was performed for selected independent variables campus climate, engineering climate, planned involvement, STEM identity, and dependent variable departmental sense of belonging.

CHAPTER 4

FINDINGS

The purpose of this quantitative study was to examine the relationship between collegiate experiences of perceptions of departmental sense of belonging, planned involvement, STEM identity, and perceived campus and engineering climates among undergraduate QT engineering majors. The research questions sought to understand

1. What are the characteristics of QT undergraduate engineering students and what are their experiences of departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity?
2. How are departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity correlated to one another among QT engineering students?
3. After controlling for students' demographic characteristics, what are predictors of sense of belonging among QT engineering students?
4. Whether STEM identity or planned involvement mediated the relationship between climate and sense of belonging for QT undergraduate engineering students?
5. Group differences with departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity.

While chapter three focused on the process of data collection and analysis, chapter four provides descriptive statistics and the statistical analyses used to examine the above research questions.

The Statistical Package for the Social Sciences 29.0.2.0 was used to analyze the data gathered through a Qualtrics survey.

Characteristics of Participants

While the number of eligible participants who saw the recruitment materials is unknown, the survey link was accessed by 185 individuals who responded to the informed consent and QT identification question. Among the 185 individuals who clicked on the survey, 74 of the questionnaires (40%) were included in the sample. The other 107 responses were discarded due to the respondents starting but not completing the survey or checking no to the filter question of identifying as QT ($n = 4$). Inclusion criteria required that all respondents be current undergraduate students who are majoring in engineering and identify as members of the QT community.

Research Questions

Research Question 1

RQ1: *What are overall characteristics of QT students and their experiences on departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity?*

Demographic information recorded from each participant include institution, engineering major, Grade Point Average (GPA), grade level, if they were international students, if they identify as transgender, gender, sexual orientation, racial/ethnic identity, and which social class group they identify with. Participant demographic information as grouped into social demographics (international student, transgender identification, gender, sexual orientation, racial/ethnic identity, and social class group) and academic (institution, engineering major, GPA, and grade level).

Social Demographics

Gender. Response options on this demographic question allowed participants to click “all that apply” and to specify another gender identity that was not included in the list. Among the 74 participants, four identified with a gender not included in the list (genderfae, genderfluid, transmasculine) and 13 with a gender identity that were described using multiple labels (agender, man, or woman in combination with nonbinary/genderqueer) for a total of 23%. Participants who recorded a singular gender identity did so as nonbinary/genderqueer (n = 17), man (n = 14), and woman (n = 23). The remaining (n = 3) participants choose “Prefer Not to Respond” or left the response field blank.

Trans Identification. In Table 1, transgender students made up 41.9% (n = 31) of participants. Among these 31 participants, 6.6% are men, 16.13% are woman, and 74.2% were categorized into the group Nonbinary. 10.8% of participants (n = 8) chose not to response to this survey item.

Table 1

Transgender Identification Within Gender Groups

Trans Identification	Do you identify as transgender?		n
	Yes	No	
Man	2	11	13
Nonbinary	23	6	29
Woman	5	17	22
Prefer Not to Disclose	1	1	2
Total	31	35	66

Sexual Orientation. Similarly to gender, participants in this study identified their sexual orientation using a variety of terms and combinations of identity labels. Table 2 highlights the responses among participants to the “check all that apply” survey item. Among survey respondents, 39.8% identified as Bisexual/Pansexual (n = 41), 22.3% as Lesbian/Gay (n = 23),

18.4% as Queer (n = 19), 13.6% as Aromantic/Asexual (n = 14), and 4.9% utilizing the “Another Identity, Please Specify” response option. Response options recorded included Demisexual (n = 4), and Polysexual (n = 1). No participants identified as Straight/Heterosexual. Participant responses to sexual orientation varied, while many participants (n = 52) selected a singular identity label, 18 participants selected two, 4 participants selected three, and 1 participant selected four. Participants who selected two labels often selected queer or asexual/aromantic, in combination with other identity labels like lesbian/gay or bisexual/pansexual. For participants who reported three or more labels to define their sexual orientation, their responses included

- Participant 1: Aromantic/Asexual, Bisexual/Pansexual, and Queer
- Participant 2: Lesbian/Gay, Queer, and Demisexual
- Participant 3: Aromantic/Asexual, Bisexual/Pansexual, and Queer
- Participant 4: Bisexual/Pansexual, Queer, and Polysexual
- Participant 5: Aromantic/Asexual, Bisexual/Pansexual, Lesbian/Gay, and Queer

Table 2

Sexual Orientation within Survey Response Options

Sexual Orientation	Responses		Percent of Cases %
	n	Percent of Responses %	
Aromantic/Asexual	14	13.6	18.9
Bisexual/Pansexual	41	39.8	55.4
Lesbian/Gay	23	22.3	31.1
Queer	19	18.4	25.7
Another Identity, Please Specify	5	4.9	6.8
Prefer Not To Say	1	1.0	1.4
Total	103	100.0	139.2

Race and Ethnicity. Table 3 represents the variety of responses available to participants regarding their race/ethnicity. Within the racial categories provided, participants identified with

being White (63%, n = 51), Asian or Asian American (16%, n = 13), Hispanic or Latinx/e (7.4%, n = 6), Black or African American (6.2%, n = 5), American Indian or Alaskan Native (1.2%, n = 1), Middle Eastern or North African (1.2%, n = 1), and Biracial (1.2%, n = 1). Two participants (2.5%) chose not to respond with their racial or ethnic identity and one participant utilized the “Another Identity, Please Specify” to include their identification as an Ashkenazi Jew.

Table 3

Racial/Ethnic Identification within Survey Response Options

Racial/Ethnic Identity	Responses		Percent of Cases %
	n	Percent %	
American Indian or Alaskan Native	1	1.2	1.4
Asian or Asian American	13	16.0	17.6
Black of African American	5	6.2	6.8
Hispanic or Latinx/e	6	7.4	8.1
White or European	51	63.0	68.9
Biracial	1	1.2	1.4
Another Identity, Please Specify	1	1.2	1.4
Prefer Not to Disclose	2	2.5	2.7
Total	81	100.0	109.5

In Table 4, participants who disclosed a racial/ethnic identity, 35.1% (n = 26) were placed into a category of “Underrepresented Racial/Ethnic Identity” (UREI) for the purposes of this study. This category is inclusive of all students who selected any racial/ethnic identity independently or in combination with a White racial/ethnic identity. Participants in the White category are those who exclusively selected White as their racial/ethnic identity.

Table 4*Underrepresented Racial/Ethnic Identity*

Grouped UREI	Frequency n	Percent %
White	46	62.2
Underrepresented Racial/Ethnic Identity	26	35.1
Prefer Not to Disclose	2	2.7
Total	74	100.0

International Students. Among 74 participants, 5.4% (n = 4) were international students. The remaining 94.5% did not identify as international students on the survey instrument.

Social Class. Student self-identified social class was reported by participants as wealthy (1.4%), upper-middle or professional (39.2%), middle-class (41.9%), working class (10.8%), and low-income or poor (6.8%).

Academic Demographics

As previously stated, academic collected in study include institution, engineering major, grade level, and GPA.

Institution. Table 5 highlights the various institutions represented in this study. The Georgia Institute of Technology had the most representation with 29.7% followed by the University of Michigan – Ann Arbor (18.9%) and Worcester Polytechnic Institute (14.9%). The remaining institutions represented less than 7% of respondents. 10.8% of survey respondents chose to skip this question.

Table 5*Institutions Represented Among Survey Participants*

Engineering Major. Table 6 highlights the variety of engineering majors represented

Institution	Frequency n	Percent %	
Georgia Institute of Technology	22	29.7	among survey
Massachusetts Institute of Technology	1	1.4	participants.
North Carolina State University	2	2.7	Student
Purdue University	1	1.4	response
University of California - Berkeley	1	1.4	options
University of Delaware	2	2.7	
University of Georgia	1	1.4	allowed them
University of Kansas	5	6.8	to denote
University of Michigan – Ann Arbor	14	18.9	double majors
University of Minnesota – Twin Cities	1	1.4	
University of Texas at Arlington	1	1.4	and specify
University of Wisconsin – Madison	4	5.4	alternative
Worcester Polytechnic Institute	11	14.9	
Left Blank	8	10.8	majors not
Total	74	100.0	included on

this list. Among survey responses, Electrical and Computer Engineering, the largest major reported, was selected by 26.9% (n = 21) of participants. Write-in options provided by students included Applied Computing and Biology (n = 1), Computer Science (n = 1), Environmental Engineering Science (n = 1), Nuclear (n = 2), and Robotics (n = 2). Five students in the study reported double majoring.

Table 6*Majors Reported within Survey Response Options*

Major	Responses		Percent of Cases %
	n	Percent %	
Aerospace	7	9.0	9.6
Biomedical	8	10.3	11.0
Chemical & Biomolecular	7	9.0	9.6
Civil & Environmental	7	9.0	9.6
Electrical & Computer	21	26.9	28.8
Industrial & Systems	12	15.4	16.4
Materials Science & Mechanical	9	11.5	12.3
Other Major, Please Specify:	7	9.0	9.6
Total	78	100.0	106.8

Grade Level. Seniors comprised 45.5% of study participants; juniors made up 18.2%; sophomores made up 14.3%; and first-years made up 16.9%. Four survey respondents did not respond to this survey item.

GPA. GPAs were recorded by participants on a 4.0 scale. 75.3% reported a grade of 3.1-4.0. 14.3% reported a grade within the range of 2.1-3.0; 1.3% reported a response of a grade within the range of 1.1-2.0, and 1.3% responded with a response of 0.0-1.

Descriptive Statistics of Main Variables

Participants completed an online Qualtrics survey consisting of the Departmental Sense of Belonging and Involvement Scale (DeSBI) (Knekta et al.'s, 2020), LGBTQ College Climate Scale (Szymanski & Bissonette, 2020), a modified LGBTQ College Climate Scale, STEM Professional Identity Overlap Scale (McDonald et al., 2019) and a section on demographic information with a total survey instrument of 56 questions. Table 7 provides descriptive statistics

for the dependent and main independent (campus climate, engineering climate, planned involvement, and STEM identity) variables in this study. Cronbach's alpha scores for each variable were above .7, which Christopher (2017) defined as the minimal level for social science research.

Participants mean scores across all five scales highlighted that their overall perceptions of departmental sense of belonging and planned involvement which on a scale from Strongly Disagree (1) to Strongly Agree (6), participants response average in the Slightly Agree to Agree, range trends more positive. Regarding campus and engineering climates, response options were available to participants that ranged from a Strongly Disagree (1) to Strongly Agree (7) with a neutral score of 4. Reminder that lower scores are associated with a more positive perception of climate. Engineering and institutional climate were reported at similar levels with responses falling in the Slightly Disagree to Neutral range. Participant planned involvement was positive with the average representing Slight Agreement with intentions to engage outside the classroom in this academic year. Finally, STEM identity among participants were reported with participants seeing their identity overlap at $\frac{1}{2}$ to $\frac{3}{4}$ of the way overlapped with that of a STEM professional.

Table 7

Descriptive Statistics for Main Variables

Variables	Mean (n=74)	SD (n=74)
Departmental Sense of Belonging	4.6	0.8
Planned Involvement	4.1	1.1
Campus Climate	3.3	1.3
Engineering Climate	3.3	1.4
STEM Identity	4.2	1.2

Research Question 2

RQ2: *How are departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity correlated to one another among QT engineering students, as measured by Departmental Sense of Belonging Scale (Knekta et al., 2020), Involvement Scale (Knekta et al., 2020), LGBTQ College Climate Scale (Szymanski & Bissonette, 2020), LGBTQ College Climate Scale-Modified (Szymanski & Bissonette, 2020), and STEM Professional Identity Overlap (McDonald et al., 2019)?*

A correlation analysis was conducted to analyze the statistical relationship between participant perceptions of departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity. In Table 8, there are positive correlations and significance between perceptions of departmental sense of belonging and STEM identity, $r = .31$, $p = .007$ and departmental sense of belonging and planned involvement, $r = .60$, $p < .001$. Negative correlations were found between perceptions of departmental sense of belonging and campus climate, $r = -.35$, $p = .002$ and engineering climate, $r = -.48$, $p < .001$ that were each significant. Engineering and campus climates are coded in such a way that negative climates are represented as higher numbers so that the greater the prevalence of a negative environment, the higher the score. Thus, a negative correlation would indicate the more negative the climate (higher score), the lower the belonging (lower score). Negative correlations were found between engineering climate and STEM identity, $r = -.02$, $p = .851$, and STEM identity and campus climate, $r = -.21$, $p = .077$. The correlation of STEM identity with campus climate and engineering climate were not significant. No significance was found in the positive correlation between planned involvement and STEM identity $r = .15$, $p = .20$ or the negative correlations between involvement and engineering $r = -.17$, $p = .14$ or campus climate $r = -.12$, $p = .31$.

Table 8*Correlation For Main Variables*

Variable	n	M	SD	1	2	3	4	5
1. Departmental Belonging	74	4.6	.8	—				
2. Planned Involvement	74	4.1	1.1	.603**	—			
3. Campus Climate	74	3.3	1.3	-.352**	-.120	—		
4. Engineering Climate	74	3.3	1.4	-.477**	-.174	.786**	—	
5. STEM Identity	74	4.2	1.2	.312**	.151	-.207	-.022	—

Note. ** $p < .01$.

Research Question 3

RQ3: *After controlling for students' characteristics, what are predictors of departmental sense of belonging among QT engineering students, as measured by Knekta et al.'s (2020)*

Departmental Sense of Belonging Scale?

Sense of Belonging Scale

Hierarchical regression analysis was conducted to control demographic variables to better understand the influence of perceptions of campus climate, engineering climate, planned involvement, and STEM identity on departmental sense of belonging. Specifically, we are looking to predict departmental sense of belonging with social demographics, academic background, and STEM identity, planned involvement, engineering climate, and campus climate. In the first block of Table 9, only gender is a significant predictor of departmental sense of belonging, $p = .015$. The results of hierarchical multiple regression analyses found that planned involvement was a significant positive predictor of departmental belonging ($\beta = .425, p < .001$) as was STEM identity ($\beta = .267, p = .014$). Engineering climate was a significant negative predictor of departmental sense of belonging ($\beta = -.591, p = .002$), meaning that higher

perceptions of an unsupportive climate were associated with lessened departmental belonging.

Campus climate was not found to be a significant predictor of departmental sense of belonging.

Table 9

Hierarchical Regression Analysis

Variable	Model 1					R ²	ΔR^2	F for ΔR^2
	B	SE B	β	t	p			
<i>Step 1 – Social Demographics</i>						.193	.088	1.844
Trans Identification	.207	.217	.129	.950	.346			
Gender	-.327	.130	-.321	-2.504	.015			
Asexual/Aromantic	.131	.272	.065	.481	.632			
Bisexual/Pansexual	-.033	.301	-.021	-.111	.912			
Lesbian/Gay	.312	.292	.184	1.067	.291			
Queer	.047	.274	.025	.172	.864			
UREI	.047	.179	.034	.263	.794			
<i>Step 2: Academic Demographics</i>						.210	.073	0.562
Trans Identification	.181	.226	.113	.803	.426			
Gender	-.319	.132	-.314	-2.424	.019			
Asexual/Aromantic	.149	.278	.073	.535	.595			
Bisexual/Pansexual	-.061	.310	-.038	-.197	.844			
Lesbian/Gay	.326	.296	.193	1.100	.276			
Queer	-.010	.287	-.005	-.034	.973			
UREI	.017	.184	.012	.092	.927			
GPA	.013	.194	.009	.065	.948			
Grade Level	-.094	.092	-.134	-1.026	.309			
<i>Step 3: Independent Variables</i>						.624	.522	13.192
Trans Identification	.025	.179	.015	.138	.891			
Gender	-.130	.100	-.128	-1.309	.197			
Asexual/Aromantic	.039	.207	.019	.190	.850			
Bisexual/Pansexual	.064	.227	.040	.284	.778			
Lesbian/Gay	.175	.217	.103	.805	.425			
Queer	.202	.209	.108	.968	.338			
UREI	-.053	.137	-.039	-.386	.701			
GPA	-.005	.150	-.004	-.035	.972			
Grade Level	-.012	.075	-.017	-.157	.876			

	B	SE B	β	<i>t</i>	<i>p</i>	R^2	ΔR^2	F for ΔR^2
<i>Step 3: Independent Variables (cont.)</i>						.624	.522	13.192
Planned Involvement	.236	.076	.425	4.293	<.001***			
Campus Climate	.156	.110	.256	1.414	.164			
Engineering Climate	-.332	.102	-.591	-3.255	.002**			
STEM Identity	.188	.074	.267	2.554	.014*			

Note. UREI = Underrepresented Racial/Ethnic Identity, * $p < .05$, ** $p < .01$, *** $p < .001$.

The first block of the regression model included students' social demographics (e.g., trans identification, gender, sexual orientations, and underrepresented racial/ethnic identity) and explained an initial 19.3% of the variance ($R^2 = .193$, $\Delta F = 1.844$, $p = .098$). Academic demographics, GPA and grade level, were entered next and accounted for 1.7% of additional variance in feelings of departmental belonging ($R^2 = .210$, $\Delta F = .562$, $p = .160$). Independent variables (planned involvement, campus climate, engineering climate, and STEM identity) were entered into block 3 and accounted for an additional 41.4% of the variance ($R^2 = .624$, $\Delta F = 13.192$, $p < .001$).

Research Question 4

RQ4: *Does STEM identity or planned involvement mediate the relationships between climate and departmental sense of belonging for QT undergraduate engineering students, as measured by Knekta et al.'s (2020) Departmental Sense of Belonging Scale, LGBTQ College Climate Scale (Szymanski & Bissonette, 2020), Involvement Scale (Knekta et al., 2020), and STEM Professional Identity Overlap (McDonald et al., 2019)?*

Departmental Sense of Belonging & Campus Climate

STEM Identity. To investigate RQ4, a simple mediation analysis was performed. The outcome variable for analysis was departmental sense of belonging. The predictor variable for analysis was campus climate. The mediator variable for analysis was STEM identity. Multiple

regression analysis between departmental sense of belonging and campus climate was found to be significant ($p = .002$). In Step 2, results from multiple regression analysis between STEM identity and campus climate were not significant ($p = .077$). STEM identity was found to not be a mediating factor in this regression analysis.

Planned Involvement. To investigate RQ4, a simple mediation analysis was performed. The outcome variable for analysis was departmental sense of belonging. The predictor variable for analysis was campus climate. The mediator variable for analysis was planned involvement. Multiple regression analysis between departmental sense of belonging and campus climate was found to be significant ($p = .002$). In Step 2, results from multiple regression analysis between planned involvement and campus climate were not significant ($p = .308$). Planned involvement was found to not be a mediating factor in this regression analysis.

Departmental Sense of Belonging & Engineering Climate

STEM Identity. To further investigate RQ4 a simple mediation analysis was performed. The outcome variable for analysis was sense of belonging. The predictor variable for analysis was engineering climate. The mediator variable for analysis was STEM identity. Multiple regression analysis between sense of belonging and engineering climate was found to be significant ($p < .001$). In Step 2, results from multiple regression analysis between STEM identity and engineering climate were not significant ($p = .851$). STEM identity was found to not be a mediating factor in this regression analysis.

Planned Involvement. To further investigate RQ4 a simple mediation analysis was performed. The outcome variable for analysis was sense of belonging. The predictor variable for analysis was engineering climate. The mediator variable for analysis was planned involvement. Multiple regression analysis between sense of belonging and engineering climate was found to

be significant ($p < .001$). In Step 2, results from multiple regression analysis between planned involvement and engineering climate were not significant ($p = .139$). Planned involvement was found to not be a mediating factor in this regression analysis.

Research Question 5

RQ5: *How departmental sense of belonging, planned involvement, campus climate engineering climate, and STEM identity are experienced differently across students' identities.*

Departmental Sense of Belonging

Gender. In Table 10, a one-way ANOVA was used to examine whether there was a significant difference based on gender in the participants' perceptions of departmental sense of belonging. Results from the One-way ANOVA analysis on gender and perceptions of departmental sense of belonging revealed Between Groups significance, $[F(3,73) = 4.040, p = .010]$. Table 11 provides follow-up TUKEY's analysis for the significance found in the ANOVA test highlighted significance for Woman ($p = .008$) and Nonbinary ($p = .018$) participants when compared to Men. While Men's perceptions of departmental sense of belonging were highest ($M = 5.2$), there was no significance found ($p = .931$) between Nonbinary ($M = 4.5$) participants and Women ($M = 4.4$).

Sexual Orientation. To maintain the unique ways in which participants identified their sexual orientation, the researcher decided not to simplify sexual orientation data or create consolidated categories for data analysis. Rather, one-way ANOVA tests were run for each sexual orientation category to determine if there was any significant difference between participants who identified with a certain pair of identities (Aromantic/Asexual, Bisexual/Pansexual, Lesbian/Gay, or Queer) and those who did not. Additionally, an

independent sample t-test was run to examine whether the use of multiple labels to define one's sexual orientation resulted in any significant difference from use of a singular identity label.

In Table 10, a one-way ANOVA was used to examine whether there was a significant difference based on survey response options for sexual orientation. For departmental sense of belonging no significance was found between participants who identified as Aromantic/Asexual ($p = .554$) or Queer ($p = .736$). Significance was found between those participants who identified as Bisexual/Pansexual ($p = .011$) and Lesbian/Gay ($p = .019$) when compared to those who did not identify with either of these two pairs of identity labels. An independent samples t-test was conducted to compare the difference between the scores of 51 participants who selected one label to identify their sexual orientation ($M = 4.6$, $SD = .9$) and 23 participants who used multiple ($M = 4.7$, $SD = .5$) participants in their perceptions of departmental sense of belonging. The results from this analysis demonstrated no significance in their perceptions of departmental sense of belonging $t(67.477) = -.340$, $p = .735$.

GPA. In Table 10, one-way ANOVA tests were used to examine the difference between grade point average (GPA) and participant perceptions of departmental sense of belonging. Results from the analysis found no significance between GPA and departmental sense of belonging ($p = .350$).

Grade Level. In Table 10, a one-way ANOVA test examined the difference between grade level and participant perceptions of departmental sense of belonging. Results from the analysis found no significant differences between grade level and departmental sense of belonging ($p = .664$).

Table 10*One-Way ANOVA Analysis for Perceptions of Departmental Sense of Belonging*

Demographics		Sense of Belonging			F (3, 73)
Gender		n	M	SD	
Man		14	5.2	.7	4.04*
Nonbinary		34	4.5	.7	
Woman		23	4.4	.9	
Sexual Orientation					F (1, 73)
		n	M	SD	
Asexual/Aromantic					.354
Asexual/Aromantic		14	4.7	.6	
Not Selected		60	4.6	.9	
Bisexual/Pansexual					6.90*
Bisexual/Pansexual		41	4.4	.8	
Not Selected		33	4.9	.7	
Lesbian/Gay					5.73*
Lesbian/Gay		23	4.9	.7	
Not Selected		51	4.5	.8	
Queer					.12
Queer		19	4.6	.6	
Not Selected		55	4.6	.9	
GPA					F (3, 70)
		n	M	SD	
0.0-1		1	4.9	-	1.11
1.1-2		1	5.5	-	
2.1-3		11	4.3	1.0	
				1	
3.1-4		58	4.7	.8	
Grade Level		Sense of Belonging			F (3, 72)
		n	M	SD	
First-Year		13	4.8	.7	.53
Sophomore		11	4.6	.9	
Junior		14	4.8	.7	
Senior		35	4.5	.9	

Note: * $p < .05$

Table 11*Tukey Analysis Summary for Gender & Departmental Sense of Belonging*

	Mean Difference		
	Man	Nonbinary	Woman
Departmental Sense of Belonging			
Man	-	.72*	.84*
Nonbinary	-.72*	-	.12
Woman	-.84*	-.12	-

Note: * $p < .05$

Trans Identification. An independent-samples t-test was conducted to compare the difference between the scores of 31 trans-identified ($M = 4.5$, $SD = .8$) and 35 non-trans-identified ($M = 4.7$, $SD = .8$) participants in their perceptions of sense of belonging. The results from this analysis demonstrated no significance in their perceptions of departmental sense of belonging $t(63.713) = -1.206$, $p = .116$.

Underrepresented Racial/Ethnic Identity. Independent sample t-tests were conducted to compare the difference between participants who identified with a Underrepresented Racial/Ethnic Identity and White participants in their perceptions of sense of belonging. The 46 participants who identified as White ($M = 4.5$, $SD = .8$) compared to the 26 participants whose identification was included in the Underrepresented Racial/Ethnic Identity category ($M = 4.7$, $SD = .8$) demonstrated no significance in their perceptions of departmental sense of belonging $t(70) = -1.019$, $p = .637$.

Campus Climate

Gender. In Table 12, a one-way ANOVA was used to examine whether there was a significant difference based on gender in the participants' perceptions of campus climate. Results from the One-way ANOVA analysis on gender and perceptions of campus climate revealed no significance ($p = .530$).

Sexual Orientation. In Table 12, a one-way ANOVA was used to examine whether there was a significant difference based on survey response options for sexual orientation. For campus climate no significant effect was found between those who identified as Aromantic/Asexual ($p = .312$), Bisexual/Pansexual ($p = .832$), Lesbian/Gay ($p = .764$), or Queer identity ($p = .061$). An independent-samples t-test was conducted to compare the difference between the scores of 51 participants who selected one label to identify their sexual orientation ($M = 3.2$, $SD = 1.2$) and 23 participants who used multiple ($M = 3.6$, $SD = 1.4$) participants in their perceptions of campus climate. The results from this analysis demonstrated no significance effect found in their perceptions of campus climate $t(72) = -1.156$, $p = .252$.

GPA. In Table 12, one-way ANOVA tests were used to examine the difference between grade point average (GPA) and participant perceptions of campus climate. Results from the analysis found no significance between GPA and campus climate ($p = .756$).

Grade Level. In Table 12, one-way ANOVA tests were used to examine the difference between grade level and participant perceptions of campus climate. Results from the analysis found no significance between grade level and campus climate ($p = .523$).

Table 12

One-Way ANOVA Analysis for Perceptions of Campus Climate

Demographics		Campus Climate		
Gender				F (3,73)
		n	M	SD
	Man	14	2.9	1.1
	Nonbinary	34	3.5	1.5
	Woman	23	3.3	1.2
Sexual Orientation				F (1, 73)
		n	M	SD
	Asexual/Aromantic			1.04
	Asexual/Aromantic	14	3.0	.9
	Not Selected	60	3.4	1.4

Sexual Orientation	Campus Climate			F (1, 73)
<i>Bisexual/Pansexual</i>				.045
Bisexual/Pansexual	41	3.4	1.4	
Not Selected	33	3.3	1.2	
<i>Lesbian/Gay</i>				.091
Lesbian/Gay	23	3.3	1.4	
Not Selected	51	3.4	1.3	
<i>Queer</i>				3.62
Queer	19	3.8	1.2	
Not Selected	55	3.2	1.3	
GPA				F (3,70)
	n	M	SD	.396
0.0-1	1	3	-	
1.1-2	1	3.8	-	
2.1-3	11	3.7	1.4	
3.1-4	58	3.3	1.3	
Grade Level				F (3, 72)
	n	M	SD	.756
First-Year	13	3.1	1.0	
Sophomore	11	2.9	1.2	
Junior	14	3.3	1.6	
Senior	35	3.5	1.3	

Trans Identification. An independent-samples t-test was conducted to compare the difference between the scores of trans-identified ($M = 3.9$, $SD = 1.4$) and non-trans-identified ($M = 2.8$, $SD = .9$) participants in their perceptions of campus climate. The results from this analysis demonstrated significance in their perceptions of campus climate $t(50.195) = 3.607$, $p < .001$.

Underrepresented Racial/Ethnic Identity. Independent sample t-tests were conducted to compare the difference between participants who identified with a Underrepresented Racial/Ethnic Identity and White participants in their perceptions of campus climate. No significant effect was found for perceptions of campus climate $t(70) = -1.284$, $p = .931$ between the 26 participants who were URM ($M = 3.6$, $SD = 1.3$) and 46 who were White ($M = 3.2$, $SD = 1.3$).

Engineering Climate

Gender. In Table 13, a one-way ANOVA was used to examine whether there was a significant difference based on gender in the participants' perceptions of engineering climate. Results from the One-way ANOVA analysis on gender and perceptions of engineering climate revealed Between Groups significance, [$F(3,73) = 2.951, p = .039$]. In Table 14, a follow-up TUKEY's analysis for the significance found in the ANOVA test highlighted significance was found between Nonbinary and Men participants ($p = .020$) with Men reporting a less negative perception of engineering climate ($M = 2.4$) than Nonbinary participants ($M = 3.7$). Significance was not found for Women ($M = 3.3$).

Sexual Orientation. In Table 13, a one-way ANOVA was used to examine whether there was a significant difference based on survey response options for sexual orientation. For engineering climate no significant difference was found between those who identified as Aromantic/Asexual ($p = .588$), Bisexual/Pansexual ($p = .253$), Lesbian/Gay ($p = .337$), or Queer identity ($p = .098$). An independent-samples t-test was conducted to compare the difference between the scores of 51 participants who selected one label to identify their sexual orientation ($M = 3.2, SD = 1.4$) and 23 participants who used multiple ($M = 3.7, SD = 1.5$) participants in their perceptions of engineering climate. The results from this analysis demonstrated no significance in their perceptions of engineering climate $t(72) = -1.347, p = .182$.

GPA. Table 13, results from the one-way ANOVA tests used to examine the difference between grade point average (GPA) and participant perceptions of engineering climate are reported. Results from the analysis found no significance between GPA and campus climate ($p = .756$).

Grade Level. Table 13, One-way ANOVA tests were also used to examine the difference between grade level and participant perceptions of engineering climate. Results from the analysis found no significant differences between grade level and engineering climate ($p = .316$).

Table 13

One-Way ANOVA Analysis for Perceptions of Engineering Climate

Demographics		Engineering Climate			
Gender					F (3, 73)
	n	M	SD		2.95*
Man	14	2.4	1.3		
Nonbinary	34	3.7	1.4		
Woman	23	3.3	1.4		
Sexual Orientation					F (1, 73)
Asexual/Aromantic	n	M	SD		.297
Asexual/Aromantic	14	3.1	1.1		
Not Selected	60	3.4	1.5		
Bisexual/Pansexual					
Bisexual/Pansexual	41	3.5	1.5	1.33	
Not Selected	33	3.1	1.3		
Lesbian/Gay					.935
Lesbian/Gay	23	3.1	1.6		
Not Selected	51	3.4	1.4		
Queer					2.81
Queer	19	3.8	1.2		
Not Selected	55	3.2	1.5		
GPA		Engineering Climate			F (3, 70)
	n	M	SD		.80
0.0-1	1	2.2	-		
1.1-2	1	2.8	-		
2.1-3	11	3.9	1.5		
3.1-4	58	3.2	1.4		
Grade Level					F (3, 72)
	n	M	SD		1.2
First-Year	13	2.8	1.1		
Sophomore	11	3.1	1.7		
Junior	14	3.2	1.4		
Senior	35	3.6	1.5		

Note: * $p < .05$

Table 14*Tukey Analysis Summary for Gender & Engineering Climate*

	Mean Difference		
	Man	Nonbinary	Woman
Engineering Climate			
Man	-	-1.30*	-.93
Nonbinary	1.30*	-	.37
Woman	.93	-.37	-

Note: * $p < .05$

Trans Identification. An independent sample t-test was conducted to compare the difference between the scores of trans-identified ($M = 3.9$, $SD = 1.6$) and non-trans-identified ($M = 2.8$, $SD = 0.2$) participants in their perceptions of engineering climate. The results from this analysis demonstrated significance in their perceptions of engineering climate $t(53.767) = 3.368$, $p < .001$.

Underrepresented Racial/Ethnic Identity. Independent sample t-tests were conducted to compare the difference between participants' perceptions of engineering climate among those who identified with an underrepresented racial/ethnic identity and those who identified exclusively as White in their perceptions of engineering climate. No significance was found in their perceptions of engineering climate $t(70) = -.511$, $p = .462$ for the 26 participants who identified with an underrepresented racial/ethnic identity ($M=3.4$, $SD = 1.3$) and the 46 participants who identified as only White ($M=3.3$, $SD 1.5$).

STEM Identity

Gender. In Table 15, a one-way ANOVA was used to examine whether there was a significant difference based on gender in the participants' perceptions of STEM identity. Results from the One-way ANOVA analysis on gender and STEM identity revealed no significance ($p = .819$).

Sexual Orientation. In Table 15, a one-way ANOVA was used to examine whether there was a significant difference based on survey response options for sexual orientation. For STEM identity no significant difference was found between those who identified as Aromantic/Asexual ($p = .401$), Bisexual/Pansexual ($p = .650$), Lesbian/Gay ($p = .183$), or Queer ($p = .362$). An independent samples t-test was conducted to compare the difference between the scores of 51 participants who selected one label to identify their sexual orientation ($M = 4.1$, $SD = 1.2$) and 23 participants who used multiple ($M = 4.3$, $SD = 1.2$) participants in their perceptions of STEM identity. The results from this analysis demonstrated no significance in their perceptions of STEM identity $t(72) = -.424$ $p = .673$.

GPA. In Table 15, one-way ANOVA test examined the difference between grade point average (GPA) and participant perceptions of STEM identity. Results from the analysis found no significance between GPA and STEM identity ($p = .285$).

Grade Level. In Table 15, one-way ANOVA test examined the difference between grade level and participant perceptions of STEM identity. Results from the analysis found no significance between grade level and STEM identity ($p = .135$).

Table 15

One-Way ANOVA Analysis for Perceptions of STEM Identity

Demographics		STEM Identity			
Gender					F (3, 73)
	n	M	SD		.308
Man	14	4.2	1.0		
Nonbinary	34	4.3	1.2		
Woman	23	4.0	1.3		
Sexual Orientation					F (1, 73)
	n	M	SD		.713
Asexual/Aromantic					
Asexual/Aromantic	14	4.4	1.1		
Not Selected	60	4.1	1.2		

Sexual Orientation	STEM Identity			F (3, 73)
	n	M	SD	
<i>Bisexual/Pansexual</i>				.207
Bisexual/Pansexual	41	4.1	1.2	
Not Selected	33	4.3	1.1	
<i>Lesbian/Gay</i>				1.808
Lesbian/Gay	23	4.5	1.2	
Not Selected	51	4.1	1.2	
<i>Queer</i>				.842
Queer	19	3.9	0.8	
Not Selected	55	4.3	1.3	
GPA				F (3,70)
	n	M	SD	1.29
0.0-1	1	3.5	-	
1.1-2	1	4.3	-	
2.1-3	11	3.6	1.2	
3.1-4	58	4.4	1.2	
Grade Level				F (3, 72)
	n	M	SD	1.92
First-Year	13	3.5	.9	
Sophomore	11	4.0	1.3	
Junior	14	4.5	1.3	
Senior	35	4.3	1.1	

Trans Identification. An independent samples t-test was conducted to compare the difference between the scores of 31 trans-identified ($M = 4.2$, $SD = 1.2$) and 35 non-trans identified ($M = 4.1$, $SD = 1.1$) participants in their perceptions of STEM identity. The results from this analysis demonstrated no significance in their perceptions of STEM identity $t(64) = .394$, $p = .719$.

Underrepresented Racial/Ethnic Identity. Independent samples t-tests were conducted to compare the difference between identification with an underrepresented racial/ethnic identity and White identification among participants in their perceptions of STEM identity. No significance was found in the perceptions of STEM Identity ($p = .539$) between the 26 participants who identified with an underrepresented racial/ethnic identity ($M = 4.3$, $SD = 1.3$) and the 46 participants who identified exclusively as White ($M = 4.1$, $SD = 1.1$).

Planned Involvement

Gender. In Table 16, a one-way ANOVA was used to examine whether there was a significant difference based on gender in participant ratings of their planned involvement. Results from the One-way ANOVA analysis on gender and planned involvement revealed no significance ($p = .162$).

Sexual Orientation. In Table 16, a one-way ANOVA was used to examine whether there was a significant difference based on survey response options for sexual orientation. Regarding participant planned involvement no significant difference was found between those who identified as Aromantic/Asexual ($p = .657$), Bisexual/Pansexual ($p = .087$), Lesbian/Gay ($p = .272$), or Queer ($p = .571$). An independent samples t-test was conducted to compare the difference in planned involvement reported between the scores of 51 participants who selected one label to describe their sexual orientation ($M = 4.1$, $SD = 1.2$) and 23 participants who used multiple ($M = 4.1$, $SD = .7$). The results from this analysis demonstrated no significance in their anticipated involvement $t(72) = .088$, $p = .930$ during this academic year.

GPA. In Table 16, one-way ANOVA tests were used to examine the difference between grade point average (GPA) and participant perceptions of planned involvement. Results from the analysis found no significance between GPA and planned involvement ($p = .895$).

Grade Level. In Table 16, one-way ANOVA tests were used to examine the difference between grade level and participant perceptions of their planned involvement. Results from the analysis found no significance between grade level and their planned involvement ($p = .385$).

Table 16*One-Way ANOVA Analysis for Participant Planned Involvement*

Demographics		Involvement			F (3, 73)
Gender		n	M	SD	
Man		14	4.6	1.2	1.76
Nonbinary		34	4.1	0.8	
Woman		23	3.8	1.3	
Sexual Orientation					F (1, 73)
		n	M	SD	.20
Asexual/Aromantic					3.02
Asexual/Aromantic		14	3.9	0.8	
Not Selected		60	4.1	1.1	
Bisexual/Pansexual					1.22
Bisexual/Pansexual		41	3.9	1.1	
Not Selected		33	4.3	1.0	
Lesbian/Gay					.32
Lesbian/Gay		23	4.3	1.2	
Not Selected		51	4.0	1.0	
Queer					F (3, 70)
Queer		19	3.9	0.8	
Not Selected		55	4.2	1.2	
GPA					.202
		n	M	SD	
0.0-1		1	4.9	-	F (3, 72)
1.1-2		1	4.1	-	
2.1-3		11	4.1	0.9	
3.1-4		58	4.1	1.1	
Grade Level					1.03
		n	M	SD	
First-Year		13	4.3	0.7	
Sophomore		11	4.5	0.6	
Junior		14	4.1	1.1	
Senior		35	3.9	1.3	

Trans Identification. An independent samples t-test was conducted to compare the difference between the scores of 31 trans-identified ($M = 4.0$, $SD = .8$) and 35 non-trans identified ($M = 4.2$, $SD = 1.2$) participants in their planned involvement. The results from this analysis demonstrated no significance in their planned involvement $t(58.90) = -.682$, $p = .498$.

Underrepresented Racial/Ethnic Identity. Independent sample t-tests were conducted to compare the difference between participants who identified with an underrepresented racial/ethnic identity ($n = 26$) and those who identified exclusively as white ($n = 46$). Participants who reported underrepresented racial/ethnic identities reported statistically significant $t(70) = -2.267$, $p = .026$, higher anticipated involvement ($M = 4.5$, $SD = 1.1$) when compared to White participants ($M = 3.9$, $SD = 0.9$) in this study.

Conclusion

This chapter provides the results of the study designed to explore the relationships between departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity for undergraduate QT engineering students. Scale results highlight that participant experiences were slightly positive across all main variables. The results from this study indicated that there is a significant correlation between participant perceptions of departmental sense of belonging and their perceptions of campus climate, engineering climate, planned involvement, and STEM identity. Increases in identification as a STEM professional (increasing STEM identity) and increasing plans to be involved in their engineering department has a positive impact on departmental sense of belonging while negative perceptions of campus and engineering climates negatively impacts sense of belonging. Neither engineering nor campus climates were significantly correlated to student perceptions of their STEM identities or planned involvement. Neither STEM identity nor involvement were found to have a mediating effect on the relationships of either campus or engineering climate on departmental sense of belonging.

While student perceptions of campus climate are significantly correlated to departmental sense of belonging, results from hierarchical regression analysis found no significance for campus climate as a predictor of departmental sense of belonging. Independent variables found

to be significant were engineering climate, planned involvement, and STEM identity. Additionally, no social nor academic demographics were found to be significant predictors of departmental sense of belonging. One-way ANOVA analysis to test for between-group differences found that women and nonbinary students experienced a lessened perception of departmental sense of belonging when compared to men participants in this study. Additionally, significant differences in perceptions of engineering climate were found between nonbinary participants and men. Finally, transgender participants demonstrated, when compared to their non-trans-peers, a significant difference in their perceptions of campus and engineering climate with trans student perceiving more hostile climates in both contexts.

In addition to gender and trans identification, between-group differences were also found across sexual orientation and underrepresented racial/ethnic identity. Specifically, participants who held underrepresented racial/ethnic identities reported higher rates of anticipated involvement compared to White students. Finally, regarding sexual orientation, significant between-group differences were found for those who identified as Bisexual/Pansexual Lesbian/Gay when compared to those who did not in their perceptions of departmental sense of belonging. Specifically, participants who identified as Bisexual/Pansexual reported lower levels of departmental belonging than those participants who were not Bisexual or Pansexual. Among the 23 participants who identified solely or in combination as Lesbian/Gay they reported higher rates of departmental belonging than the 51 participants who identified as non-Lesbian/Gay.

In the next chapter, I will provide a discussion of the key findings, limitations of the study, implications for practice, and recommendations for future research.

CHAPTER 5

DISCUSSION

This last chapter is a discussion of the results from Chapter Four. This chapter includes an overview of the study and the research questions, then offers a discussion of results and key findings, limitations, implications for practice, and recommendations for future research.

The purpose of this study is to examine the relationship between collegiate experiences of perceptions of departmental sense of belonging, planned involvement, STEM identity, and perceived campus and engineering climates among undergraduate QT engineering majors.

Research questions sought to understand

1. The characteristics of QT undergraduate engineering students and what their experiences of departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity?
2. How departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity are correlated to one another among QT engineering students?
3. After controlling for students' demographic characteristics, what are predictors of departmental sense of belonging among QT engineering students?
4. Does STEM identity or planned involvement mediated the relationship between climate and departmental sense of belonging for QT undergraduate engineering students?
5. How departmental sense of belonging, campus climate engineering climate, planned involvement, and STEM identity are experienced differently across students' identities.

Summary Of Findings

I analyzed the data and conducted statistical analysis to answer the research questions that guided this study. Significance was found in the positive correlation of departmental sense of belonging with STEM identity and planned involvement. Additionally, the negative correlation found between campus and engineering climates and departmental sense of belonging was significant. A significant, positive correlation was also found between engineering climate and campus climate. Among the main and demographic variables, predictors of departmental sense of belonging were found to be engineering climate, STEM identity, and planned involvement.

Upon further examination of participant experiences with the main variables, between-group differences were found in participant perceptions of departmental sense of belonging and engineering climate across gender categories. Specifically, women were more likely to report negative perceptions of departmental sense of belonging and nonbinary participants were more likely to report negative perceptions of departmental sense of belonging and engineering climate when compared to men. Significant difference was also found among Bisexual/Pansexual and Lesbian/Gay participants in their perceptions of departmental belonging. Regarding planned involvement, participants who held Underrepresented Racial/Ethnic Identities reported higher rates than their White peers. Finally, more negative perceptions of climate and engineering climates were found for participants who identified as transgender when compared to those who were not trans-identified.

Discussion of Findings

Research Question 1: *The characteristics of QT undergraduate engineering students and their experiences of departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity?*

Participant Characteristics

To understand key characteristics among QT undergraduate engineering students, data was analyzed using frequencies, means, and standard deviations. In this study, 41.9% of all participants identified as transgender (n = 31) and 77% would be classified as holding an underrepresented gender identity. Specifically, 31.1% of study participants were women and 45.9% of participants held a nonbinary gender identity. Among all degree granting institutions, women accounted for 25% percent of all bachelor's degrees awarded in engineering for academic year 2021-2022 (National Center for Education Statistics, 2024), this data is not inclusive of nonbinary students who also graduated during this timeframe. While little is known about nonbinary gender representation in engineering, a national study on transgender individuals found that 31% of the transgender population identified as nonbinary (James et al., 2016). James et al. (2024), found in the 2022 U.S. Transgender Survey that among all transgender participants, 38% identified as nonbinary. In this study, nonbinary identification among transgender participants was 74.2%.

Regarding racial/ethnic identity, 35% of participants identified with an underrepresented racial/ethnic identity (n = 26). When it comes to sexual orientation, all participants identified with a queer sexual orientation. Meaning no participants, in isolation or combination, selected straight/heterosexual to define their sexual orientation. This finding is dissimilar from past research which found among transgender adults that the most frequently selected sexual

orientation identities were bisexual (18.9%), queer (18.1%), and straight (17.6%) (Reisner et al., 2023). Sexual orientation, trans identification, and gender identity may have been impacted by the limited number of first and second-year students in this study. Specifically, participants in this study were more advanced in their academic careers with juniors and seniors comprising 63.7% of all participants. The age of our participants may have also had an impact on the average means recorded across each of the scales used in this study to examine departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity.

Descriptive Statistics of Main Variables

As previously stated, reliability testing was conducted and the Cronbach's alpha scores for each variable were above .70, which Christopher (2017) defined as the minimal level for social science research.

Departmental Sense of Belonging. Departmental sense of belonging was measured by the Belonging sub-scale with participants being able to rank their perceptions from Strongly Disagree (1) to Strongly Agree (6). The survey instrument provided students with the option to select "prefer not to respond" for each scale item. Among all participants the response average for the Belonging sub-scale was Slightly Agree to Agree. This sub-scale did not allow for a Neutral response option, meaning the departmental sense of belonging experienced by the participants in this study was slightly more positive than negative. This study did not include a comparison group of cisgender and heterosexual participants, meaning it is impossible to say if results from this study parallels past research which found lessened perceptions of sense of belonging for QT students (Cech & Waidzunas, 2009; Hughes, 2017; Hughes, 2018, Skorodinsky, 2024) when compared to their non-QT peers.

Campus Climate. Regarding campus climate, response options were available to participants that ranged from a Strongly Disagree (1) to Strongly Agree (7) with a neutral score of 4. Reminder that lower scores are associated with a more positive perception of climate. Engineering and institutional climate were reported at similar levels with responses falling in the Slightly Disagree to Neutral range. Past campus climate literature often highlights the challenges QT students experience with their campus climates citing direct experiences with microaggressions (Dortch & Patel, 2017; Leyva, 2022; Ovink et al., 2024) and explicit and implicit forms of anti-gay discrimination (Cech & Waidzunus, 2021; Strayhorn, 2019). The results from this study offer new perspectives for QT undergraduate engineers as past research focuses on experiences of bias or discrimination while this study centers on the perceptions of a supportive campus climate.

Engineering Climate. Engineering climate was assessed in this study utilizing a modified version of the LGBTQ College Campus Climate Scale (Szymanski & Bissonette, 2020). Perceptions of engineering climate among study participants mirrored those found for campus climate and the average response provided was that participants Slightly Disagreed or were Neutral with their perceptions of a negative engineering climate. Hughes (2018) found that for 36.2% of students who leave STEM before their senior year, climate and culture are often non-academic factors that contribute to STEM departure for sexual minorities. Perceptions of engineering climate experienced by the participants of this study are likely to be influenced by the portion of study respondents who are in their senior year. QT students who make it to senior year may be more likely to have developed coping strategies to navigate the hostile environment of engineering where students have been found to experience more situations of exclusion than in other areas of their campus (Cech, 2022; Cech & Waidzunus, 2021; Trenshaw et al., 2013).

STEM Identity. Findings in this study highlighted that QT undergraduate engineering students perceive a generally positive science identity and identified their identity overlap at $\frac{1}{2}$ to $\frac{3}{4}$ of the way overlapped with that of a STEM professional. These results, particularly given the higher proportion of participants in their fourth year, align with research on STEM identity that found that a STEM identity was the strongest predictor of retention in STEM to a fourth year (Hughes, 2018).

Planned Involvement. Finally, participants averaged a mean score on the 12-item involvement sub-scale (Knetta et al., 2020) that trended positively with a Slightly Agree to Agree response average to questions about outside the classroom involvement with engineering faculty, staff, and peers in this academic year. While data on QT involvement in academic disciplines is limited, Hughes (2018) did find that sexual minority STEM students were more likely to have participated in undergraduate research when compared to their heterosexual peers. The higher rates of engagement among study participants are aligned with these research findings where students demonstrated intentions to be involved in their departments through a variety of ways.

Research Question 2: How are sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity correlated to one another among QT engineering students?

Correlations between independent variables campus climate, engineering climate, planned involvement, and STEM identity were each found to be significant in their correlation to the dependent variable, departmental sense of belonging. The strength of the correlation, as defined by Cohen (1988), between departmental sense of belonging and STEM identity ($r = .31$), planned involvement ($r = .60$), campus climate ($r = -.35$), and engineering climate ($r = -.477$) are moderate, strong, moderate, and moderate, respectively. Findings of significant correlation align

with past research on the influence that negative experiences with climate have on QT student experiences with belonging (Cech & Wadzunas, 2011; Miller & Downey, 2020; Strayhorn, 2019). Specifically, and replicated in this study, negative experiences in climate at the campus or department level resulted in more negative perceptions of departmental sense of belonging. Alternatively, planned involvement and STEM identity were positively correlated to departmental sense of belonging which aligns with past research (Carlone & Johnson, 2007; Frank et al., 2023; Hughes, 2018; Rainey et al., 2008). Results from the correlation analysis align with the theoretical framework emphasizing the connections between environment, involvement, and relationships influence on student experiences with sense of belonging (Carlone & Johnson, 2007).

The correlations found among the main independent variables in this study were found to be weak, falling between .10-.29 (Cohen, 1988) and not significant. This finding offers a new perspective from previous research which emphasizes the prevalence of heteronormative STEM environments that limit the ability of LGBTQ+ students from fully participating in their STEM discipline (Miller et al., 2020; Woodford & Kulick, 2014). Specifically, past research would predict a significant, negative correlation between climate and planned involvement that was not found in this study.

Research Question 3: After controlling for students' demographic characteristics, what are predictors of departmental sense of belonging among QT engineering students?

Modeled after Vaccaro and Newmans' (2016) Model of Sense of Belonging for Privileged and Minoritized Students, a hierarchical multiple regression analysis was performed to identify what were the predictors for departmental sense of belonging among QT undergraduate engineering students. After controlling for academic and social demographic

characteristics, among QT undergraduate engineering students, planned involvement and STEM identity were significant positive predictors for departmental sense of belonging, whereas engineering climate was a significant negative predictor of departmental sense of belonging.

Findings in this study align with past research that has found anti-LGBTQ bias in engineering climate (Cech & Rothwell, 2018) and that negative climate experiences are associated with a lessened sense of belonging (Evans et al., 2017; Strayhorn, 2019; Vaccaro & Newman, 2017). The importance of peer and relational connections which are associated with stronger STEM identity and involvement have also been found to be positive contributors to sense of belonging for QT students (Duran et al., 2022; Lange et al., 2019; Skorodinsky, 2024; Vaccaro & Newman, 2017).

Engineering Climate

Past research has shown that LGBTQIA students lack a sense of belonging in STEM fields (Strayhorn, 2019) and experience anti-LGBTQ bias (Cech & Rothwell, 2018). Findings in this study on engineering climate align with this literature, specifically negative perceptions of STEM climate have a direct impact on participant sense of belonging (Cech & Waidzunas, 2021; Dortch & Patel, 2017). While this study did not compare QT undergraduate engineering students to their heterosexual, cisgender peers, a slightly positive perception of departmental sense of belonging was found among the QT participants in this study which may be dissimilar to past research (Cech & Rothwell, 2018). The findings also aligned with the importance of environment as a factor for how students experience belonging (Vaccaro & Newman, 2016). Interventions to address STEM sense of belonging must address climate issues at the departmental level (Cech & Rothwell, 2018). Institutional efforts, as evidenced in this study, will not lend to significant changes in departmental sense of belonging.

Planned Involvement

The significance and strong correlation of planned involvement and departmental sense of belonging in this study aligns with current literature on the connections between sense of belonging in STEM environments and co-curricular/extracurricular involvement among underrepresented students (Forsythe et al., 2023; Litzler & Samuelson, 2013; Nelson, 2024). When looking at QT students specifically, findings from this study identify planned involvement as a significant predictor for sense of belonging which is reflected in past literature that found increases in sense of belonging in STEM among QT students who were involved in LGBTQ STEM clubs/student organizations (Forsyth et al., 2023; Hughes, 2017) and the effects of negative social climates on LGBTQ professional outcomes (Cech et al, 2021). While involvement in LGBTQ STEM-based clubs/student organizations was not assessed in this study, the significance of planned involvement on the sense of belonging of QT undergraduate engineering students is clear.

STEM Identity

STEM identity, also referred to as science identity, has been found to be a key factor that is essential to a sense of belonging among current and previous STEM majors (Chen et al., 2020; Rainey et al., 2018). Hughes (2018) found that STEM identity was the strongest predictor of retention to fourth year. Findings from this study support this research and our theoretical framework. Specifically, our theoretical framework identifies relationships as one of three factors for sense of belonging experienced by privileged and minoritized students. STEM identity, used as a proxy for social relationships in this study, was also found to be a significant predictor of sense of belonging among QT undergraduate engineers. Supportive social

environments and established interpersonal relationships are also factors that contribute positively to LGBTQ scientist work environments (Cech et al., 2021; Cech & Waidzun, 2022). These findings support the use of STEM identity, or the ability to see oneself as a member of community of scientists (Carlone & Johnson, 2007), as a proxy for social relationships.

Research Question 4: Does STEM identity or planned involvement mediate the relationship between campus climate and departmental sense of belonging for QT undergraduate engineering students?

Mediation analysis was conducted to examine if planned involvement or STEM identity had any mediating effects on the relationship between campus or engineering climate and departmental sense of belonging. Neither mediation analysis on planned involvement nor STEM identity were found to be significant in mediating the effects of campus or engineering climate on departmental sense of belonging. Vaccaro & Newman (2016) found that factors that contributed to participant sense of belonging were the environment, social relationships, and campus involvement. The findings in this study align with this literature. Specifically, despite the positive impact of increased plans for involvement and developed STEM identity as positive predictors of departmental sense of belonging they do not mediate the negative impact of a hostile climate. While not significant, the results from these analyses are important to understanding the experiences of QT undergraduate engineering students and what institutions and academic departments must do to address their barriers to belonging.

Research Question 5: How are departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity are experienced differently across students' identities.

Departmental Sense of Belonging

When it comes to departmental sense of belonging, between-group differences were found across gender and sexual orientation. Specifically, when compared to men, women and nonbinary participants reported significantly lower perceptions of departmental belonging. These findings align with past research that has found gender to be a predictor of belonging for women in STEM fields (Rainey et al., 2018; Seymour & Hewitt, 1997; Strayhorn, 2019; Walton & Cohen, 2007). Regarding sexual orientation, participants who identified as bisexual/pansexual or lesbian/gay reported significant between group differences when compared to students who did not identify in those ways. BrckaLorenz et al. (2021) found that bisexual students, when compared to other sexual orientations reported more than average sense of belonging. Findings from this study offer a new perspective as Bisexual/Pansexual students reported lower perceptions of departmental belonging ($M = 4.40$) compared to non-Bisexual/Pansexual peers ($M = 4.88$). Gay/Lesbian students reported a higher perception of departmental belonging ($M = 4.93$) compared to their non-Gay/Lesbian peers ($M = 4.47$). Duran et al. (2022) in a study on LGBTQ+ students of color found that gay students reported a more positive sense of belonging which is aligned in this study.

Campus Climate

Among survey participants, significant between group differences were found in perceptions of campus climate between participants who identified as trans and those who did not. Trans-identified participants were more likely than their non-trans-identified peers to report negative perceptions of campus climate. This finding aligns with past research that found that campus climate can be especially challenging for transgender and nonbinary members of the

LGBTQ community (James et al., 2016 as cited in Lange et al., 2019, p. 512). Vaccaro and Newman (2016) defined factors of a hostile environment for minoritized students as those that 1) restrict authenticity, make the student feel that they are the only one, and treat them differently. Utilizing the theoretical framework to understand trans experiences with campus climate, we can theorize that they are more likely to report negative perceptions of campus climate because the factors that facilitate supportive campus climates are missing for this population of students. Simply put, not only were institutions of higher education not built for trans students; they are regularly organized in ways that create barriers for trans students and how they navigate the campus environment. When it comes to campus climate, these findings diverge from previous literature that highlighted the significance of underrepresented racial/ethnic identity or intersectional barriers to campus climate for LGBTQ scientists (Cech, 2022; Douglas et al., 2024)

Engineering Climate

Among the participants of this study, significant between-group differences were found in perceptions of engineering climate. Nonbinary participants were significantly more likely than their men peers to perceive an unsupportive engineering environment. Additionally, trans identification also revealed significant between-group differences in perceptions of engineering climates. Specifically, trans-identified participants reported less positive, or more negative, perceptions of their engineering climates. Among study participants, trans students reported the most negative perception of climate within their engineering departments. These findings support the work of Miller and Downey (2020) that found that STEM environments have continually been found to not have an inclusive climate for students who are different in their gender. While trans students experienced significant differences in both climate types from their non-trans-

identified peers, this was not the case for nonbinary students. Nonbinary students only experience significant negative perceptions with their engineering climate. These findings lend support for the saliency in gender in navigating engineering and other STEM climates.

Planned Involvement

On-campus involvement has long been associated with contributing to a student's sense of belonging on campus (Thornhill et al., 2023). The benefits of QT involvement, especially in QT-themed/centered resource centers or student organizations are well documented (Coley & Das, 2020; Vaccaro & Mena, 2011). When it comes to QT involvement in academic practices (research, office hours, etc.) queer students have been found to participate in undergraduate research at higher rates than their heterosexual peers (Hughes, 2018). The benefits of involvement for underrepresented students are clear (Demetriou et al., 2017) but significant barriers exist in their ability to access these opportunities (Havlik et al., 2020). In this study, planned involvement among QT students who also hold underrepresented racial/ethnic identities was reported at higher rates than their White peers. This difference in planned involvement was statistically significant and offers a new perspective to involvement research among QT students who hold underrepresented racial/ethnic identities.

STEM Identity

A lack of significant between-group findings for STEM identity among study participants are unique when compared with the science identity model created by Carlone and Johnson (2007) and past literature (Hazari et al., 2013; Rainey et al., 2008). Carlone and Johnson's model, which was utilized in this study, assumes that gender, racial, or ethnic identity affect one's science identity (2007). A lack of significant findings between different gender categories and in the comparison of participants who hold underrepresented racial/ethnic identities to their

White peers offers new consideration regarding STEM identity for QT undergraduate engineering students. This finding also resonates with past research that found STEM or science identity to be more developed in higher level students (Hughes, 2018). Non-significant between-group differences may have been the result of the relative age, majority juniors and seniors, who participated in this study.

Connections to Theoretical Framework

The Model of Sense of Belonging for Privileged and Minoritized (Vaccaro & Newman, 2016) was utilized as the theoretical framework in this study. This model demonstrates that sense of belonging is influenced by factors like the environments, relationships, and involvement for both privileged and minoritized students. In this study significant predictors for departmental sense of belonging were engineering climate, planned involvement, and STEM identity. Findings in this study align with the theoretical framework with inclusive departmental climate (environment), greater involvement, and more solidified STEM identity (relationships) contributing to a greater perception of departmental sense of belonging among QT undergraduate engineers. While the model was developed to examine institutional belonging and institutional environments, results from this study highlight the importance of considering belonging and environment at both departmental and institutional levels as campus climate was not found to be a significant predictor for departmental sense of belonging.

Vaccaro and Newman (2016) also found that in college environments, minoritized students “required an environment where students could be their authentic selves” (p. 933) to feel belonging. While significant between-group differences were found in climate experiences across gender and trans-identification and higher rates of planned involvement for participants who hold underrepresented racial/ethnic identities were reported, the lack of demographic

predictors for sense of belonging is surprising given the large body of literature that highlights the White, heteronormative, masculine climate of engineering (Casad et al., 2018; Evans et al., 2017; Rainey et al., 2018; Vaccaro & Newman, 2017) which is likely to limit QT student ability to be their authentic self.

Limitations

This quantitative study focused on departmental sense of belonging, perceived campus and engineering climates, planned involvement, and STEM identity among QT undergraduate students majoring in engineering. For practitioners and researchers wanting to use the findings, the limitations of the study must be taken into consideration. The first limitation is sample size. This study engaged 185 individuals, resulting in 74 participants. Results from the study, and their findings, may differ if a larger sample size was achieved.

Second, the representativeness of the study sample has some limitations. Among the participants in this study, Hispanic or Latinx/e (7.4%) and those who identified with *Two or More Races* (1.2% of participants identified as biracial) are underrepresented when compared to the National Center for Education Statistics (2023). Among all bachelor's engineering degrees conferred in 2020, 56.65% were granted to White students, 4.45% to those who are Black/African American, 13.03% to Hispanic/Latino, 12.71% to Asian & Pacific Islander, 4.09% to students who identified with *Two or More Races*, and less than 1% of all bachelor level engineering degrees were awarded to American Indian/Alaska Native (NCES, 2023). Despite the proportional representation of Black or African American, Asian or Asian American, or American Indian or Alaskan Native students when it comes to departmental sense of belonging, campus climate, engineering climate, involvement, or STEM identity the findings from this study are not generalizable to the experience of students who hold underrepresented racial/ethnic

identities in engineering or other STEM environments. Additionally, while data analysis was conducted comparing participants who hold an underrepresented racial/ethnic identity to their white peers, representation among participants of color was not substantial enough to conduct between group differences for participants who hold underrepresented racial/ethnic identities.

Third, this study only surveyed engineering students from a few institutions of higher education. Limitations exist when applying these findings to QT undergraduate student experience in other academic units, within or outside of STEM, and to students enrolled at different institutions or institutional types. Additionally, STEM-supportive pre-college experiences have been found to have a direct impact on the strength of an individual's science identity (Carlone & Johnson, 2007) but were outside the scope of this study and were not considered in the data collection or analysis phases.

Finally, this study explores student perceptions of departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity at a specific moment in their undergraduate career. Participant's self-reported ranking of each of these variables, through the associated scales, represents what they were feeling then and may differ if they had engaged with the survey at a different time.

Implications for Future Research

This study explored departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity among QT undergraduate engineering students. Findings from this study add to a growing body of literature and highlight the need for additional research into key elements of the academic experiences of QT students. Specifically, more research is needed that broadens the focus of this study beyond engineering departments to explore the concepts of departmental sense of belonging, campus climate, engineering climate,

planned involvement, and STEM identity for all QT undergraduate STEM majors. As the study was small ($n = 74$), a larger study is needed to examine the relationships between the main variables and QT undergraduate engineering student experience. Past research highlights the impact that pre-college experiences have on STEM identity (Carlone & Johnson, 2007) so studies that include this variable in their scope are needed.

Next, the level of outness has been found in the literature to impact QT sense of belonging and perceptions of climate (Garvey & Rankin, 2015a; Garvey & Rankin, 2015b; Garvey et al., 2018). Studies that include level of outness as a research variable are also needed to nuance the understanding of undergraduate QT experience. Another way to nuance our understanding of QT student experience is to conduct studies that are multi-wave longitudinal or have a more equal distribution among grade levels. Among all participants in this study, 63.7% were in their junior or senior year. Future research that has greater representation among first- and second-year students is needed to best address the needs of QT undergraduate student's belonging, climate, and involvement experiences as they navigate through their programs of study.

From the findings, several instances emerged where social demographics contributed to significant between-group differences. Larger studies are needed to further examine the significance of trans, women, nonbinary, lesbian/gay, bisexual/pansexual, and underrepresented racial/ethnic identification for QT undergraduate students. The significance of trans and nonbinary identity calls for future research that utilizes inclusive data practices. Practices must include incorporation of gender, trans identification, and sexual orientation (Myanna, 2023; The Consortium of Higher Education LGBT Resource Professionals, 2024). The inclusion of nonbinary genders and trans-identification in future research on perceptions of climate and

departmental sense of belonging is needed as both were significant in their relationship to engineering climate. Finally, qualitative methodology may serve as a more effective tool to better explain the differences in perceptions around belonging, climate, involvement or planned involvement, and STEM identity shared by the participants in this study.

A final suggestion for future research is to continue distinctions between institutional belonging, department belonging, campus climate, and engineering climate. While this study did not examine institutional belonging, campus climate was not found to be a significant predictor of departmental sense of belonging. Future research that differentiates between experiences at the departmental and institutional level are needed to better understand student experience.

Implications for Practice

This study identified planned involvement, engineering climate, and STEM identity as significant predictors of departmental sense of belonging for QT undergraduate students. There are several meaningful implications for practice that can be pulled from the findings of this study.

Departmental Sense of Belonging

As anticipated, departmental sense of belonging is correlated with campus climate, engineering climate, planned involvement and STEM identity are correlated to one another among QT engineering students. Predictors of departmental sense of belonging identified in this study are engineering climate, STEM identity, and planned involvement. Findings from this study emphasize the need to create department specific interventions that target the specific needs of QT students in STEM environments. Larger, campus-wide initiatives, that focus on bettering the campus climate for QT individuals will not impact QT students' sense of belonging at the department level. Faculty and academic units, in consultation with student affairs offices that

serve QT populations, are best equipped when working collaboratively to address departmental barriers to engineering climate and departmental belonging. Engineering faculty and administrators bring an expertise and credibility that resource center professionals, like myself, are less likely to leverage when working on enhancing QT experiences in engineering fields.

Gender equity initiatives in engineering that have shifted their practices to expand to all marginalized genders (women, nonbinary, trans, etc.) is supported by this study. Individual chapters of the Society for Women Engineers have had great success as they have expanded their programs, resources, and membership to include people of all underrepresented gender identities. Gender, specifically identifying as a woman or nonbinary, was associated with less positive perceptions of departmental sense of belonging. Additionally, sexual orientation was also a student demographic that saw significant between-group difference on perceptions of departmental sense of belonging. These findings counter current STEM climate practices of pushing issues of gender and sexual orientation to spaces outside of STEM (Friedensen et al., 2021) and point to the importance of raising QT visibility and the saliency of a QT identity for engineering students in efforts to increase departmental sense of belonging. The saliency of gender and sexual orientation to perceptions of departmental sense of belonging demonstrate the importance of addressing climate head on as campuses are unable to mediate the impact of an unsupportive climate through increasing QT involvement or strengthening STEM identity.

Engineering Climate

Negative perception of campus climate, while correlated, is not a predictor of departmental sense of belonging in this study. This finding is dissimilar from past research that highlights students feeling a sense of belonging is enhanced by positive perceptions of campus climate (Duran et al., 2022; Parker, 2021). This difference emphasizes the importance of considering key

differences between sense of belonging at the institutional versus departmental levels. It also points to the importance of targeting intervention strategies at both the institutional and departmental level to address climate barriers. Resource Centers that support QT populations, which are currently under attack, cannot be the only spaces on campus where QT engineering students are able to engage authentically.

Since engineering climate was found to be a significant predictor for departmental sense of belonging in this study, strategies that target the climate in engineering will be more effective than those that attempt to target overall campus climate. These findings suggest that for institutions looking to enhance departmental sense of belonging among QT engineering students, intervention strategies must occur at the departmental level. Specifically, findings from this study emphasize the need for intervention strategies that specifically target the engineering climate experienced by nonbinary, and trans-identified students. While student affairs led initiatives to address climate issues are essential, engineering departments must also be committed to climate change work. For example, policy and practice changes that target gender equity, that expands beyond the experiences of cisgender women, will enhance the departmental sense of belonging for QT undergraduate engineering students who are nonbinary and trans-identified. Increasing the QT visibility in academic settings and adopting policies and practices, like those put forth by the Consortium of Higher Education LGBT Resource Professionals, which are supportive of trans and nonbinary students in higher education are needed (2024).

Language & Terminology for QT Individuals

Among survey respondents 45.95% identified nonbinary, genderqueer or agender either singularly or in combination with the gender identities of man or woman. Nonbinary and genderqueer individuals commonly have gendered experiences that do not align with the

male/man and female/woman binary that is present in STEM environments. The prevalence of a nonbinary/genderqueer identity and overall trans identification 41.9% highlights clear implications for institutional practice, procedure, and policy change that creates space for students who do not identify as cisgender men or women. Additionally, it should be noted that among nonbinary participants who responded to the item on trans-identification, 26% (n = 6) did not identify as trans while holding a nonbinary/genderqueer identity label. This disrupts common practice of applying a trans-identification to all individuals who identify as nonbinary/genderqueer and narrowing the definition of nonbinary to mean “not a man or woman”. When it comes to sexual orientation, many participants in this study utilized more than one identity label to define their sexual orientation. Participant selection of a range of terms to explain their sexual orientation is continued support of the complexity of sexual orientation and will allow supportive measures to be most effective. Finally, while no participants identified as heterosexual/straight in this study, this should not be taken as evidence that all students who identify as members of the QT community would not utilize these terms, solo or in combination, to describe their sexual orientation.

As previously stated, inclusive data practices must be incorporated into larger institute data practices, departmental evaluations and assessments, and student data systems. In the growing higher education landscape of data-informed decision making, accurate, and inclusive data practices, provide usable data about the experiences of QT students which are often missing for those of us who work in higher education. Inclusive data practices at all levels, from program assessments to larger institution-wide assessments, must incorporate QT inclusive data practices to get a fuller picture of QT student experiences, success, and retention. Additionally, it allows institutions to capture students who navigate our campus communities with multiple

marginalized identities which have been found to influence student experiences with climate and belonging (Strayhorn, 2019).

STEM Identity & Involvement

While the saliency of a STEM identity was not found to mediate the relationship between departmental sense of belonging and campus or engineering climates, it still provides a key avenue to institutions looking to support marginalized student experience in engineering programs. Specifically for students who are QT, campuses should identify ways to strengthen STEM identity as it is a significant predictor of departmental sense of belonging. I've seen programs like Queer Science, a high school outreach program for QT students interested in STEM, may provide a specific opportunity to enhance STEM identity while creating involvement opportunities for QT engineers. Since its founding in 2016 by Dr. Juliet Johnston at the University of Minnesota, Queer Science has expanded to the University of Connecticut and Georgia Tech. Queer Science provides interested high school students with an opportunity to connect with and learn from QT college students, faculty, and researchers (Georgia Tech, 2024). This program also provided an opportunity for QT undergraduate students to find mentorship with involved graduate students, learn about other engineering disciplines, and strengthen their professional skills around organization, planning, and communication. In addition to enhancing peer-to-peer relationships and connections to faculty, thus resulting in increases in STEM identification, youth outreach programs also have the potential to be a recruitment tool for prospective STEM majors as aspiring scientists are invited to campus for a day of hands-on learning.

Professional organizations and networking opportunities exist for QT undergraduate STEM students that function similarly to the National Society of Black Engineers, Society of

Women Engineers, or the Society of Hispanic Professional Engineers are essential despite the pitfalls that some QT students experience with participation (Forsythe et al., 2023). Institutional support should also be directed towards funding QT student engagement with these organizations. Specifically, Out in STEM (oSTEM) or Out to Innovate are two examples of professional STEM organizations while conferences like Lesbians in Tech provide opportunities for networking and professional development that may not exist at traditional conferences. Providing institute resources to establish a campus chapter of the national organization or attendance at national events provides opportunities for QT college students to expand their professional network, meet potential role models and identify mentors who are QT.

Significance of the Study

This study's findings inform current practice and identify areas for further research. Findings add to the body of literature on QT student experience in higher education and contribute to the research in STEM, student affairs, and higher education. Given the limited scope of research on the experiences of QT undergraduates in STEM programs, findings from this study provide key insights with their experiences of departmental belonging, campus climate, engineering climate, planned involvement, and STEM identity. Additionally, this study adds valuable information regarding the characteristics of QT undergraduate students in STEM disciplines as data on these students is often excluded from institutional records, STEM research (Cech & Waidzunas, 2011; Hughes, 2018; Strayhorn, 2019), and efforts to diversify STEM.

In addition to contributing to a limited body of research on QT undergraduate engineering experience, this study also contributes to the limited body of research that explores connections between departmental sense of belonging, climate, planned involvement, and STEM identity. Specifically, this study is unique in its examination of the predictors of departmental

sense of belonging, through student experiences with engineering and campus climates, planned involvement, and STEM identity.

This study will help inform the current practices of student affairs professionals, academic departments, and researchers in their work with QT undergraduate students majoring in STEM disciplines. Given the almost 20% LGBT identification in 2022 among adults aged 18-25 (Jones, 2023) and 9.5% of LGBT identification among youth aged 13-17 (Conron, 2020) there are youth who have the potential to become amazing science and contribute significantly to their STEM field, if they are provided opportunities to flourish in these disciplines. We are unable to retain amazing scientists because QT individuals are driven out of the engineering field (Bilimoria & Stewart, 2009) through the heteronormative culture that facilitates the exclusionary behaviors and overt discrimination experienced by QT individuals in STEM spaces. It is imperative that QT barriers to success are included in the conversations on STEM inclusion and belonging as their experiences in these spaces matter.

Conclusion

The present study examined collegiate experiences with departmental sense of belonging for QT undergraduate engineering students through their perceptions of campus climate, engineering climate, planned involvement, and STEM identity. Findings highlight the need for additional research that explores QT undergraduate engineering experience across both departmental and campus perceptions of climate, involvement, and identity. The need to expand the body of literature so we can better understand QT experiences in STEM is in direct conflict with calls to eliminate diversity, equity, and inclusion efforts on college campuses. My own efforts, in recruiting for this study, were likely challenged by engineering departments or academic administrators unable to get institutional approval to share a call for recruitment that

specifically targeted QT community members. QT engineers, the focus of this study, may have paused or skipped participating in this study as a result of this context. This is a context that we must face.

QT identification, especially among younger generations, is growing and they deserve the ability to thrive in engineering or STEM fields. Their ability to flourish in these spaces will also assist higher education in meeting the need in STEM workforce demands. QT students are currently underrepresented in STEM and their negative experiences force them from the field or lessen their experience of belonging. Findings from this study highlight the significant role that academic departments must take to enhance QT undergraduate experiences with departmental belonging. While this study offered a different perspective to past literature, which emphasized negative perceptions of belonging, climate, and identity experienced by QT populations (Carlone & Johnson, 2007; Dortch & Patel, 2017; Rainey et al., 2018; Seymour & Hewitt, 1997; Strayhorn, 2019; Walton & Cohen, 2007) between-group differences that arose across the main study variables (departmental sense of belonging, campus climate, engineering climate, planned involvement, and STEM identity) primarily emphasized the importance of gender on student experience. More specifically, identifying as nonbinary or trans resulted in significantly different perceptions with departmental sense of belonging and engineering climate which hold important considerations for faculty, student affairs professionals, and institutions of higher education in their work with students.

References

- Aschbacher, P.R., Li, E., & Roth, E.J. (2010). Is science me? High school students' identities, participation, and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching*, 47(5), 565-582. <https://doi.org/10.1002/tea.20353>
- Bauer, G. R., Braimoh, J., Scheim, A.I., Dharma, C. (2017). Transgender-inclusive measures of sex/gender for population surveys: Mixed-method evaluation and recommendations. *PLoS ONE* 12(5): e0178043. <https://doi.org/10.1371/journal>.
- Baumeister, R. F., & Leary, M. R. (2005). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117(3), 497–529. PMID: 7777651
- Bernard, M. A. (2021, June 22). *Experiences and inclusion of sexual and gender minority scientists in the STEM workforce*. National Institutes of Health. <https://diversity.nih.gov/blog/2021-06-22-experiences-and-inclusion-sexual-and-gender-minority-scientists-stem-workforce>
- Bilimoria, D., & Stewart, A. (2009). "Don't ask, don't tell": The academic climate for lesbian, gay, bisexual, and transgender faculty in science and engineering. *NWSA Journal*, 2(2), 85-103. <https://www.muse.jhu.edu/article/316151>.
- Biddix, J. P., (2018). *Research methods and applications for student affairs*. Jossey-Bass
- Bowman, K. J. (2018). Queer identities in materials science and engineering. *Diversity in Materials Science and Engineering*. (43), 303-307. <https://doi.org/10.1557/mrs.2018.83>

- BrckaLorenz, A., Duran, A., Fassett, K., & Palmer, D. (2021). The within-group differences in LGBQ+ college students' belongingness, institutional commitment, and outness. *Journal of Diversity in Higher Education*, 14(1), 135–146. <https://doi.org/10.1037/dhe0000135>
- Brenner, P. S., & Bulgar-Medina, J. (2018). Testing mark-all-that-apply measures of sexual orientation and gender identity. *Field Methods*, 30(4), 357-370. <https://doi.org/10.1177/1525822X18795872>
- Butterfield, A., McCormick, A., & Farrell, S. (2018). Building LGBTQ-inclusive chemical engineering classrooms and departments. *Chemical Engineering Education*, 52, 107-113.
- Carlone, H. B., Johnson, A., (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching* 44(8). 1187-1218. <https://doi.org/10.1002/tea.20237>
- Casad, B.J., Oyler, D. L., Sullivan, E. T., McClellan, E. M., Tierney, D. N., Anderson, D. A., Greely, P. A., Fague, M. A., & Flammang, B. J. (2018). Wise psychological interventions to improve gender and racial equality in STEM. *Group Process and Intergroup Relations* 21(5). P. 767-787. <https://doi.org/10.1177/1368430218767034>.
- Casper, A.M.A, Atadero, R.A., Fuselier, L.C. (2022). Revealing the queer-spectrum in STEM through robust demographic data collection in undergraduate engineering and computer science courses at four institutions. *PLoS ONE* 17(3): e0264267. <https://doi.org/10.1371/journal.pone.0264267>
- Cech, E. A., (2022). The intersectional privilege of white able-bodied heterosexual men in STEM. *Science Advances*, 8(24). DOI:10.1126/sciadv.abo1558
- Cech, E. A., Montgomery, G., Settles, I. H., Elliot, K., Cheruvelil, K., & Brassel, S. T. (2021). The social is professional: The effects of team climate on professional outcomes for

- LGBTQ persons in environmental science. *Journal of Women and Minorities in Science and Engineering* 27(5). p 25-48. DOI: 10.1615/JWomenMinorScienEng.2021037211.
- Cech, E. A. & Rothwell, W. R. (2018). LGBTQ inequality in engineering education. *The Research Journal for Engineering Education* 107(4). p 583-610.
<https://doi.org/10.1002/jee.20239>
- Cech, E. A., & Waidzunas, T. J. (2009, June). “Engineers who happen to be gay”: Lesbian, gay, and bisexual students’ experiences in engineering. Presented at the Annual Conference and Exposition of the American Society for Engineering Education, Austin, TX.
<https://peer.asee.org/engineers-who-happen-to-be-gay-lesbian-gay-and-bisexualstudents-experiences-in-engineering.pdf>
- Cech, E. A., & Waidzunas, T. J. (2011). Navigating the heteronormativity of engineering: The experiences of lesbian, gay, and bisexual students. *Engineering Studies*, 3, p. 1-24.
<https://doi.org/10.1080/19378629.2010.545065>.
- Cech, E. A., & Waidzunas, T. J. (2021). Systemic inequalities for LGBTQ professionals in STEM. *Science Advances*. 7(3). <https://doi.org/10.3389/fnins.2023.1104419>.
- Cech, E. A., & Waidzunas, T. J. (2022). LGBTQ@NASA and beyond: Work structure and workplace inequality among LGBTQ STEM professionals. *Work and Occupations*, 49(2), p 187-228. <https://doi.org/10.1177/07308884221080938>.
- Cech, E. A., Waidzunas, T. J., & Farrell, S. (2016). *Engineering deans’ support for LGBTQ inclusion*. Proceedings of the 2016 American Society for Engineering Education National Conference, New Orleans, LA.
https://rdw.rowan.edu/cgi/viewcontent.cgi?article=1024&context=engineering_facpub

- Cech, E. A., & Waidzun, T. J., & Farrell, S. (2017, June), *The inequality of LGBTQ students in U.S. engineering education: Report on a study of eight engineering programs* paper presented at 2017 ASEE Annual Conference & Exposition, Columbus, Ohio.
<https://peer.asee.org/28981>.
- Chen, S., Binning, K. R., Kaufmann, N. (2020). Am I a science person? A strong science identity bolsters minority students' sense of belonging and performance in college. *Personality and Social Psychology Bulletin*. <https://doi.org/10.1177/0146167220936480>
- Chen, J.H., Gardner, A.K. (2022). Promoting inclusive environments through best practices in demographic survey design. *Global Surgical Education* 1(47).
<https://doi.org/10.1007/s44186-022-00045-w>
- Christopher, A. W. (2017). *Interpreting and using statistics in psychological research*. Sage Publications, Inc.
- Coley, J. S., & Das, D. (2020). Creating safe spaces: Opportunities, resources, and LGBTQ student groups at U.S. colleges and universities. *Socius*.
<https://doi.org/10.1177/2378023120971472>
- Conron, K. J. (2020). LGBT youth population in the United States. *The Williams Institute, UCLA, Los Angeles, CA*. <https://williamsinstitute.law.ucla.edu/wp-content/uploads/LGBT-Youth-US-Pop-Sep-2020.pdf>
- Creswell, J.W. (2014). *Research design: Qualitative, quantitative, and mixed methods (4th ed.)*. Sage Publications, Inc.
- Creswell, J. W., & Poth, C. N., (2016). *Qualitative inquiry and research design: Choosing among five approaches 4th edition*. Sage Publications.

- Demetriou, C., Meece, J., Eaker-Rich, D., & Powell, C. (2017). The activities, roles, and relationships of successful first-generation college students. *Journal of College Student Development*, 58(1), 19–36. <https://doi.org/10.1353/csd.2017.0001>
- Dortch, D. & Patel, C. (2017). Black undergraduate women and their sense of belonging in STEM at predominately white institutions. *NASPA Journal About Women in Higher Education* 10(2). P. 202-215. <https://doi.org/10.1080/19407882.2017.1331854>.
- Douglas, E. P., Koro-Ljungberg, M., & Borrego, M. (2010). Challenges and promises of overcoming epistemological and methodological partiality: Advancing engineering education through acceptance of diverse ways of knowing. *European Journal of Engineering Education*, 35(3), 247–257. DOI: <https://doi.org/10.1080/03043791003703177>
- Douglas, H. M., Settles, I. H., Spence Cheruvelil, K., Montgomery, G. M., Elliott, K. C., Cech, E. A., Davis, T. M., Ma, G., Hawkins, A. K., & Nadolsky, L. R. (2024). The importance of inclusive climate within the research group, department, and profession for marginalized science scholars' career outcomes. *Journal of Diversity in Higher Education*. Advance online publication. <https://doi.org/10.1037/dhe0000589>.
- Duran, A., Dahl, L. S., Prieto, K., Hooten, Z., & Mayhew, M. J. (2022). Exposing the intersections in LGBTQ+ Student of Color belongingness: Disrupting hegemonic narratives sustained in college impact work. *Journal of Diversity in Higher Education*, 15(2). 153-166. <http://dx.doi.org/10.1037/dhe0000222>.
- Evans, R., Nagoshi, J., Nagoshi, C., Wheeler, J., & Henderson, J. (2017). Voices from the stories untold: Lesbian, gay, bisexual, trans, and queer college students' experiences with

campus climate. *Journal of Gay and Lesbian Social Services*. 29(4). P. 426-444.

<https://doi.org/10.1080/10538720.2018.1378144>.

Forbes, T.D. (2020). Queer-free majors?: LGBTQ+ college students' accounts of chilly and warm academic disciplines. *Journal of LGBT Youth*. 19(3), 330-349

<https://doi.org/10.1080/19361653.2020.1813673>.

Forsyth, D., Vaccaro, A., Jones, M. C., Friedensen, R. E., Miller, R. A., Kimball, E., & Forester, R., (2023). Negotiated involvement in STEM organizations by students with minoritized identities of sexuality and/or gender. *Journal of Women and Minorities in Science and Engineering* 29(1). p. 21-43. DOI: 10.1615/JWomenMinorScienEng.2022037432.

Fowler, F. J. (2009). *Survey research methods (4th ed.)*. SAGE Publications, Inc.,

<https://doi.org/10.4135/9781452230184>.

Frank, T., DePorres, D., & Sloan, J. (2023). *Work in progress: Developing a foundational engineering course to improve student's sense of belonging and increase diversity* [Conference Session]. ASEE Annual Conference & Exposition. Baltimore, Maryland. 10.18260/1-2—44210

Friedensen, R.E., Kimball, E., Vaccaro, A., Miller, R., & Forester, R., (2021). Queer science: Temporality and futurity for queer students in STEM. *Time & Society*, 1.

<https://doi.org/10.1177/0961463x211008138>.

Garvey, J.C., Matsumura, J.L., Silvis, J.A., Kiemele, R., Eagan, H., & Chowdhury, P. (2018). Sexual borderlands: Exploring outness among bisexual, pansexual, and sexually fluid undergraduate students. *Journal of College Student Development* 59(6), 666-680.

<https://doi.org/10.1353/csd.2018.0064>.

- Garvey, J. C., & Rankin, S. R. (2015a). The influence of campus experiences on the level of outness among trans-spectrum and queer-spectrum students. *Journal of Homosexuality*, 62(1-3), 364-394. <https://doi.org/10.1080/00918369.2014.977113>.
- Garvey, J.C. & Rankin, S. R. (2015b). Making the grade? Classroom climate for LGBTQ students across gender conformity. *Journal of Student Affairs Research and Practice*, 52(2), 190-203, DOI: 10.1080/19496591.2015.1019764
- Garvey J. C., Sanders, L. A., Flint, M. A. (2017). Generational perceptions of campus climate among LGBTQ undergraduates. *Journal of College Student Development*, 58(6). 795-817. <http://doi.org/10.1353/csd.2017.0065>.
- Georgia Tech (2024, May 03). Queer science expands access to science for Atlanta high school students. School of Chemistry & Biochemistry, College of Sciences.
<https://chemistry.gatech.edu/news/queer-science-expands-access-science-atlanta-high-school-students>
- Godwin, A., Benedict, B., Rohde, J., Thielmeyer, A., Perkins, H., Major, J., & Chen, Z. (2021). New epistemological perspectives on quantitative methods: An example using topological data analysis. *Studies in Engineering*, 2(1), 16-34. DOI: <https://doi.org/10.21061/see.18>
- Gortmaker, V. J. & Brown, R. D. (2006). Out of the college closet: Differences in perceptions and experiences among out and closeted lesbian and gay students. *College Student Journal*, 40. 606-619
- Hausmann, L. R. M., Schofield, J. W. & Woods, R. L. (2007). Sense of belonging as a predictor of intentions to persist among African American and White first-year college students. *Research in Higher Education* 48, 803-839. <http://dx.doi.org/10.1007/s11162-007-9052-9>

- Havlik, S., Pulliam, N., Malott, K., & Steen, S. (2020). Strengths and struggles: First-generation college-goers persisting at one predominantly white institution. *Journal of College Student Retention: Research, Theory & Practice*, 22(1), 118–140.
<https://doi.org/10.1177/1521025117724551>
- Hazari, Z., Sadler, P. M., & Sonnert, G. (2013). The Science Identity of College Students: Exploring the Intersection of Gender, Race, and Ethnicity. *Journal of College Science Teaching*, 42(5), 82–91. <http://www.jstor.org/stable/43631586>
- Hill, R. & Grace, A. P. (Eds.) (2009). *Adult and higher education in queer contexts: Power, politics, and pedagogy*. Discovery Association.
- Hughes, B. E. (2017). “Managing by not managing”: How gay engineering students manage sexual orientation identity. *Journal of College Student Development*, 58, 385–401.
<https://dx.doi.org/10.1353/csd.2017.0029>.
- Hughes, B. E. (2018). Coming out in STEM: Factors affecting retention of sexual minority STEM students. *Science Advances*, 4(3), 1-5. <http://advances.sciencemag.org/>
- Hurtado, S., & Carter, D. F. (1997). Effects of college transition and perceptions of the campus racial climate on Latino college students’ sense of belonging. *Sociology of Education*, 70(4), 324-345. <https://doi.org/10.2307/2673270>.
- Institute of Education Sciences. (2023, May). *Undergraduate degree fields*. National Center for Education Statistics. <https://nces.ed.gov/programs/coe/indicator/cta>
- James, S. E. Herman, J.L., Rankin, S., Keisling, M., Mottet, L., & Anafi, M (2016). *The Report of the 2015 U.S. Transgender Survey*. Washington, DC: National Center for Transgender Equality. <https://transequality.org/sites/default/files/docs/usts/USTS-Full-Report-Dec17.pdf>

- James, S.E., Herman, J.L., Durso, L.E., & Heng-Lehtinen, R. (2024). *Early Insights: A Report of the 2022 U.S. Transgender Survey*. National Center for Transgender Equality, Washington, DC.
- Johnson, B. R., & Christensen, L. (2014). *Educational research: Quantitative, qualitative, and mixed approaches* (5 edition). Sage Publications.
- Jones, J. M. (2023, February 22). *U.S. LGBT identification steady at 7.2%*. Gallup.
<https://news.gallup.com/poll/470708/lgbt-identification-steady.aspx>
- Knekta E., Chatzikyriakidou K., McCartney M. (2020). Evaluation of a questionnaire measuring university students' sense of belonging to and involvement in a biology department. *CBE Life Science Education*, 19(3), <https://doi.org/10.1187/cbe.19-09-0166>.
- Krutsch, E. & Roderick, V. (2022, November 4). *STEM day: Explore growing careers*. U.S. Department of Labor Blog. <https://blog.dol.gov/2022/11/04/stem-day-explore-growing-careers#:~:text=In%202021%2C%20there%20were%20nearly%2010%20million%20workers,STEM%20occupations%2C%20compared%20to%20%2440%2C120%20for%20non-STEM%20occupations.>
- Lange, A. C., Duran, A., & Jackson, R. (2019). The state of LGBT and queer research in higher education revisited: Current academic houses and future possibilities. *Journal of College Student Development*, 50(5), 511-526. <https://doi.org/10.3102/0013189X10362579>.
- Lewis, K. L., Stout, J. G., Finkelstein, N. D., Pollock, S. J., Miyake, A., Cohen, G. L., & Ito, T. A. (2017). Fitting in to move forward: Belonging, gender, and persistence in the physical sciences, technology, engineering, and mathematics (pSTEM). *Psychology of Women Quarterly* 41(4). 420-436. <https://doi.org/10.1177/0361684317720186>.

- Leyva, L. A. (2022, Nov 17-20). *Undergraduate Latin* Queer students' intersectionality of mathematics experiences: A boarderlands perspective* [Conference Session]. Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Nashville, TN.
- Linley, J. L., Renn, K. A., & Woodford, M. R. (2018). Examining the ecological systems of LGBTQ STEM majors. *Journal of Women and Minorities in Science and Engineering*, 24, 1-16. <https://doi.org/10.1615/JWOMENMINORSCIENENG.2017018836>.
- Litzler, E. & Samuelson, C. (2013). *How underrepresented minority engineering students derive a sense of belonging from engineering* [conference paper]. 120th ASEE Annual Conference & Exposition. Atlanta, GA. <https://peer.asee.org/19688>.
- Lucas, K.L. & Spina A.D., (2022). Science identity and its implications for STEM retention and career aspirations through a research-based first-year biology seminar. *Journal of College Science Teaching*. 52(1), 63-71. <https://www.nsta.org/journal-college-science-teaching/journal-college-science-teaching-septemberoctober-2022/science>.
- Lussenhop, A. (2018). Beyond the male/female binary: Gender equity and inclusion in evaluation surveys. *Journal of Museum Education*, 43:3, 194-207. <https://doi.org/10.1080/10598650.2018.1484201>.
- Maghsoodi, A. H., Ruedas-Garcia, N., & Jiang, G., (2023). Measuring college belongingness: Structure and measurement of the sense of social fit scale. *Journal of Counseling Psychology* 70(4). pp. 424-425. <https://doi.org/10.1037/cou0000668>.
- Mattheis, A., De Arellano D. C. R., & Yoder, J. B. (2019). A model of queer STEM identity in the workplace. *Journal of Homosexuality*, 67(3), 1839–1863. <https://doi.org/10.1080/00918369.2019.1610632>.

- McDonald, M. M., Zeigler-Hill, V., Vrabel, J., & Escobar, M. (2019). A single-item measure for assessing STEM identity in college students. *Frontiers Education*, 4(78). p. 1-15.
<http://dx.doi.org/10.3389/feduc.2019.00078>.
- Mertens, D. M. (2021). *Research and evaluation in education and psychology* (5th edition, pp. 7-34 & 41-42). SAGE Publications.
- Miller, R & Downey, M. (2020). Examining the STEM climate for queer students with disabilities. *Journal of Postsecondary Education and Disability*, 33(2), 169-181.<https://api.semanticscholar.org/CorpusID:235488266>.
- Miller, R. A., Vaccaro, A., Kimball, E. W., & Forester, R. (2020, January 30). “It’s dude culture”: Students with minoritized identities of sexuality and/or gender navigating STEM majors. *Journal of Diversity in Higher Education*.
<http://dx.doi.org/10.1037/dhe0000171>.
- Myanna, T. (2023). Strategies for LGBTQIA inclusive data collection and reporting. *Journal of Diversity in Higher Education*. Advance online publication.
<https://doi.org/10.1037/dhe0000485>
- National Center for Education Statistics. (2023). IPEDS: Integrated Postsecondary Education Data System: Bachelor’s degrees conferred by postsecondary institutions, by race/ethnicity and field of study: Academic years 2020-21 and 2021-22. Washington, D.C.. U.S. Department of Education.
https://nces.ed.gov/programs/digest/d23/tables/dt23_322.30.asp
- National Center for Education Statistics. (2024). Undergraduate Degree Fields. *Condition of Education*. U.S. Department of Education, Institute of Education Sciences.
<https://nces.ed.gov/programs/coe/indicator/cta>.

- Nelson, T. C. (2024). How women in Science, Technology, Engineering, and Mathematics (STEM) professions describe the benefits of belonging to a professional network: A multiple case study [ProQuest Information & Learning]. In *Dissertation Abstracts International: Section B: The Sciences and Engineering* (Vol. 85, Issue 7–B).
- Ovink S.M., Byrd W.C., Nanney M., & Wilson A. (2024). Figuring out your place at a school like this: Intersectionality and sense of belonging among STEM and non-STEM college students. *PLoS ONE* 19(1). <https://doi.org/10.1371/journal.pone.0296389>
- Parker, E. T. (2021). Campus climate perceptions and sense of belonging for LGBTQ students: A Canadian case study. *Journal of College Student Development*, 42(2). 248-253. <https://doi.org/10.1353/csd.2021.0019>.
- Puente, K., Starr, C.R., Eccles, J.S., & Simpkins, S. D. (2021). Developmental trajectories of science identity beliefs: Within-group differences among Black, Latinx, Asian, and White students. *Journal of Youth Adolescence* 50, 2394–2411 <https://doi.org/10.1007/s10964-021-01493-1>.
- Rainey, K., Dancy, M., Mickelson, R., Steams, E., & Moller, S. (2018). Race and gender differences in how sense of belonging influences decisions to major in STEM. *International Journal of STEM Education* 5(10). <https://doi.org/10.1186/s40594-018-0115-6>.
- Rankin, S.R. (2005). Campus climates for sexual minorities. In: Sanlo, R. L., (ed.) *Gender Identity and Sexual Orientation: Research, Policy, and Personal*. New Directions for Student Services, No. 111. Jossey-Bass, pp. 17–23.

- Reggiani, M., Gagnon, J.D. & Lunn, R.J. (2023). LGBT + academics' and PhD students' experiences of visibility in STEM: more than raising the rainbow flag. *Higher Education*. <https://doi.org/10.1007/s10734-023-00993>.
- Reisner, S.L., Choi, S.K., Herman, J.L. et al. (2023). Sexual orientation in transgender adults in the United States. *BMC Public Health* 23, 1799. <https://doi.org/10.1186/s12889-023-16654-z>
- Robinson, K. A., Perez, T., Nuttall, A. K., Roseth, C. J., & Linnenbrink-Garcia, L. (2018). From science student to scientist: Predictors and outcomes of heterogeneous science identity trajectories in college. *Developmental Psychology*, 54(10), 1977–1992. <https://doi.org/10.1037/dev0000567>.
- Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Westview Press.
- Skorodinsky, M. A. (2024). *More Than Binary, More Than Normative, More Than Quantities: Transgender and Gender Nonconforming Students in Postsecondary Computer Science Education (Order No. 31141348)*. Available from ProQuest Dissertations & Theses A&I; ProQuest Dissertations & Theses Global. (3083770395).
- Stout, J. G. and Wright, H. M. (2016, May-June). Lesbian, gay, bisexual, transgender, and queer students' sense of belonging in computing: An intersectional approach. *Computing in Science & Engineering* (18)3. pp. 24-30. <https://doi.org/10.1109/MCSE.2016.45>.
- Strayhorn, T. L. (2012). Coming out, fitting in: Interrogating the social experiences of Black gay male undergraduates at predominantly White institutions. In T. E. Dancy, II, & M. C. Brown (Eds.), *African American males and education: Researching the convergence of race and identity* (pp. 151–170). Charlotte, NC: Information Age.

- Strayhorn, T. L. (2019). *College students' sense of belonging: A key to educational success for all students* (2nd ed.). Routledge.
- Sue, D. W., (2010). *Microaggressions in everyday life: Race, gender, and sexual orientation*. Hoboken, NJ: Wiley.
- Szymanski, D. M. & Bissonette, D. (2020). Perceptions of the LGBTQ college campus climate scale: Development and psychometric evaluation. *Journal of Homosexuality* 67(10). 1412-1428. <https://doi.org/10.1080/00918369.2019.1591788>.
- Tate, E. D., & Linn, M. C. (2005). How does identity shape the experiences of women of color engineering students? *Journal of Science Education and Technology*, 14(5–6), 483–493. <https://doi.org/10.1007/s10956-005-0223-1>.
- The Consortium of Higher Education LGBT Resource Professionals. (2024). *Supporting trans and nonbinary people in postsecondary education*. The Consortium of Higher Education LGBT Resource Professionals. <https://lgbtcampus.memberclicks.net/assets/docs/supporting-trans-nonbinary-people-postsecondary-education-20240628.pdf>
- Thornhill, C. W., Wied, C. M., Spooner, M. M. N., Terrazas, A., & Evans, T. S. (2023). Factors of college involvement and belonging for first-generation students of color. *Journal of First-Generation Student Success*, 3(1), 20–32. <https://doi.org/10.1080/26906015.2022.2156826>
- Trenshaw, K., Hetrick, A., Oswald, R., Vostral, S., & Loui, M. (2013). *Lesbian, gay, bisexual, and transgender students in engineering: Climate and perceptions*. Proceedings - Frontiers in Education Conference. 1238-1240. <https://doi.org/10.1109/FIE.2013.6685028>.

- Vaccaro, A., Russell, E. I., & Koob, R. M. (2015), Students with minoritized identities of sexuality and gender in campus contexts: An emergent model. In D.-L. Stewart, K. A. Renn, & G. B. Brazelton (Eds.), *New Directions for Student Services*: No. 152. Gender and sexual diversity in US higher education: Contexts and opportunities for LGBTQ college students (pp.25-39). Jossey-Bass.
- Vaccaro, A., & Mena, J. A., (2011). It's not burnout, it's more: Queer college activists of color and mental health. *Journal of Gay and Lesbian Mental Health* 15(4): 339–367.
<https://doi.org/10.1080/19359705.2011.600656>.
- Vaccaro, A., Miller, R. A., Kimball, E. W., Forester, R., & Friedensen, R. (2021). Historicizing minoritized identities of sexuality and gender in STEM fields: A grounded theory model. *Journal of College Student Development*, 62(3), 293–309.
<http://dx.doi.org/10.1353/csd.2021.0026>.
- Vaccaro, A., & Newman, B. M. (2016). Development of a sense of belonging for privileged and minoritized students: An emergent model. *Journal of College Student Development*, 57(8), 925–942. <https://doi.org/10.1353/csd.2016.0091>.
- Vaccaro, A. & Newman, B. M. (2017). A sense of belonging through the eyes of first-year LGBPQ students. *Journal of Student Affairs Research and Practice*. 54(2). p. 137-149.
<https://doi.org/10.1080/19496591.2016.1211533>.
- Victorino, C., Denson, N., Ing, M., & Nylund-Gibson, K. (2022). Comparing STEM majors by examining the relationship between student perceptions of campus climate and classroom engagement. *Journal of Hispanic Higher Education* 21(1). 33-48.
<https://doi.org/10.1177/1538192719896343>.

- Walton, G. M., & Cohen, G. L. (2007). A question of belonging: race, social fit, and achievement. *Journal of Personality and Social Psychology*, 92(1), 82-96.
<https://doi.org/10.1037/0022-3514.92.1.82>.
- Wilson, D., Jones, D., Bocell, F., Crawford, J., Kim, M. J., Veilleux, N., Floyd-Smith, T., Bates, R., Plett, M. (2015). Belonging and academic engagement among undergraduate STEM students: A multi-institutional study. *Research Higher Education*, 56. 750-776.
<https://doi.org/10.1007/s11162-015-9367-x>.
- Woodford, M.R. & Kulick, A. (2015). Academic and social integration on campus among sexual minority students: The impacts of psychological and experiential campus climate. *American Journal of Community Psychology*. 55. 13–24. <https://doi.org/10.1007/s10464-014-9683-x>.
- Xavier Hall C.D., Wood C.V., Hurtado M., Moskowitz D.A., Dyar C., & Mustanski, B. (2022). Identifying leaks in the STEM recruitment pipeline among sexual and gender minority US secondary students. *PLoS ONE* 17(6):e0268769. <https://doi.org/10.1371/journal.pone.0268769>.
- Yang, J. A., Sherard, M. K., Julien, C., & Borrego, M. (2021a). LGBTQ+ in ECE: Culture and (non)visibility. *IEEE Transactions on Education*, 64(4). 345-352.
<https://doi.org/10.1109/TE.2021.3057542>.
- Yang, J. A., Sherard, M. K., Julien, C., & Borrego, M. (2021b). Resistance and community-building in LGBTQ+ engineering students. *Journal of Women and Minorities in Science and Engineering*, 27(4). 1-33.
<http://dx.doi.org/10.1615/JWomenMinorScienEng.2021035089>.

Appendix A

Institutions Contacted for Recruitment

College or University

(responses received from bolded institutional names)

California Institute of Technology
Carnegie Mellon University
Colorado State University -Fort Collins
Emory University
Georgia Institute of Technology
Massachusetts Institute of Technology
North Carolina State University
Purdue University - Main Campus
Rensselaer Polytechnic Institute
Rochester Institute of Technology
The Ohio State University
The Pennsylvania State University - University Park
University of California, Davis
University of California, Berkeley
University of Delaware
University of Kansas
University of Maryland, College Park
University of Massachusetts-Amherst
University of Michigan - Ann Arbor
University of Minnesota, Twin Cities
University of Nebraska-Lincoln
University of Texas at Austin
University of Washington
University of Wisconsin-Madison
Virginia Tech
Worcester Polytechnic Institute
Yale University
 Arizona State University
 Auburn University
 Boston University

Brown University
Case Western Reserve University
Clemson University
Colorado School of Mines
Columbia University
Cornell University
Drexel University
Duke University
Florida State University
Harvard University
Iowa State University
Johns Hopkins University
Kansas State University
Kennesaw State University
Louisiana State University and Agricultural & Mechanical College
Michigan State University
Michigan Technological University
Missouri University of Science and Technology
New York University
Northeastern University
Northwestern University
Oregon State University
Princeton University
Rice University
Rutgers University
Stanford University
Stony Brook University
Texas A&M University
Tufts University
University of New Mexico
University at Buffalo
University of Arizona
University of California, San Francisco
University of California, Riverside
University of California, Los Angeles
University of California, San Diego
University of California, Irvine
University of Central Florida
University of Chicago
University of Cincinnati
University of Colorado Boulder
University of Connecticut
University of Georgia

University of Houston
University of Illinois at Chicago
University of Illinois Urbana-Champaign
University of Iowa
University of Kentucky
University of Miami
University of Missouri-Columbia
University of North Carolina
University of Notre Dame
University of Pennsylvania
University of Pittsburgh
University of Rochester
University of Southern California
University of South Carolina-Columbia
University of South Florida
University of Tennessee - Knoxville
University of Utah
University of Virginia
Vanderbilt University
Washington University in St. Louis
Washington State University
Wayne State University

Appendix B

Professional Organizations Contacted for Recruitment

Professional Organizations Contacted
(those bolded responded)

Queer Engineer

LGBTQ+ in STEM

Out to Innovate (formally NOGLSTP)

oSTEM

Society of Women Engineers

Society of Hispanic Professional Engineers

National Society of Black Engineers

NSBE Chapters (214)

Alpha Omega Epsilon

Alpha Phi Mu

American Academy of Environmental Engineers

American Indian Council of Architects & Engineers

American Institute of Aeronautics and Astronautics

American Nuclear Society

American Society of Agricultural and Biological
Engineers

American Society of Mechanical Engineers

Biomedical Engineering Society

Chi Epsilon

IEE-Eta Kappa Nu

Phi Sigma Rho

Pi Tau Sigma

Tau Beta Pi

Theta Tau

Appendix C

Participant Recruitment Email-College/School of Engineering

Good morning [College/School of Engineering]

My name is Tegra Myanna (they/them), and I'm a doctoral student at the University of Georgia conducting dissertation research. This study aims to examine how campus climate and science identity predict sense of belonging among LGBTQIA (QT) undergraduate engineering students. **I'm inviting all QT undergraduate engineering students to participate in this study.** This study is being conducted under the supervision of Dr. Katie Koo in the Department of Counseling and Human Development at the University of Georgia. IRB Project 00008030.

Click this link to access the survey and participate: https://bit.ly/QT_engineers

Additionally, I'd love it if you could share this survey with your student community or campus partners. I've attached an 8x11.5 flyer to this email and copied a blurb below. I'm happy to provide graphics for other uses (social media, digital signage, etc.) upon request.

In Community,

Tegra Myanna (they/them)

tegra.myanna@uga.edu

Tegra Myanna (they/them) is seeking participants for their quantitative dissertation research on **Queer & Trans undergraduate engineers**. This study aims to examine how campus climate and science identity predict sense of belonging among LGBTQIA (QT) undergraduate engineering students. They are inviting all QT undergraduate engineering students to participate in this study. This study is being conducted by Tegra Myanna (they) under the supervision of Dr. Katie Koo in the Department of Counseling and Human Development at the University of Georgia.

Please click this link to access the 15-minute survey and for more information about this study: https://bit.ly/QT_engineers

Direct Survey Link: https://ugeorgia.ca1.qualtrics.com/jfe/form/SV_0J4Z5mmUmAHgPyK

Appendix D

Recruitment Email – Follow Up

(send in the same email thread to maintain the previous email for content)

Greetings [NAME]

I hope you had a relaxing weekend. I wanted to follow up on my previous email and see if there was an opportunity to share my call for participants with undergraduate engineers on your campus. Campuses have identified several ways to share the recruitment materials. For many campuses, inclusion in a departmental/college newsletter has been the preferred method.

Additional ways that institutions have partnered with me are by posting physical flyers and/or emailing leaders of their campus engineering student organizations.

I'd be happy to schedule a meeting to discuss options and opportunities to share at your campus community.

Thanks,

Tegra Myana

tegra.myanna@uga.edu

Appendix E

Participant Recruitment Email – Identity-Based Resource Centers

Good morning [National Office of Organization Name]

My name is Tegra Myanna (they/them), and I'm a doctoral student at the University of Georgia conducting dissertation research. This study aims to examine how campus climate and science identity predict sense of belonging among LGBTQIA (QT) undergraduate engineering students. **I'm inviting all QT undergraduate engineering students to participate in this study.** This study is being conducted under the supervision of Dr. Katie Koo in the Department of Counseling and Human Development at the University of Georgia. IRB Project 00008030.

Click this link to access the survey and participate: https://bit.ly/QT_engineers

Additionally, I'd love it if you could share this survey with your undergraduate members. I've attached an 8x11.5 flyer to this email and copied a blurb below. I'm happy to provide graphics for other uses (social media, digital signage, etc.) upon request.

In Community,

Tegra Myanna (they/them)

tegra.myanna@uga.edu

Tegra Myanna (they/them) is seeking participants for their quantitative dissertation research on **Queer & Trans undergraduate engineers**. This study aims to examine how campus climate and science identity predict sense of belonging among LGBTQIA (QT) undergraduate engineering students. They are inviting all QT undergraduate engineering students to participate in this study. This study is being conducted by Tegra Myanna (they) under the supervision of Dr. Katie Koo in the Department of Counseling and Human Development at the University of Georgia.

Please click this link to access the 15-minute survey and for more information about this study: https://bit.ly/QT_engineers

Direct Survey Link: https://ugeorgia.ca1.qualtrics.com/jfe/form/SV_0J4Z5mmUmAHgPyK

Appendix F

Recruitment Flyer



UNIVERSITY OF
GEORGIA

SEEKING STUDENT PARTICIPANTS

We are conducting a research study that examines **campus climate and science identity as predictors of sense of belonging among QT undergraduate engineering students**. This research is designed to better understand QT experience in STEM and the role that institutional type has on this experience.

WHO IS ELIGIBLE?

Any LGBTQIA undergraduate engineering major.
Scan QR Code to access survey.

DESCRIPTION OF STUDY

Study has minimal risk to participants and takes about 15-20 minutes to complete. It is being conducted under the supervision of Dr. Katie Koo, Dept. of Counseling and Human Development. IRB Project 00008030



bit.ly/QT_engineers
(case sensitive)

QUESTIONS?

Contact **Tegra Myanna** (they),
doctoral candidate at UGA and
primary researcher at
tegra.myanna@uga.edu



Appendix G

Participant Recruitment Email – Professional Organizations

Good Morning [**Organization**],

My name is Tegra Myanna (they/them), and I'm a doctoral student at the University of Georgia conducting dissertation research that examines how campus climate and science identity predict sense of belonging among LGBTQIA (QT) undergraduate engineering students. **I'm inviting all QT undergraduate engineering students to participate in this study.** This study is being conducted under the supervision of Dr. Katie Koo in the Department of Counseling and Human Development. IRB Project 00008030.

I'd appreciate a share of this survey with your undergraduate members. I've attached an 8x11.5 flyer to this email and copied a blurb below. Upon request, I'm happy to provide graphics for other uses (social media, digital signage, etc.).

In Community,

Tegra Myanna (they/them)

tegra.myanna@uga.edu

Tegra Myanna (they/them) is seeking participants for their dissertation research on **Queer & Trans undergraduate engineers**. Their study examines how campus climate and science identity predict sense of belonging among LGBTQIA (QT) undergraduate engineering students. They are inviting all QT undergraduate engineering students to participate in this study. This study is being conducted by Tegra Myanna (they) under the supervision of Dr. Katie Koo in the Department of Counseling and Human Development at the University of Georgia. IRB Project Number 00008030.

Please click the link below to access the 15-minute anonymous survey. For more information about this study please contact Tegra Myanna at tegra.myanna@uga.edu.

Survey Link: https://ugeorgia.ca1.qualtrics.com/jfe/form/SV_0J4Z5mmUmAHgPyK

Appendix H

Recruitment Materials for Social Media

Please assist in sharing my recruitment materials to all undergraduate LGBTQIA engineering majors.

Assist Tegra Myanna in their dissertation research! Tegra is conducting a research study on the experiences of queer and trans undergraduate engineers. Their study aims to examine how campus climate and science identity predict sense of belonging among LGBTQIA (QT) undergraduate engineering students. This study is being conducted under the supervision of Dr. Katie Koo in the Department of Counseling and Human Development at the University of Georgia. IRB Project Number 00008030.

Tegra is inviting all QT undergraduate engineering students at your campus to participate by completing their 15-minute survey. **Survey Link:** https://bit.ly/QT_engineers



Perceptions of Queer & Trans Undergraduate Engineers

Participate in the study at
bit.ly/QT_engineers
(case sensitive)

STUDY ELIGIBILITY

- Identify as LGBTQIA
- Undergraduate student
- Engineering major

PRIMARY RESEARCHER
Tegra Myanna (they), Doctoral Candidate
tegra.myanna@uga.edu

PRINCIPLE INVESTIGATOR
Dr. Katie Koo (she), Faculty Advisor
katie.koo@uga.edu

UNIVERSITY OF GEORGIA

ABOUT THE STUDY

Purpose of the study is to examine how campus climate and science identity predict sense of belonging among QT undergraduate engineering students at institutes of technology compared to comprehensive universities.

IRB PROJECT 00008030

UNIVERSITY OF GEORGIA

Appendix I

Survey Instrument

Departmental Sense of Belonging and Involvement Questionnaire

Please rate your agreement with the following statements based on how you feel about the Engineering Department at your: (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, and 6 = strongly agree)

- People in the engineering department notice when I'm good at something.
- Faculty and staff in the engineering department value my opinions.
- Other students in the engineering department take my opinions seriously.
- Most faculty and staff in the engineering department are interested in me.
- There is at least one instructor or other engineering faculty or staff in the department I can talk to if I have a problem.
- People in the engineering department are friendly to me.
- Students in the engineering department help each other to succeed.
- I am treated with as much respect as other students.
- I have a good relationship with other students in the engineering department.
- I can really be myself in the engineering department.
- The faculty and staff in the engineering department respect me.
- People in the engineering department know I can do good work.
- The instructors in the engineering department give me compliments when I do something good.
- I feel proud of belonging in the engineering department.
- Other students in the engineering department like me the way I am.
- Faculty and staff in the engineering department really want me to succeed.

During this academic year, it is likely that I will: (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, and 6 = strongly agree)

- participate in undergraduate research (paid or unpaid) in the engineering department.
- interact closely with engineering faculty or staff outside of class.
- talk about my career plans with the engineering faculty or staff.
- discuss course topics, ideas, or concepts with engineering faculty or staff outside of class.
- discuss my academic performance with engineering faculty or staff outside class.
- ask for advice from an engineering faculty or staff who is not my instructor.
- attend the office hours of an engineering faculty member.
- read research papers from an engineering faculty member.
- attend a seminar hosted by the engineering department.
- visit the lab of an engineering faculty member.
- join an engineering-related student group or club at [my university].
- participate in engineering-related volunteer work not connected to research.

LGBTQ College Campus Climate Scale

Rate each item on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- My university/institute provides a support environment for QT students.
- Heterosexism, homophobia, biphobia, transphobia, and cissexism are visible on my university/institute campus.
- Negative attitudes toward QT persons are openly expressed on my university/institute campus.
- My university/institute is unresponsive to the needs of QT students.
- QT students are harassed on my university/institute campus.
- My university/institute is cold and uncaring toward QT students and issues.

LGBTQ College Campus Climate: Engineering Department Scale

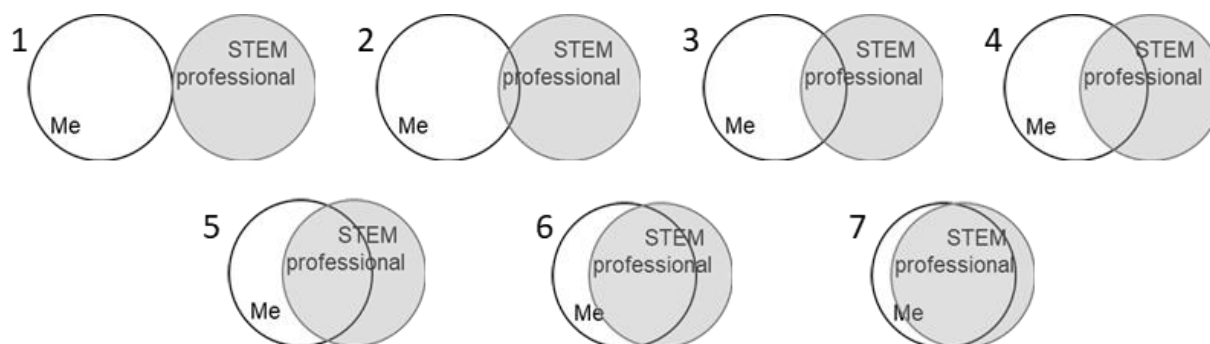
Rate each item on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- My engineering department provides a support environment for QT students.
- Heterosexism, homophobia, biphobia, transphobia, and cissexism are visible in my engineering department.
- Negative attitudes toward QT persons are openly expressed in my engineering department.
- My engineering department is unresponsive to the needs of QT students.
- QT students are harassed in my engineering department.
- My engineering department is cold and uncaring toward QT students and issues.

STEM-PIO-4

Item responses are averaged to create a composite scale:

1. (Overall) Select the picture that best describes the current overlap of the image you have of yourself and your image of what a STEM professional is.
2. (Competence) Select the picture that best describes the extent to which your knowledge of STEM concepts matches that of a STEM professional.
3. (Performance) Select the picture that best describes the extent to which your capacity to use STEM skills in a public setting matches that of a STEM professional.
4. (Recognition) Select the picture that best describes the extent to which you think others (such as your STEM professors) see your identity as overlapping with a STEM professional.



Demographic Questions

Institution

Engineering Major

- aerospace
- biomedical
- chemical and biomolecular
- civil and environmental
- electrical and computer
- industrial and systems
- materials science and mechanical
- Other Major, Please specify

GPA (0-4.0 Scale):

Grade Level

- First-Year
- Sophomore
- Junior
- Senior

Which social class group do you identify with?

- Wealthy
- Upper-middle or Professional
- Middle-class
- Working-class
- Low-income or Poor

Are you an international student?

- Yes
- No
- Prefer not to disclose.

Do you identify as transgender?

- Yes
- No
- Prefer not to disclose.

What is your gender?

- Agender
- Nonbinary/Genderqueer
- Man
- Woman
- Another Identity, please specify_____
- Prefer not to disclose.

What is your sexual orientation?

- Aromantic/Asexual
- Bisexual/Pansexual
- Heterosexual/Straight
- Lesbian/Gay
- Queer
- Another identity, Please Specify

Prefer Not to Disclose.

Racial/Ethnic Identity

- American Indian or Alaskan Native
- Asian or Asian American
- Black or African American
- Hawaiian or Pacific Islander
- Hispanic or Latinx/e
- Middle Eastern or North African
- White or European
- Another Identity, Please Specify_____
- Prefer Not to Disclose.

Appendix J

Modified-LGBTQ College Campus Climate Scale

LGBTQ College Campus Climate Scale

Rate each item on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- My university/college institute provides a support environment for LGBTQ-QT students.
- Heterosexism, homophobia, biphobia, transphobia, and cissexism are visible on my university/college institute campus.
- Negative attitudes toward LGBTQ-QT persons are openly expressed on my university/college institute campus.
- My university/college institute is unresponsive to the needs of LGBTQ-QT students.
- LGBTQ-QT students are harassed on my university/college institute campus.
- My university/college institute is cold and uncaring toward LGBTQ-QT students and issues.

LGBTQ College Campus Climate: Engineering Department Scale

Rate each item on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- My engineering department provides a support environment for QT students.
- Heterosexism, homophobia, biphobia, transphobia, and cissexism are visible in my engineering department.
- Negative attitudes toward QT persons are openly expressed in my engineering department.
- My engineering department is unresponsive to the needs of QT students.
- QT students are harassed in my engineering department.
- My engineering department is cold and uncaring toward QT students and issues

Appendix K

Informed Consent Letter

Dear Participant:

My name is Tegra Myanna (they/them), and I am a doctoral candidate in the Department of Counseling and Human Development Services under the supervision of Dr. Katie Koo at the University of Georgia. I am inviting you to take part in a voluntary research study.

The purpose of this quantitative study is to examine the relationship between collegiate experiences of perceptions of departmental sense of belonging, planned involvement, STEM identity, and perceived campus and engineering climates among undergraduate QT engineering majors.

You will be asked to complete a 15–20-minute online questionnaire. Participation is voluntary. You can refuse to take part or stop at any time without penalty. Your decision to participate will have no impact on your academic or co-curricular involvement on campus. There are questions that may make you uncomfortable. You can skip these questions if you do not choose to answer them. Your participation is important to gaining a deeper understanding of QT experience in engineering fields and ways to enhance sense of belonging for QT students in STEM disciplines.

Any identifiable information will be removed prior to data analysis. De-identified, aggregated results may be used in learning sessions, presentations, or publications. An institutional report will be provided to each research site. No data will be disaggregated to make individual participants identifiable.

Principal Investigator:
Dr. Katie Koo (she)

Department of Counseling and Human Development Services
University of Georgia
katie.koo@uga.edu

Co-Investigator/Principal Researcher:

Tegra Myanna (they)
Doctoral Candidate, Ed.D. in Student Affairs Leadership
University of Georgia
tm76747@uga.edu

Study Details:

Your participation will involve completing an online survey and should only take 15-20 minutes. Your feedback and participation are important in understanding and enhancing the experience of QT students in STEM fields.

Privacy/Confidentiality:

The research involves the transmission of data over the internet. Every reasonable effort has been taken to ensure the effective use of technology; however, confidentiality during online communication cannot be guaranteed. You will not be asked to disclose your name, email address, or other similar identifying information. Data from this survey may be used in publications, presentations, etc. Any information utilized will be in aggregate form and individual responses will not be utilized.

Voluntary Participation:

Participation is voluntary, and you may choose not to participate or stop at any time without penalty. Your decision of whether to take part in the research or not will have no effect on your grades or class standing. If you do decide to stop participation, the information collected from you to that point will be kept as part of the study and may be analyzed. To permanently delete your response please contact the principal investigator.

If you have questions, or would like further information, please contact tm76747@uga.edu. If you have any complaints or questions about your rights as a research volunteer, contact the IRB at 706-542-3199 or by email at IRB@uga.edu.

I have read the above informed consent document and have had the opportunity to ask questions about this study. I have been told my rights as a research participant, and I voluntarily consent to participate in this research study. By selecting, "Agree," I agree to participate in this research study.

_____ Agree _____ Decline UGA IRB Approval Number: **PROJECT NUMBER**

Do you identify as a queer and/or trans community member?

_____ **Yes (direct to survey)** _____ **No (direct to survey close)**

Appendix L

Modified-Departmental Sense of Belonging and Involvement (DeSBI) Questionnaire

Sense of belonging: All items were rated on a six-point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, and 6 = strongly agree). Students also had the option to choose “prefer not to respond.”

Question prompt: Please rate your agreement with the following statements based on how you feel about the Engineering Department of Biological Sciences at your campus [the university] (called “biology department” here):

- People in the ~~biology~~ engineering department notice when I’m good at something
- Faculty and staff in the ~~biology~~ engineering department value my opinions
- Other students in the ~~biology~~ engineering department take my opinions seriously
- Most faculty and staff in the ~~biology~~ engineering department are interested in me
- There is at least one instructor or other ~~biology~~ engineering faculty or staff in the department I can talk to if I have a problem
- People in the ~~biology~~ engineering department are friendly to me
- Students in the ~~biology~~ engineering department help each other to succeed
- I am treated with as much respect as other students.
- I have a good relationship with other students in the ~~biology~~ engineering department
- I can really be myself in the ~~biology~~ engineering department
- The faculty and staff in the ~~biology~~ engineering department respect me
- People in the ~~biology~~ engineering department know I can do good work.
- The instructors in the ~~biology~~ engineering department give me compliments when I do something good.
- I feel proud of belonging in the ~~biology~~ engineering department.
- Other students in the ~~biology~~ engineering department like me the way I am.
- Faculty and staff in the ~~biology~~ engineering department really want me to succeed.

Involvement: All items were rated on a six-point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, and 6 = strongly agree). Students also had the option to choose “prefer not to respond.”

During this academic year, it is likely that I will:

- participate in undergraduate research (paid or unpaid) in the ~~biology~~ engineering department.
- interact closely with ~~biology~~ engineering faculty or staff outside of class
- talk about my career plans with the ~~biology~~ engineering faculty or staff
- discuss course topics, ideas, or concepts with ~~biology~~ engineering faculty or staff outside of class
- discuss my academic performance with ~~biology~~ engineering faculty or staff outside class

- ask for advice from a ~~biology~~ biology engineering faculty or staff who is not my instructor.
- attend the office hours of a ~~biology~~ biology engineering faculty member.
- read research papers from a ~~biology~~ biology engineering faculty member.
- attend a seminar hosted by the ~~biology~~ biology engineering department.
- visit the lab of a ~~biology~~ biology engineering faculty member.
- join a biology engineering-related student group or club at [my university].
- participate in biology engineering-related volunteer work not connected to research (e.g., clean up beaches or volunteer in a state park).

Appendix M

STEM-PIO-4

Item responses are averaged to create a composite scale:

1. (Overall) Select the picture that best describes the current overlap of the image you have of yourself and your image of what a STEM professional is.
2. (Competence) Select the picture that best describes the extent to which your knowledge of STEM concepts matches that of a STEM professional.
3. (Performance) Select the picture that best describes the extent to which your capacity to use STEM skills in a public setting matches that of a STEM professional.
4. (Recognition) Select the picture that best describes the extent to which you think others (such as your STEM professors) see your identity as overlapping with a STEM professional.

