More Than Binary, More Than Normative, More Than Quantities: Transgender and Gender Nonconforming Students in Postsecondary Computer Science Education

by

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A dissertation accepted and approved in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

in Critical & Socio-Cultural Studies in Education

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Spring 2024

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DISSERTATION ABSTRACT

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Doctor of Philosophy in Critical & Socio-Cultural Studies in Education

Title: More Than Binary, More Than Normative, More Than Quantities: Transgender and Gender Nonconforming Students in Postsecondary Computer Science Education

Transgender and gender nonconforming (TGNC) students are underrepresented in CS education and have been found to leave the field at higher rates than their counterparts. While there is a great deal of Computer Science (CS) education research focused on other underrepresented groups, it rarely includes those who are TGNC. Overall, there is a dearth of research in CS education which acknowledges and investigates lived gender outside of the binary. Employing voices of non-binary and transgender students in computing, this project employs surveys, interviews, and a focus group to gain a deeper understanding of the experience of gender diverse people in CS education. The study finds that TGNC students enjoy the field of computing, feel confident about their skills and abilities, and foresee being successful in their coursework. At the same time, they do not feel that they belong and they worry about their future in CS employment. A high percentage of study respondents do not feel able to express their gender authentically and do not feel supported by faculty and staff in their departments. Students with multiple marginalized identities report compounded and unique challenges. Participants recommend that the CS education community integrate TGNC-related topics in curriculum, increase representation of TGNC people, and invest in the development of TGNC centered/aware mentorships. Based on the findings, a new paradigm, TransForm CS, is put forth, which centers TGNC students in each of its core pillars: curriculum, pedagogy, policy, and CS education research.

Keywords: Computer Science, Education, Transgender, Broadening Participation, Belonging

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ACKNOWLEDGEMENTS

I wish to express my sincere appreciation and gratitude to Professor Joanna Goode for her mentorship, guidance, and support through my entire doctoral journey, and in the preparation of this manuscript. In addition, special thanks are due to professors Lisa Mazzei, Jenefer Husman, and Judith Raiskin for their feedback and suggestions on improving and strengthening the manuscript. I am grateful to Professor Jerry Rosiek for his unwavering support, countless fruitful discussions, and many delicious dinners, ...plus starting me early on getting used to the sound of "Dr Skorodinsky," which I'm still getting used to. I would like to acknowledge my chosen family, Brooks, Andrew, Laura, Corrina, Tigre, Lydia, Dahlia, Kalil, Sonya, Mavis, Klara, and Marty, who were my champions through the years that it took to complete this journey. I am grateful for all your love, support, shoulders to cry on, and sustenance. Many thanks to my colleagues and peers, Niki, Allie, Roshelle, and Shareen. I am grateful to Andrea Haverkamp, Stacey Sexton, and Amanda Menier. In addition to offering support, their scholarship on trans and nonbinary students in engineering and computer science helped establish a path for my research. A well of gratitude to my four legged best friend and support being, Meeshka. and to my therapist, Mary Beth. A heartfelt acknowledgement to my ECCO High School family: staff, fellow teachers, and students. You have all nurtured and inspired me over the years. There are so many more people to thank and recognize. I could not have gotten to this point in my life without the support of family, friends, colleagues, co-workers. Whether you are listed above or not, I am grateful to all those who have lifted me up, believed in me, and helped me along the way to completing this huge milestone.

DEDICATION

I dedicate this work to all the brave Transcestors, who broke open and paved the way for me to be able to show up as a full and worthy being ...to stand on their shoulders and to feel strong enough to offer the world my contributions: Marsha P. Johnson, Sylvia Rivera, and Lou Sullivan. I dedicate this work to my mom, dad, and sister. You taught me the value of hard work, risking safety for dreams, and reaching for big things. I dedicate this work to my child, Ilya Lior Cashew, who came toward the end ...and was there all along ...as a desire and an aspiration. Ilya, you are my guiding light for doing the work. I want you (and everyone else) to live in a world where your gifts enable you to blossom and shine, and where your whole being is welcomed and valued.

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Chapter 1: Introduction

It is Monday, and Sachi is excitedly attending day one of "You Can Build," a camp on designing and programming computer games. They've waited all Summer for the camp to start and now, along with 24 other middle schoolers, are squirming in their seat awaiting the announcement of game topic choices. Unbeknownst to them this camp was designed as a university project aimed at increasing girls' self-efficacy and engagement in computer science. Several of the game choices are specifically based on research findings regarding what attracts girls to computer science, such as community focused topics and group work. A cooperative game about caring for rescue animals is announced. Sachi jumps out of their seat to join the group. When they notice that only girls have congregated around the young woman who will lead that effort, they pretend to need to use the restroom and keep walking past the group. After making a lap around the room they choose a random group of boys and try to feign enthusiasm about racing robots…

During the past several decades, researchers, educators and computer scientists have highlighted that the field of Computer Science (CS) has a gender problem – overrepresentation of men and underrepresentation of women. Indeed, CS has the largest representation gap for women out of all Science Technology Engineering and Mathematics (STEM) subjects (Ashcraft et al., 2016; Cheryan et al., 2015; Rivers, 2019). In parallel, scholars demonstrate that CS has become a field associated with men and masculinity (Cheryan et al., 2017; Faulkner, 2001; Riley, 2013). For the past several decades, researchers have engaged in analysis and interventions focused on addressing the gender disparity in CS. In these efforts, gender has been almost exclusively limited to binary categories of women and men. However, as Sachi's

experience in the classroom illustrates, the gender problem in computing is more complex and nuanced, and impacts not just cisgender men and women, but those who are transgender and gender nonconforming[1] (TGNC).

Research shows that TGNC people constitute 1.6% of the US population at large, but also reveals a significantly higher percentage amongst individuals under 30 (5.1%) (Brown, 2022; Herman et al., 2022). This means that there are potentially five TGNC students per every hundred in a CS department/program. There is ample evidence that TGNC people participate in and contribute to the field of computing. For example, TGNC scientists [2] such as Edith Windsor, Sophie Wilson, and Lynn Conway all made significant contributions to CS (Freeman, 2020; de Souza Santos et al., 2023; Stout & Wright, 2016). Additionally, studies and news media articles[3] have reported on the participation of TGNC people in STEM fields, including engineering and computing (de Souza Santos et al., 2023). Despite their presence and involvement, TGNC people are not well supported in CS, in part, due to the lack of acknowledgement and representation of gender beyond binary categories (DeNisco-Rayome, 2019). As is the case with Sachi, TGNC students in CS are often relegated to being invisible participants. At one point in my life, this was also true for me.

In the late 1990s, I was a transgender student in a CS department at a university. At that time, I had a masculine presentation, but had not yet legally or medically transitioned. My school and departmental records indicated that I was a female. I did not feel that I could discuss being a transgender person in my department. Even though I presented as a man, I was steered towards

[1] A glossary of transgender and gender nonconforming terms: https://glaad.org/reference/trans-terms/
[2] https://reference.linkedin.com/pulse/trans-woman-who-revolutionized-computing-martyn-mendyuk/ https://cord.co/insights/working-culture/articles/three-transgender-women-who-changed-technology https://reference.thecodingspace.com/blog/2022-03-01-six-trans-programmers-who-shattered-the-lavender-ceiling/
[3] https://reference.zdnet.com/article/transgender-employees-in-tech-whythis-progressive-industry-has-more-work-to-do-to-achieve-true-genderinclusivity/

the department's Women in Computing chapter, where I volunteered to encourage and tutor undergraduate women. I felt extremely uncomfortable participating in a space designated for women and felt that I had to hide my expansive gender identity. During my years in the department, I constantly felt like I had to choose between being a man (which I wasn't yet ready to embrace) or being a woman (which was not my authentic gender either). Gender outside the binary was never acknowledged or discussed in my department or CS classes and I did not feel free to bring up the issues that impacted me and TGNC people in these spaces. My transness remained invisible and silent.

This research is in part motivated by my experience in CS education twenty-five years ago. Although, currently there is more willingness to discuss and acknowledge expansive gender in the US, many TGNC students in my study share that they struggle to be seen and many report that they do not disclose being transgender in CS education spaces. This is especially true for nonbinary students. In addition to the harm caused by not having their gender identity seen and affirmed, this also means that their voices and perspectives are not represented in CS education. Black women CS scholars, reveal that the absence of marginalized voices and perspectives in CS does not only harm the field, but it also harms those who are marginalized (Benjamin, 2023; Noble, 2022). For example, Benjamin Ruja, in *Race After Technology*, shows that the coding of blackness in computing technology increases effects of surveillance and leads to over policing and overrepresentation of blacks in the US criminal justice. Joy Buolamwini[4], Timnit Gebru, and Safia Noble both argue that today's algorithms are biased[5] against those who are Black, Indigenous, and people of color (BIPOC) and women (Buolamwini & Gebru, 2018; Noble,

[4] Race and gender bias: https://ajl.org/spotlight-documentary-coded-bias
[5] Algorithmic bias: https://vox.com/recode/2020/2/18/21121286/algorithms-bias-discrimination-facial-recognition-transparency

2018). All three scholars link the bias, in part, to the underrepresentation of these groups in CS and to the scarcity of BIPOC perspectives and voices in computing and the tech industry. Considering our growing dependence on artificial intelligence and voice/facial recognition software, trained on data coded with binary gender categories, there is real risk that TGNC people are and will continue to be negatively impacted by the field of computing[6].

This research is important for two additional reasons. One, there is a growing focus in CS education on inclusion and belonging for all students (Brown, 2016; Sahami, 2018). Projects, such as AiiCE[7] and the Kapor Canter's Culturally Responsive-Supporting Computer Science Education Framework[8], are centering student identity as a focal point in CS education reform. However, there is a real lack of research that examines the experience of TGNC students in CS education, and thus, not much is known about how to best affirm and support their identity. Two, in the past two years (2022-23), the US has seen an increase in sociopolitical attacks on TGNC people, threatening to or actively stripping away their rights, access to affirming education, health care, housing, employment, sports, etc. In 2023, six hundred anti-trans bills[9] were proposed across forty nine states. Of these, eighty seven have been passed into law. As of February 2024 alone, four hundred forty six anti-trans bills[10] have been introduced across forty states. Hate crimes against TGNC people are on the rise. According to the 2022 FBI hate crime statistics report[11], "a significant increase of nearly 40% was observed in reported anti-transgender incidents […] compared to 2021" (*FBI Hate Crimes Statistics*, 2023). Significantly,

[6] Impact of algorithms/AI on nonbinary/trans people: https://reference.ajl.org/drag-vs-ai
[7] AiiCE: https://identityincs.org/
[8] Kapor Center: https://reference.kaporcenter.org/
[9] https://translegislation.com/bills/2023
[10] https://translegislation.com/bills
[11] https://reference.justice.gov/crs/highlights/2022-hate-crime-statistics

State, and local laws that limit the rights and access of TGNC students have ramifications inside postsecondary institutions, not withstanding, CS departments and programs. For example, a TGNC student who cannot legally change their gender marker or is denied access to gender affirming health care, will face additional challenges asserting their authentic gender while they participate in CS studies. Thus, currently TGNC people are increasingly more vulnerable in and out of postsecondary CS academic settings.

The findings I present in this study show that TGNC students in CS education face hardships that are a mix of external barriers such as lack of access to legal name change, gender affirming healthcare and housing, and internal challenges, such as having their authentic gender recognized and supported by administration, faculty, and peers. As efforts to be more inclusive in CS education increase and given the rising threat to TGNC students wellbeing inside and outside of academic institutions, it is urgent that this population be centered in CS education research.

Gender is not the only identity centered problem that exists in CS education. Other groups have been pointed to as historically and currently not well supported in computing (Aspray, 2016; Hamrick, 2021). There is a growing effort in CS education to increase participation and retention of groups that have been marginalized along the lines of race, gender, disability, and class. Since the early 2000s, the National Science Foundation has been funding such efforts under the Broadening Participation in Computing (BPC) umbrella. Although, TGNC students have not been the focus of these efforts, the design and findings of BPC projects are important to consider to better support them in CS education. Early BPC research projects predominantly focus on access to and participation in computing. These studies aim to reverse the effects of historic exclusion of BIPOC students, women, and those with disabilities (Martin,

2015; Wang, 2016). More recently, scholars highlight that the focus on access and participation is insufficient to truly address the representation problems in computing (Margolis et al., 2012). They argue that in addition to making CS classes available (access) and getting students in the door (participation), what is necessary is pedagogical and curricular practices that acknowledge and support students' identities (Goode et al., 2018; Ryoo, 2019).

A number of approaches, emerging from the field of education and aiming to address academic disparities for marginalized students in the US, have been brought into CS education. These include Culturally Relevant, Culturally Responsive, and Culturally Sustaining pedagogies. Central to all three pedagogical frameworks is the idea that to make education truly accessible and beneficial for historically marginalized groups, students need to feel that they are seen, that their voices matter, and that their experiences and struggles are valid. All three of the above frameworks advocate for including topics in curriculum that are relevant to marginalized students, including the acknowledgement of historic oppressions, such as racism, sexism, etc. Several research projects, such as, CompuGirls and ECS, incorporate these frameworks explicitly (Goode & Margolis, 2011; Scott & Zhang, 2014). Efforts to improve academic experiences and outcomes for marginalized students by affirming their identity and experiences are related to another framing of student academic wellbeing, which is belonging. There is extensive research in education that links a positive sense of belonging to improved academic outcomes and persistence (Slaten et al., 2016). Notably, findings show that when marginalized students' identities are acknowledged and affirmed, their sense of belonging in a classroom, and even a field of study, increases (Scott & White, 2013; Walton & Cohen, 2011).

Belonging, the notion that humans need to feel seen, included, and valued, has been used to investigate BIPOC and female students in STEM. The frame of belonging has also been used

to study the experiences of Lesbian Gay Bisexual Transgender Queer Intersex Asexual[12] (LGBTQIA+) students in STEM and TGNC students in engineering. However, belonging has not yet been used to investigate TGNC students in CS specifically. Given the significant impact of belonging on academic outcomes and persistence, this research investigates how expansive gender impacts TGNC students' sense of belonging in postsecondary CS education and computing. The study probes what it means for students to belong in a discipline and educational spaces that are steeped in gender being understood and enacted along rigid binary categories.

The challenges that TGNC students face in postsecondary CS education are further complicated by the reality that, like other marginalized groups, this population is not a monolith. In addition to the diverse experiences and identities related to gender within the group, such as nonbinary, gender queer, and agender, there is diversity along other lines of marginalization, such as race, ethnicity, disability status, sexuality, class, etc. Intersectionality is used in this study to more deeply understand the impact of overlapping structures of power and axis of oppression experienced by TGNC students in CS education. TGNC students who live at the intersections of multiple marginalized identities navigate unique challenges in CS education because computing has a history of discriminatory practices against a number of marginalized groups. The study examines how having multiple marginalized identities impacts TGNC students' sense of belonging and their experience navigating intersectional challenges in CS education.

To address these research inquiries, this study used a mixed methods research design, employing quantitative and qualitative methods, to gain a better understanding of what it means

[12] LGBTQIA+ is an umbrella term that is dynamic – more identities have been added to the acronym over time, such as two spirit (2S) and pansexual (P). The more recent acronym, LGBTQQIP2SAA, stands for lesbian, gay, bisexual, transgender, queer, questioning, intersex, pansexual, two-spirit, asexual, and ally. https://reference.goodrx.com/health-topic/LGBTQIA+/meaning-of-lgbtqia

for TGNC students to belong in postsecondary CS. I selected the mixed methods design because there is a gap in both quantitative and qualitative findings in this area. TGNC students are rarely included in quantitative studies in CS education. When they are included, their data is not disaggregated, and the reported findings do not necessarily reflect their unique experiences. Much more frequently, TGNC students' data are explicitly removed from analysis due to a small number of participants. Additionally, mixed methods were used to take advantage of the affordances offered by the quantitative and qualitative methods. The quantitative component of the study allowed me to explore TGNC students sense of belonging by comparing percentages and numbers between strongly agree, agree, disagree, and strongly disagree responses to questions probing experiences that impact belonging, such as representation and correct name/pronoun use. The qualitative components allowed me to understand the students' experiences more deeply and to incorporate their voices in the meaning making.

The study used a survey, interviews, and a focus group in sequence. The survey portion of the study enabled me to reach a diverse set of participants across the US, including several international students. The design of the demographics section is significant in that it focused on offering participants multiple ways to mark their identity, especially, with respect to race, ethnicity, gender, and sexuality. For each one of these categories, participants could select any of the items that applied, allowing them to be seen as multiplicities of identity. I used the survey data to conduct a targeted recruitment of interview participants, prioritizing those with intersectional identities, in order to probe how intersectionality impacts students' sense of belonging in CS.

The study specifically investigated how TGNC students navigate the binarily gendered field of CS education given their expansive gender. Because TGNC students constitute a diverse

group, the study was designed to engage a broad range of TGNC voices: those who experience a spectrum of expansive gender as well as those with additional marginalized identities. Additionally, the study employs the lens of intersectional analysis to examine how expansive gender combines with other marginalized identities, such as race, ethnicity, disability status, class, etc., resulting in unique experiences and challenges for TGNC people in CS education. Finally, this study seeks to make contributions to actively shift CS education spaces to be more inclusive and supportive of TGNC students. For this reason, the project engaged TGNC students in thinking together and sharing recommendations for how CS education can be improved to be more inclusive and supportive of expansive gender. This phase of the study, a focus group, was undergirded by a transformative paradigm which informs my commitment to produce research in the service of social justice, that is, to improve living conditions and increase opportunities, equity, and justice for TGNC students in CS education (Mertens et al., 2007).

The following research questions (RQ) are examined in the study:

- How does having an expansive gender identity influence TGNC students in postsecondary CS education, with respect to belonging, persistence, leaving, etc.? (RQ1)
- How does having multiple marginalized identities result in unique experiences and challenges for TGNC students in CS education? (RQ2)
- What recommendations do TGNC students give for making CS Ed an inclusive space for people who experience gender beyond the binary? (RQ3)

TGNC students constitute a marginalized group, are underrepresented in CS education, and have been found to leave the field at greater rates than their cisgender counterparts (Linley et al., 2015; Maloy et al., 2022; Trenshaw et al., 2018). Those who work on efforts to broaden

participation in computing (BPC) assert that they are committed to *computers science for all* (CS for All). However, while there exists a substantial corpus of literature and interventions addressing the experiences of marginalized students in CS education, especially that of women, there is a dearth of research that centers the experiences and voices of TGNC postsecondary students. Given the current, increasingly hostile political climate towards TGNC people, and the emphasis on inclusion and belonging of marginalized groups in CS education, the focus and findings of this research are timely and necessary.

The following chapters present a review of the literature, an explanation of the study methodology, followed by the report of findings, and conclude with implications, recommendations, and future research directions. The literature review situates TGNC CS students in research focused on broadening participation of historically marginalized group in CS and the experiences of LGBTQIA+ students in STEM and engineering. The methodology chapter describes the study design and implementation. The findings chapter reports on results of analysis of the three phases of the study: survey, interviews, and focus group. The final chapter examines the implications of the findings with respect to the four core pillars, proposed in a new paradigm to make CS education more affirming of expansive gender, TransForm CS: curriculum, pedagogy, policy, and computer science research. The chapter ends with a discussion of the study limitations and future research directions.

Chapter 2: Literature Review

> The National Science Foundation includes broadening participation in its core values, as it seeks and accommodates "contributions from all sources while reaching out especially to groups that have been underrepresented." Nowhere at the Foundation is the need for inclusion more pressing than in the CISE[13] community, where the longstanding underrepresentation of many demographic groups coincides with the increasingly pervasive role of computing in our society, the importance of IT innovation in driving our economy, and the growing demand for IT specialists at all levels of the workforce. With respect to the CISE community, the groups designated as underrepresented are women, African Americans, Hispanics, Native Americans and indigenous peoples, and persons with disabilities. (Directorate For Computer & Information Science & Engineering, 2012)
>
> There are various reasons why this underrepresentation is important. It a social equity issue that these high-paying, fulfilling, socially transformative jobs are less available to individuals from other demographic groups than they are to many White and Asian men. (Aspray, 2016, p. 2)

TGNC people participate in and contribute to the field of computing[14]. Even though they are active in the field, there is evidence that they are not well supported in CS. Scholars note that within computing there is a resistance to acknowledging and affirming gender beyond binary categories, resulting in both an erasure of TGNC people and a barrier to their inclusion and participation (Jennings et al., 2020; Menier et al., 2021).

TGNC people are not the only marginalized group to experience negative outcomes in computing. CS has a well-documented history of being an exclusionary domain, having the highest representation gap among STEM fields for groups marginalized along race, gender, and disability (National Center for Science and Engineering Statistics, 2023). For the past several decades there have been concerted efforts to democratize the field of computing through

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[13] Directorate of Computer & Information Science And Engineering (CISE)

[14] One representation of the participation and contribution of TGNC people, is the recently convened (2023) three-day workshop on Trans and Nonbinary Computing Education Research, funded by National Science Foundation (NSF), *Expanding The Agenda For Inclusive Policy, Practices, And Research Regarding Gender And Computer Science.* The event included multiple sessions centering the perspectives of TGNC people involved in CS and CS education research on the practices and policy needs of TGNC students in CS. https://reference.sagefoxgroup.com/tnb

interventions to close the representation gap for historically and currently marginalized groups. Early interventions to close the gap focused on increasing access to computing. Recently, efforts to address historic exclusion of marginalized groups in CS are aspiring to go beyond representation parity, turning their attention toward inclusion and increasing a sense of belonging for marginalized students in CS. This is demonstrated by the work of: Exploring Computer Science[15], Alliance for Identity-Inclusive Computing Education[16], and the Kapor Center[17]. The interventions aiming to address inclusion and belonging in CS rely on findings that make sense of the experiences of marginalized students. While there exists a robust body of research investigating and documenting the experiences of BIPOC, women, and those with disabilities in CS education, there is a lack of equivalent research that informs us about the experiences of TGNC students.

Many research projects in CS education that address historic inequity have been supported by the National Science Foundation (NSF) under the Broadening Participation in CS (BPC) and CS for All grant programs. TGNC people, predominately as members of the LGBTQIA+ population, have been shown in research to be underrepresented in CS, experience discrimination, and leave the field at higher rates than their counterparts (Linley et al., 2018; Maloy et al., 2022; Trenshaw et al., 2018). However, the TGNC population is not well-researched in CS as a standalone group, and their experiences in CS education spaces are not well understood. Moreover, TGNC people are both underrepresented in and impacted by the research on increasing the participation of women in computing (a significant subset of BPC research literature), which predominately theorizes gender as a binary. More than binary gender,

[15] https://www.exploringcs.org/
[16] https://identityincs.org/
[17] https://www.kaporcenter.org/

and with it, TGNC students, are by enlarge excluded from studies that investigate gender and other marginalized identities in CS education.

This chapter examines the body of literature concerned with underrepresented groups in CS to explore how this canon of literature might inform and impact research focused on TGNC students. Next, research literature on LGBTQIA+ people in STEM, engineering, and CS, will be reviewed to probe how this umbrella group (which, in name, includes transgender people) is taken up in existing CS education research. The review of LGTBQ+ in STEM research will focus on prominent themes in the literature: climate, intersectionality, apoliticism, belonging, and coping strategies. Research focused on TGNC students in postsecondary STEM/engineering will be discussed with respect to each of the themes. The chapter concludes with a discussion of the gaps in research and implications for this study.

Computer Science: A Field of Education Marked by Exclusion

BPC is both an NSF funded directive and a commonly used phrase in computing and computing education that conveys a desire/commitment to increase participation of marginalized groups in CS. Several of the studies included in this chapter were chosen because the authors assert a commitment to BPC as an ethos and are not necessarily an NSF funded BPC project. Projects under the BPC ethos do reflect the general recognition that the field of computing has a historic and current representation gap for marginalized groups and are relevant to this study as they discuss and offer solutions to address increasing participation of these groups. There is very little research that centers TGNC students in CS education. Of the research that is relevant to TGNC students in CS, are the few studies that examine LGBTQIA+ students in CS education. A more extensive area of research, though still relatively small, that is relevant to this study and is included in the chapter is LGBTQIA+ people in Science Technology Engineering and

Mathematics education (STEM encompasses subjects related to technology, CS being one of these; STEM also encompasses engineering, another field of study that includes CS). Thus, the literature review examines research that focuses on LGBTQIA+ people in STEM and engineering in addition to studies that specifically address the field of computing.

According to the NSF Directorate for Computer Information Science and Engineering (CISE) BPC site[18], the projects under this directive are intended to: "address the longstanding underrepresentation of various populations — including women, persons with disabilities, Blacks and African Americans, Hispanics and Latinos, American Indians, Alaska Natives, Native Hawaiians, and Other Pacific Islanders — in computing and closely-related disciplines." In two volumes, documenting the history and scope of underrepresentation of marginalized groups in computing, Aspray, the historian, outlines the problem that CISE is working to address, which is that "women, African Americans, Hispanics, and American Indians have been consistently underrepresented in the computing field throughout the entire era of modern computing." Over the past several decades, BPC related studies have emerged in nearly intractable numbers. Given that TGNC students are an underrepresented and marginalized group, it is important to focus on key themes in this vast area of research to better understand how TGNC CS students fit within the corpus of BPC solutions and how the findings of BPC research impact them.

In his (2016) book, "Participation in computing: The National Science Foundation's expansionary programs," Aspray documents the trajectories of efforts that were spearheaded by the NSF/BPC to close the participation gap in CS. Two of the key themes identified in his work are relevant and can be extended to TGNC students.

(1) historical and sociocultural forces that shape who participates in CS and who doesn't

[18] https://reference.nsf.gov/cise/bpc/

(2) intersectionality

Following, is a discussion of how broadening participation efforts have infused these two themes, and how these themes map onto TGNC students' particular experiences.

Historical/Sociocultural Forces Limiting Access for Marginalized Groups

In the introduction to his (2016) volume, Aspray asserts that the underrepresentation gap and the shift to address it has roots in historical and cultural forces such as the end of World War II, when US men returned from war and displaced women from STEM jobs, and the Civil Rights movement, which activated the fight against discrimination and inequity based on race, gender, and disability status. The Civil Rights movement brought to the forefront the inequitable access to education, including lack of access all together, for BIPOC, women, and people with disabilities. A portion of research on underrepresentation of marginalized groups in CS focuses on the historic causes of why some demographic groups are less present in the field of computing. For example, scholars argue that the root causes of underrepresentation for BIPOC people is a history of racism, discrimination, and inequitable access to CS education (Erete et al., 2021; Newsome, 2022; Rankin et al., 2021). Considering this reality, these scholars advocate for structural changes to address the representation gap. In "Conversations about diversity: Institutional barriers for underrepresented engineering students," Long and Mejia (2016) argue that the underrepresentation of marginalized groups in postsecondary Engineering and STEM education has a historical context and proposes that the representation gap needs to be addressed at both the structural (legislation) and institutional (educational policies) levels. They point out that social inequities and prejudice actively drive both women and underrepresented males out of STEM fields.

At the high school level, authors demonstrate in "Stuck in the Shallow End," how students of color, in three US high schools, are prevented from engaging in CS classes, by being tracked out, actively discouraged, and ignored by teachers, who treat them as incapable when they do take CS classes (Margolis, 2017). A large set of research that examines the historical and sociocultural factors that cause the participation gap, centers access as the most salient issue. This includes studies that advocate for increased access to CS for groups marginalized along race, ethnicity, gender, and disability (Martin et al., 2015 , Royal & Swift, 2016). For example, the NSF funded CS for ALL project[19], is working towards making CS accessible to every K12 student in the US, including students with disabilities, those who live in rural parts of the country, and those who are English learners. Researchers, that prioritize access as the area of utmost focus, diverge in the underlying assumptions about the educational settings where access to CS should be prioritized: in school vs out of school. Additionally, they vary in theories of what constitutes access.

Interventions that address access to computing fall along one of two primary assumptions and approaches. One approach focuses on formal in-school K-12 education. It is undergirded by the assumption that to reduce the underrepresentation gap every student should have access to CS in school. Researchers working on projects that center access to CS education for every student argue that CS is a necessary literacy for participation in contemporary society and should be available to all, along with other school subjects, such as reading, mathematics, science, etc. (Raja, 2014; Webb et al., 2017). Additionally, scholars posit that without exposure to and

[19] (*New York, NY, Friday, March 31, 2023) — CSforALL is proud to be awarded $2,246,356.00 from the National Science Foundation (NSF) to strengthen CSforALL's national community efforts that raise awareness and build capacity to advance K-12 computer science education for ALL students* https://csforall.medium.com/new-nsf-award-will-advance-national-computer-science-education-ecosystem-f77c8e184c4a

engagement with CS concepts in K12, students will not be sufficiently prepared to continue the study of CS in postsecondary if they chose to. The significance of making CS available to all K-12 students is that, in the future, potentially every TGNC student will have an opportunity, and possibly, be required, to engage in CS education. However, given the lack of research data on their experiences, there is a risk that they will not feel included and/or supported despite having access to the subject.

Another approach focuses on informal education and assumes that increasing participation, i.e., closing the representation gap, can be achieved by providing access outside of school. Specifically, the programming is grounded in theorizing that students from marginalized groups, those that have been historically excluded, need extra preparation and opportunities to increase their confidence and skills in CS. Of note, many out of school interventions for broadening participation are projects limited to single gender participants, such as all girl technology camps and after school coding clubs. Almost exclusively, these projects take binary gender categories as a given. Additionally, they tend to essentialize certain traits as exclusively belonging to girls/women, reinforcing an inaccurate biologically determinist conceptualization of gender (Colatrella , 2011; Hyde et al., 2019; Liben &Coyle, 2014; Schmitz, 2010; Starrett et al., 2015). As such, they are troubling, if not entirely exclusive, spaces for trans and nonbinary students. Both approaches generate projects that aim to address the representation gap in CS along the lines of race, ethnicity, gender, disability status, socio economic status, etc. (Goode & Margolis, 2011; Robinson & Pérez-Quiñones, 2014). However, the approach that argues for making CS available to all students, tends to recognize that access alone is insufficient and expands the notion of access to include course content and teaching practices (Goode et al., 2012).

Computer Science for All (CS for All): Who Is Included in All?

Scholars that advocate for in-school (K12) access to CS education for all students call attention to the central roles of curriculum, pedagogy, classroom environment, and climate in efforts that aim to reduce the representation gap. These interventions move beyond access and assert that what is needed to shift the current statistics of who is included and who is not, is to focus on the *participation* and *engagement* of previously excluded students. In "Building Equitable Computer Science Classrooms: Elements of a Teaching Approach," authors assert that addressing the representation gap through equitable access to CS education also requires "pedagogical practices that account for the social and emotional aspects of learning" (Shah et al., 2013). They forward a framework for designing equitable CS class content which includes "(1) access to rich course content; (2) access to quality instruction; (3) access to identities as computer scientists; (4) and access to productive peer relationships." This approach is grounded in the frameworks of Culturally Relevant, Culturally Responsive, and Culturally Sustaining pedagogies, which have been shown to improve outcomes for marginalized students in general academic settings (Ladson-Billings, 1995; Gay, 2013; Paris, 2012).

Culturally Relevant, Culturally Responsive, and Culturally Sustaining Pedagogies

In the recent review of literature of Culturally Responsive Pedagogy (CRP), Caingcoy (2023) defines CRP as "an educational approach that recognizes the diverse backgrounds and lived experiences of students and seeks to create inclusive and engaging learning environments." Caingcoy (2023) asserts that CRP has its roots in two main social justice-oriented frameworks. The first framework, *culturally relevant pedagogy*, comes from Ladson-Billings who coined the term. In (1995), Ladson-Billings writes that culturally relevant teaching is grounded in the following: students experiencing academic success, students developing and maintaining cultural

competence, and students developing a critical consciousness through which they can challenge current injustices and inequities. Her framework is focused on addressing the educational needs of BIPOC students. The second framework, *culturally responsive teaching*, utilizes student-centered teaching which emphasizes students' lived experience, knowledge about cultural diversity, including ethnic and cultural diversity content in the curriculum, and responding to ethnic diversity in the process of instruction (Gay, 2018). Gay theorizes that:

> when academic knowledge and skills are situated within the lived experiences and frames of reference of students, they are more personally meaningful, have higher interest appeal, and are learned more easily and thoroughly. As a result, the academic achievement of ethnically diverse students will improve when they are taught through their own cultural and experiential filters.

In his literature review of culturally responsive pedagogy, Caingcoy (2023) reports on several projects that demonstrate positive academic outcomes for marginalized students.

The aspirations and positive impacts of culturally relevant/responsive/sustaining pedagogy has been incorporated in many specific domains of study, such as language arts, mathematics, and computing (Marshall, 2023; Foster, 2016; Moreno Sandoval, 2013). Most significantly, there is agreement and evidence that acknowledging and engaging students' historic, social, and cultural identities leads to better educational experiences and outcomes, in general, and in STEM specifically (Franklin et al., 2011; Scott et al., 2009). Furthermore, acknowledging, and engaging students' historic, social, and cultural identities creates opportunities to develop their critical thinking skills and builds their sense of agency to challenge and change current inequities and injustices (Ashcraft et al., 2017; Scott & Garcia, 2016).

Culturally Relevant/Responsive/Sustaining CS

Culturally Relevant/Responsive/Sustaining CS (from now on referred to as CRRS-CS) pedagogies, grounded in the CRP frameworks, acknowledge, and make explicit to students, the

historic and sociocultural causes of the gap in participation in computing for marginalized groups and aim to support students by affirming their identity, history, culture, and community in the context of CS education.

One example of a project that takes up CRRS-CS pedagogy is the work of the Kapor Center and the "Culturally responsive-sustaining computer science framework[20]" (Kapor Center, 2021). There are two facets to the framework: (1) a shared definition of the culturally responsive-sustaining computer science pedagogy; and (2) six core components for implementing culturally responsive-sustaining computer science pedagogy. The authors of the framework situate their effort within a context of racial, socioeconomic, and gender inequality in computer science education, stating that their strategy is:

> to move beyond increasing access to computer science courses and ensure all students have the opportunity to be inspired and engaged in computing education, develop critical computational skills, and have equitable opportunities to pursue computing careers and contribute to technological innovation. (Kapor Center, 2021)

They further assert that the pedagogy for which they advocate must ensure that:

> students' interests, identities, and cultures are embraced and validated, students develop knowledge of computing content and its utility in the world, strong CS identities are developed, and students engage in larger socio-political critiques about technology's purpose, potential and impact. (Kapor Center, 2021)

According to the designers of the framework, CRRS-CS pedagogy encompasses the following: *the teacher's instructional design practices, as well as the pedagogical practices, curriculum, resources, and activities used in the classroom*. They argue that while CRRS-CS instruction is necessary, it is not sufficient to achieve equity in computer science education and that it must be implemented alongside "broader solutions to dismantle racism and inequity in education,

[20] The Kapor framework can be accessed here: https://reference.kaporcenter.org/wp-content/uploads/2021/06/1_CRCSFramework-Report_v7_for-web-redesign-.pdf

employment, health, and the environment, all of which disproportionately negatively impact marginalized communities" (Kapor Center, 2021). The above excerpts from the Kapor Center's "Culturally responsive-sustaining computer science framework," captures a number of themes that have been identified in CS education research as positively impacting outcomes for marginalized students in CS. These include validation and support of students' identities, development of a strong CS identity, the connection of CS to real world uses, and examination of sociopolitical impacts of technology on people and the planet.

Another example of a project that employs the themes of CRRS-CS pedagogy is the work of Kafai and colleagues (2014). The authors designed a ten-week electronic-textiles unit designed to connect indigenous crafting practices such as sewing and decorative beading to computing and engineering practices. The unit was implemented in a junior high Native Arts class. The authors share that the unit "focused on promoting design agency through the linkage of community funds of knowledge, including local indigenous knowledges (e.g., out beading, knowledge of plants), with computing and craft practices." The intention of the course is "to show students that technology is an essential part of their heritage," reinforcing their CS identity, and to highlight that CS has real life applications and contemporary relevance to their community. The authors integrated CRRS-CS pedagogic practices such as affirming student's identity, building on cultural funds of knowledge, demonstrating the relevance of computing to their community, and engaging in real world projects. The project is grounded in theorizing that rooting computing education in the heritage/funds of knowledge of marginalized students improves engagement and outcomes. This research highlights an important gap in the research literature: what is the impact of integrating TGNC historic and

cultural heritage and TGNC funds of knowledge into computing education. Similar research has been conducted with other marginalized groups in CS (Lachney, 2021; Moreno Sandoval, 2019).

As evident from existing research on marginalized students in CS education, historical and sociocultural forces have had and continue to have a significant impact on the representation gap in CS (Long and Mejia, 2016). Pedagogical approaches such as CRRS-CS aim to ensure that "students' interests, identities, and cultures are embraced and validated." Thus, researchers have argued that the design and implementation of interventions to better support marginalized students in CS education should take historical and sociocultural forces into account (Eglash, 2006; Thomas et al., 2018; Scott & Garcia, 2016).

What does this mean for LGBTQIA+ and TGNC students? With respect to TGNC students, this requires that teachers can acknowledge gender beyond binary, are informed about the historic and sociocultural context of TGNC people, and are comfortable supporting them in educational settings. However, there is evidence that teachers are not adequately prepared to undertake this level of support of TGNC students in K12 academic settings. In one study, researchers interviewed 183 undergraduate preservice teachers and found that their responses "highlighted deep discomfort and fears related to addressing trans and gender-creative students' needs in school" (Blair & Deckman, 2020). Other studies find that "educators often report reluctance, and a lack of preparation, to address LGBTQIA+ issues or intervene in gendered harassment, including sexist, homophobic, and transphobic language and behaviors (Blair & Deckman, 2019; Brant, 2016; Kitchen & Bellini, 2012; Meyer & Leonardi, 2008).

Historic and sociocultural forces that impact LGBTQIA+ and TGNC in STEM

There is a long history in the US of pathologizing and criminalizing both homosexuality and transness (Margolin, 2023; Toscano & Maynard, 2014). For students in the LGBTQIA+

umbrella, there is not a parallel history of explicit exclusion comparable to that of students of color, where access to CS was denied due to racism. LGBTQIA+ students do not experience exclusion like that of students with disabilities, due to assumptions that they are not capable of learning CS or due to the lack of necessary accommodations. Instead, due to a history of religious, political, and legal persecution, LGBTQIA+ people were either forced to hide their identity or suffer severe consequences.

During World War II, LGBTQIA+ people were placed in concentration camps and murdered along with members of other marginalized groups (Newsome, 2022). In the US, concurrent with the "red scare" of the 1950s, a concerted effort to rid the US government of communists, was the "lavender scare" (Newsome, 2022; Smith, 2020; Johnson, 2023). During this time, Senator McCarthy falsely claimed that the government had been infiltrated by homosexuals, and that they posed an equivalent threat to national security as that of the communists. This fear that gay men and lesbians could be blackmailed into revealing state secrets resulted in a systematic campaign to identify and remove all government employees suspected of homosexuality. In his book, *"The lavender scare: The Cold War persecution of gays and lesbians in the federal government"*, David Johnson (2023), argues that the "lavender scare" permeated American cold war culture in the 1950s and 60s. He reveals that in the summer of 1950, a committee of the US Senate investigated "the employment of homosexuals and other sex perverts in the government," and that later McCarthy's Republican allies admitted to firing 91 homosexuals as "security risks." Johnson (2023) further writes that:

> in 1953, the pressure to strengthen security procedures became codified when newly elected President Eisenhower signed executive order 10450, which expanded Truman's loyalty program to include issues of character and suitability. For the first time, "sexual perversion" was included in the list of behaviors that would exclude one from holding a job with the federal government or receiving a security clearance from a federal

> contractor. Agencies set up new policies and procedures for detecting and removing men and women suspected of being gay, lesbian, or bisexual. Applicants were personally interviewed to look for subtle signs of homosexuality, such as gender non-conformity. Invoking the notion of "guilt by association," investigators checked whether an employee's friends or roommates were gay. Some were placed under surveillance to determine whether they frequented gay bars or associated with "known homosexuals." Local police agencies were encouraged to raid local gay meeting places and share their arrest records. Investigators interrogated civil servants about their private sex lives and offered a "lie-detector" test as one of the only means of establishing their innocence.

In "The Lavender Scare: How Anti-Homosexual Policy Created an Anti-Democratic Rhetoric," Elizabeth Kostina (2019) concludes that the lavender scare is to date a largely undocumented period of persecution of homosexuality in US history and encompasses the massive and systemic firing of gay and lesbian employees from the federal workforce during the Cold War. Kostina (2019) states that:

> the effects of the Lavender Scare were silently widespread. Near the end of the 'purges' in the late 1960s, as many as 10,000 gay people had lost their jobs in the civil service, others were fired for "guilt of association," and coming out became nearly impossible without fear of discrimination and hate crimes. Because of the dogma surrounding being gay, public outings and firings usually led to suicides which the government actively hid or lied about the true cause of death.

This period of systemic persecution and the firings of homosexuals which occurred within the civil service workforce during the lavender scare is only one example of employment-based discrimination experienced by LGBTQIA+ people. Similar pressures to stay closeted for fear of losing their jobs and/or unjustly losing their jobs, have been reported by LGBTQIA+ military personnel, educators, and health care professionals. Only as recently as 2020, the Supreme Court of the United States issued its landmark decision in the case Bostock v. Clayton County, which established that "the prohibition against sex discrimination in Title VII of the Civil Rights Act of 1964 (Title VII) includes employment discrimination against an individual on the basis of sexual orientation or transgender status. Thus, LGBTQIA+ people have only had federal protection from

discrimination in employment based on sexuality and gender identity since 2020.

Beyond the "lavender scare," homosexuality and transness were illegal in many states in the US during the 19th and 20th centuries. In as recently as 1998, two men were arrested and charged with violating the Texas sodomy laws, which stated that "a person commits an offense if he engages in deviate sexual intercourse with another individual of the same sex." Their case made it to the Supreme Court in 2003, where the judges decided that sodomy laws should no longer remain a binding precedent. Homosexuality was fully decriminalized in 2006[21]. Laws banning cross-dressing in the U.S. date back to the 19th century. In the 1940s, 50s, and 60s, informal "three-article" rules[22] required people to wear at least three pieces of clothing that matched their biological sex. "Masquerade" laws, initially meant to punish rural farmers, who dressed up as Native Americans to avoid tax collectors, were used to criminalize cross-dressing around the United States in the mid-19th century. New York's "masquerade" law, dating back to 1845, was one of the oldest. It declared it a crime to have your "face painted, discolored, covered, or concealed, or [be] otherwise disguised… [while] in a road or public highway" (Ryan, 2023). The scholar, William N. Eskridge, Jr. asserts in his book, *Gaylaw: Challenging the apartheid of the closet,* that in the US "by the beginning of the 20th century, gender inappropriateness… was increasingly considered a sickness and public offense" (2009).

In addition to the political and legal persecution of LGBTQIA+ people, both homosexuality and transness have been pathologized by the US mental health profession. In 1952, the American Psychiatric Association (APA) published the first edition of the Diagnostic

[21] https://supreme.justia.com/cases/federal/us/539/558/
https://academy4sc.org/video/lawrence-v-texas-2003/
[22] https://history.com/news/stonewall-riots-LGBTQIA+-drag-three-article-rule

and Statistical Manual (DSM-I), listing all the conditions psychiatrists then considered to be a mental disorder. DSM-I classified "homosexuality" as a "sociopathic personality disturbance." In 1968, the second release of the DSM reclassified homosexuality as a "sexual deviation." Homosexuality was removed from the DSM as a mental disorder in 1973[23]. In 1980, with the publication of DSM–III, the diagnosis "transsexualism" first appeared. In 1990, the World Health Organization (WHO) also added this diagnosis to its manual, the ICD-10. With the release of DSM–IV in 1994, "transsexualism" was replaced with "gender identity disorder in adults and adolescence." With the publication of the DSM–5 in 2013, "gender identity disorder" was replaced with "gender dysphoria." Although, intended to shift from a frame of mental disorder to a focus on gender identity-related distress, transgender people are required to get a DSM diagnosis in order to receive psychiatric, medical, and surgical treatments. As such, transgender people who seek gender affirming interventions must have a record of a psychiatric diagnosis, which, in addition to being a barrier if one doesn't have access to a psychiatrist, could have unforeseen harmful consequences, as the fate of TGNC people is frequently at the whim of politicians and legislators in power.

Finally, it is significant to note the impact of colonialism, imperialism, and slavery specifically on LGBTQIA+ and TGNC black, Indigenous, and people of color. These systems and forces imposed rigid rules and criteria around superiority, purity, and morality, rooted in Western European ways of thinking and Christianity. There is evidence that many indigenous people in the Americas (and the African continent) had a more than binary conception of sexuality and gender[24]. As the colonizers sought to control black and brown bodies, they did so,

[23]For more information see: https://ncbi.nlm.nih.gov/pmc/articles/PMC4695779/
[24]For more information: https://reference.pbs.org/independentlens/content/two-spirits_map-html/

in part, by reducing what was valid and permissible to heterosexuality and binary gender (Barker, 2017; Dietze, 2014; Driskill et al., 2011; Finley, 2011; Two-Spirit, 2023) .

As can be seen from above, there is a substantial history of structural oppression of LGBTQIA+ people in general and TGNC people specifically. In "Increasing inclusion & competency in STEM: Understanding LGBTQ+ history, barriers, and heteronormativity," authors assert that it is necessary "to expand conversations on LGBTQIA+ advocacy in science beyond personal beliefs and actions, and toward the recognition of structural and societal barriers to participation" (2022). The authors argue that to understand contemporary barriers to LGBTQIA+ people working in science, it is necessary to understand how oppression is rooted in historic anti-LGBTQIA+ policies and discrimination. To this end the authors forward a timeline of historical events that impacted LGBTQIA+ people and argue (similarly to CRP and CRRS-CS) that STEM educators need to be aware of this history and acknowledge and integrate it in STEM classrooms and curricula. The recommendations have implications for CS classrooms and curriculum.

In (2020), Freeman highlights historic discrimination against LGBTQIA+ people in STEM, identifying Alan Turing and Lynn Conway as examples of people who were negatively impacted for being gay and transgender, respectively. He points out that even though in 2020, the U.S. Supreme Court ruled it unlawful to discriminate in the workplace against individuals on the basis of their sexual orientation or gender identity (SO/GI), "anti-LGBTQIA+ attitudes remain strong nationally, and negative attitudes against transgender individuals remain highly prevalent in the United States (Jones et al., 2019)." Freeman notes that an extension of the history of discrimination and erasure of LGBTQIA+ people, is how "STEM education literature generally regards LGBTQIA+ identity as an irrelevant demographic detail […] and that nationally

representative data sets regularly collected by NSF that serve as a 'gold standard' for STEM education research and policymaking do not currently include SO/GI measures" (2020).

Current Experiences of LGBTQIA+ students in STEM

The body of literature that centers TGNC experiences in CS and/or STEM education is sparce. However, there is a significant body of research that investigates the experiences of LGBTQIA+ students in STEM. In (Jennings et al., 2020), the authors conducted a literature review of research on LGBTQIA+ students in STEM and identified the following themes that aligned with the broader literature about LGBTQIA+ students in higher education: climate, the LGB monolith, and intersectionality. They found three additional themes unique to STEM: coping strategies, policy change, and technical/social dualism. In (2022), authors reviewed publications investigating LGBTQI+ students in the field of chemistry and confirmed these recurring themes. The following section of this chapter will discuss literature pertaining to five of the six themes: LGB monolith, climate, intersectionality, technical/social dualism, and coping strategies. Literature regarding policy recommendations will be discussed in the Conclusion chapter.

LGB Monolith

In their (2020) literature review, Jennings et al., note that earlier research on LGBTQIA+ students "largely focused on the experiences of primarily white, cisgender, middle-class, and homosexual men and women. There were some exceptions belonging to bisexuals in the same demographic groups." As an example of this finding, the work of Cech in (2009, 2011) exclusively focused on LGB students. Researchers of the study conducted interviews and focus groups with seventeen LGB postsecondary engineering students and found that prejudicial cultural norms in engineering (understood as a component of the climate of the field) limited the

students' opportunities to succeed as compared to their heterosexual peers. In another study (2018), Hughes reports that LGB students persist in STEM fields 7% less than non-LGB students despite more engagement in undergraduate research. The author posits that this is likely because of issues with marginalization in their programs. Jennings and colleagues (2020) identify a gap in the literature and points out that it is important to understand whether the issues that impact LGB students also impact TGNC students in STEM/CS. The authors state that while conducting their literature review:

> it was challenging to locate engineering-specific work that addressed a more holistic view of the LGBTQIA+ community. Often, research with the LGBTQIA+ engineering student community neglected the experiences of transgender and gender nonconforming (TGNC) people and queer People of Color (QPOC). (Jennings, 2020)

The issue of representing marginalized groups as a monolith is not unique to the LGBTQIA+ community. This issue has been raised with respect to other marginalized groups, such as BIPOC students and students with disabilities. It points to the need to explore the breadth of LGBTQIA+ students' experiences as well as experiences of specific and intersecting marginalized identities. A consistent theme across literature focused on participation of marginalized groups in CS, including LGBTQIA+ students, is the impact of climate.

Climate: LGB and TGNC students

In (2018), Linley and colleagues assert that when climate is investigated in research on LGBTQIA+ students in STEM, two spheres are addressed: general academic climate and STEM climate. General academic climate includes campus-wide culture, policies, support services/resources, advising, housing, physical and emotional safety. STEM climate includes departmental/within-major culture, policies, faculty and peers, lab spaces, advising and mentorship. The findings of a "chilly climate" are well established in research on marginalized students in STEM, such as BIPOC, women, and those with disabilities (Cabay et al., 2018;

Wilkins-Yel et al., 2022). A "chilly climate" refers to a combination of policies, attitudes, and stereotypes which contribute to students not feeling that they belong (Cabay et al., 2018; Morris, 2003). For TGNC students, a chilly climate can comprise of overt acts of discrimination as well as more subtle, such as expectations of professional dress that falls along strict binary gender lines.

A number of studies examine the impact of STEM climate on LGBTQIA+ students. In (2017), Cech et al. utilizes survey data of over 1700 students (both LGBTQIA+ and non-LGBTQIA+) from eight engineering colleges across the U.S. to paint the landscape of inequalities for LGBTQIA+ students. The research investigates whether LGBTQIA+ students experience greater marginalization than their classmates, if their engineering work is more likely to be devalued, and if they experience greater personal consequences than their peers in terms of stress, insomnia, and unhappiness. The findings reveal that:

> LGBTQIA+-identifying students are significantly less likely than non-LGBTQIA+ students to report that they feel accepted by their engineering classmates […] and they are less likely to be included in invitations to social gatherings with their engineering classmates, more frequently avoid social events, are more likely than their classmates to feel the need to hide their personal lives from their peers, and are more likely to stay home from school because they do not feel welcome. Finally, LGBTQIA+ students are more likely than their classmates to report having seen or heard offensive comments in their engineering programs. (Cech et al., 2017)

The authors' statistical model demonstrates that "part of the reason LGBTQIA+ students report more negative health and wellness outcomes is that they are more likely to encounter devaluation and marginalization in their engineering programs."

Although the studies above make significant contributions to our understanding of the experiences of LGBTQIA+ students in engineering, they contain several design limitations worth highlighting as they shed light on how existing research on LGBTQIA+ students in STEM falls short with respect to TGNC students. The first limitation is related to how the authors

count/don't count TGNC participants as a statistical category. The authors report that 8.7% of the study participants identify as LGBTQIA+ and that 1% identify as nonbinary. It is not clear if the nonbinary participants are included in the LGBTQIA+ number, meaning that 1% of the 8.7% are non-binary. It is also unclear what percentage of the LGBTQIA+ participants are transgender rather than nonbinary? What is the percentage of participants who have an intersectional identity, identifying as both a gender and sexuality minority?

The second limitation is related to how the researchers count/don't count TGNC participants when reporting results. For example, the authors report the following finding: "LGBTQIA+-identifying women were marginally more likely than other LGBTQIA+ students to report encountering offensive comments […] and marginally less likely to report that their classmates treat them with respect." Of note is how they address non-binary respondents in the study: "We include gender non-binary respondents in the LGBTQIA+ indicator but because of concerns about identifiability of this small proportion, we do not include gender non-binary as a dichotomous indicator in the models nor provide the precise percent of the gender non-binary population […]. As such, the category "woman" (which includes those who identify as cis-gender and transgender women) is compared to both the categories of men (which includes cis-gender and transgender men) and gender non-binary." Given the above statement, the research forwards nothing about the experience of transgender participants, as, even though transgender identity is included in the demographics section, the analysis does not disaggregate this data from the cisgender LGB data.

The third limitation is that climate is assumed to have a universal impact on sexuality minority students, gender minority students, and those with the intersection of the two. The instrument used in the study to measure the impact of climate includes the following statements:

- LGBTQIA+ students [in engineering] are met with thinly veiled hostility.
- Some faculty seem condescending toward colleagues who are lesbian, gay, bisexual transgender, or queer.
- Are you aware of instances in which students in your engineering/ engineering technology classes have been treated negatively due to their sexual identity, gender expression, or transgender status?

Each of the three statements indicate that they measure the experience of TGNC students (by including "T" in the first statement, the word "transgender" in the second, and "gender expression, or transgender status" in the third. However, as the statements do not ask specifically about students' experience with discrimination based on TGNC identity, the uniqueness of the experiences is obscured and/or erased all together. If a participant answers that they have observed instances of students being treated negatively "due to their sexual identity, gender expression, or transgender status," the assumption is that these instances all have the same impact and that TGNC students experience these in the same manner as LGB students. Additionally, the researchers report on findings segregated by demographics along race. The findings are as follows: "Black students are significantly less likely than White students to feel accepted by other students, and Native American/Pacific Islander respondents are more likely than White students to report that they feel the need to hide their personal lives at school." This finding, although important, does not offer an understanding of the experiences of BIPOC TGNC students. This confirms the finding in Jennings et al. (2020) review of literature that points to "the erasure of the 'TQIA+' portion" of LGBTQIA+ students in STEM and the lack of examination of TBIPOC experiences.

The above two studies limit the focus on climate to engineering education spaces of a department. Although, the research examines engineering departments at eight different universities, impacts outside the department, such as the climate of the university as a whole or the availability of LGBTQIA+ support services/resources, are not considered. In (2018), Linley et al. report on an analysis of a subset of qualitative data (fifteen interview transcripts) from the National Study of LGBTQIA+ Student Success, applying a framework of ecological systems to understand the experience of LGBTQIA+ STEM students differentiating between several different contexts (microsystems) that students occupy, such as interactions with faculty, interactions with peers, interactions outside of classrooms but within STEM education spaces, interactions outside of STEM spaces. The authors explain the theoretical framework as follows: "[the] model includes four systems—microsystems, mesosystems, exosystems, and macrosystems—which make up a person's ecology. An individual exists in multiple microsystems, with each microsystem viewed as a single immediate environment. For students in higher education, microsystems might include social groups, classes, roommates, and jobs […] the macrosystem involves social and cultural forces that influence how the person interacts with the other levels of the ecological system […]. In the ecological systems of college students, the macrosystem encompasses forces such as historical trends and events, societal expectations, political forces, and cultural expectations." The participants of this study were diverse along race, ethnicity, sexuality, etc. and included six participants who identified as "transgender or genderqueer." The researchers find that LGBTQIA+ STEM majors are influenced by multiple STEM microsystems, with varying degrees of discrimination and support depending on whom students interacted with. Study participants held expectations for affirming experiences in "social" academic microsystems. They indicated that LGBTQIA+ peer microsystems were

invaluable in the context of their meso-, exo-, and macro-systems, and that they established a primary sense of community with LGBTQIA+ peers. Even though the authors include several statements from TGNC students to demonstrate their findings, they report the results of the study almost exclusively using the term LGBTQIA+, and thus diluting the unique experiences of, and impacts on, TGNC students. Thus, a gap remains in the scholarly understanding of the experiences of TGNC students within the STEM ecosystem/microsystems.

There are a few studies that report on the experiences of TGNC students in STEM majors, when included under the LGBTQIA+ umbrella. TGNC participants in these studies report chilly campus climates, increased experiences of harassment and bullying, microaggressions, and difficulty finding peer support groups (Yoder and Mattheis, 2016; Cech and Rothwell, 2018). In (2022), Maloy et al, investigate the impact of STEM climate on retention of transgender and gender nonconforming students in undergraduate STEM majors. The study uses national, longitudinal data from the Higher Education Research Institute at the University of California, Los Angeles. The authors analyzed the experiences of 20,910 students who marked an initial intent to major in a STEM field. They found that TGNC students (n = 117) continue in STEM majors at a rate almost 10% lower than their cisgender peers, a rate similar to or higher than other minoritized groups, and that the gap exists despite TGNC students' high levels of academic ability and academic self-confidence. Through multilevel regression modeling, the authors found that "the difference is not explained by experiences that have predicted the likelihood of cisgender students leaving STEM. The only significant predictor of STEM attrition for TGNC students in [the] model was whether they sought personal counseling; TGNC students who more frequently sought personal counseling were 21% less likely to remain in STEM majors." The authors report that: "nearly 54% of TGNC students reported feeling depressed

frequently, and 30% frequently sought personal counseling, compared with 15% and 8%, respectively, of their peers." They speculate that students who sought counseling left STEM in an attempt to prioritize their mental health over the unsupportive STEM climate.

LGBTQIA+ students exist in and navigate multiple microclimates: university, department, classrooms, labs (Linley et al., 2018). Simultaneously, they embody an identity or multiple identities in a dynamic constellation. As pointed out by Jennings and colleagues in (2020), LGBTQIA+ students in general and in STEM/CS in particular, are not monoliths. In terms of sexuality[25], there is a breadth of categories and lived experiences, heterosexual, bisexual, and homosexual being a small subset. The same can be said of gender[26], where transgender, nonbinary, and cisgender, are a small subset of a dynamic and growing number of identities. LGBTQIA+ students are also not monoliths in terms of race, ethnicity, disability status, etc. For this reason, researchers, especially those who embody multiple marginalized identities, argue that it is necessary to use the lens of intersectionality to better understand the experiences of LGBTQIA+ students in STEM/CS, specifically, the ways that students with the most minoritized identities encounter interlocking forces of oppression and exclusion (Leyva, 2016; Menier, 2021).

Intersectionality

The lens of intersectionality is forwarded as a significant topic in BPC efforts by Aspray in (2016). It is also noted as a recurring theme in research focused on LGBTQIA+ students in postsecondary education (Jennings, 2020). Intersectional analysis has been utilized by black women scholars to critique research focused on increasing access to CS which fails to recognize

[25] https://www.healthline.com/health/different-types-of-sexuality#a-c
[26] https://helpfulprofessor.com/types-of-genders-list/

the compounded barriers and challenges facing black women in computing education (Erete, 2021; Rankin, 2020). There are a number of studies, including ones that focus on LGBTQIA+ and TGNC students in STEM, that employ intersectional analysis and thus offer a more in depth set of findings.

The intellectual roots of intersectionality date back more than half a century and are found in US Black feminism, Latina and Asian American feminism, Indigenous feminism, and third-world feminism (Collins, 1990; Combahee River Collective, 1977; hooks, 1984). The term *intersectionality* was coined by the work of legal theorist Kimberle Crenshaw (Crenshaw 1991a and 1991b). She critiqued the use of a single-axis identity framework for understanding oppression in the context of legal discrimination. A single-axis framework treats race and gender as mutually exclusive categories of experience. Dr Crenshaw developed the theory of intersectionality to demonstrate how black women experience discrimination in employment along two overlapping axis of oppression, gender and race. The intersectionality framework makes visible the experiences of Black women, who are simultaneously subject to multiple and intersecting forms of discrimination. As Crenshaw explains, “the intersection of racism and sexism factors into Black women’s lives in ways that cannot be captured wholly by looking at the race or gender dimensions of those experiences separately” (Crenshaw, 1991b). Intersectionality has become a significant research paradigm and theoretical resource, used across studies to bring to light the interacting factors that contribute to experiences of inequality and the dynamics of oppression for those with multiple marginalized identities.

Black feminist scholars in computing have extended and applied the framework to examine the compounded challenges experienced by black women in Computer Science education (Garcia & Scott, 2016; Scott & Elliott, 2019). In CS ed research focused on

broadening participation, intersectionality is often overlooked. In (2016), Garcia and Scott argue that "many approaches to addressing disparity in technology fields have focused on gender as the determining variable and have not scrutinized technology as a sociotechnical system that maintains and replicates power and privilege through the matrix of domination (Collins 2009b)." The authors point out that many projects focused on increasing participation of women overemphasizes the role of gender above all other identity categories as the cause for the underrepresentation of women in CS, obfuscating how race and class intertwine to "socially shape technology" and who is included in its engagement. Garcia's and Scott's (2016) article discusses the intersectionality of race, class, and gender in the context of CompuGirls, a culturally responsive technology program for girls of color. The study's authors state that:

> [they] are aware that intersecting identity categories are not limited to race, gender, and class. Additional identity categories such as sexual orientation and ability have also been the focus of intersectional analysis […]. However, for the purposes of this paper, the authors will focus on the interplay between race, gender, and class. (Garcia & Scott, 2016)

This is an example of how the lens of intersectionality is used in CS education research to center the experience and challenges faced by some groups of students, meanwhile overlooking LGBQ+ students and those whose gender is more than binary.

Black women scholars have raised a critique that in CS ed research, intersectionality theory is often employed to simply recruit and/or point out that participants have multiple marginalized identities (Garcia & Scott, 2016). In (Shin, 2017), scholars argue that this is "weak" intersectionality and does not capture the intention and goal of the framework. The scholars assert that, in contrast, a "strong" intersectionality lens investigates how marginalized identities combine to exacerbate power imbalance and attends to the multiple interacting factors, including processes of oppression (e.g., racism, classism, sexism, ableism, ageism, and heterosexism) that

influence people's everyday lives and identities. They argue that intersectional analysis is not achieved by adding together several inequities or systems of oppression. Instead, its power lies in the interrogation of how the multiple forces of oppression are inextricable from one another and co-construct challenges and exclusion for people with multiple marginalized identities.

An example of strong intersectional analysis is the work of Miller et al. In (2021), the authors address a gap in research which investigates LBGTQ students with disabilities in STEM. They report on a study of five queer students with disabilities in STEM fields at a predominantly white research university. Their findings reveal that participants encounter male-centered, heteronormative STEM spaces, physical and social inaccessibility on campus, and marginalization in and out of the classroom. The study analysis captures experiences and marginalization related not only to disability and LGBTQIA+ identities, but also to gender, race, and ethnicity. In two cases, the students' experience of struggle caused them to leave STEM education. One student left a pre-university CS scholarship program due to the students in the program being "more invested in […] bro culture" (Miller et al., 2021). Another student, a transgender person of color, left engineering and switched to a liberal arts major. The trans student of color reflected that diversity is an "afterthought" in the sciences and stated the following: "There's not a space there to kind of express these identities. If there could be like a multi-identity group for science majors." Another significant finding is that "curricula and course content, including textbooks and documentaries, often rendered the contributions of people with disabilities, LGBTQIA+ people, and women in STEM as invisible." Finally, the authors highlight the lack of intersectional STEM resources. Students with multiple intersecting identities are forced to choose resources that target one specific identity, such as resources for women in STEM, or resources for BIPOC in STEM, or for students with disabilities.

The work of Leyva et al. (2022a), examines STEM experiences and counter-narratives of 39 Queer and Trans (QT) students of color at historically white and minority-serving universities. Data for this study included a STEM autobiography, journaling, individual interviews, and group interviews. This work is focused on introductory physics education (IPE). In prior research the team developed a framework for physics education, defining it as a white, cisheteropatriarchal space to guide their data analysis. They identified three levels at which white cisheteropatriarchy operates in IPE: ideological, institutional, and relational. Their findings show that "students' perceptions of racial and gender bias (ideological) created tensions in faculty interactions (relational) that reinforced inequitable access to classroom participation and STEM persistence (institutional)." The findings include a theme of ***asociality***:

> anchored in epistemological values of objectivity and abstractness in physics (ideological), that shaped classrooms as 'neutral' spaces void of faculty support with consciousness for participants' Black queer identities (relational). Such erasure through instruction neglected participants' social realities and upheld dehumanizing inflexibility in response to students' struggles (institutional). (Leyva et al., 2022a)

Study participants highlight how uncertainty about faculty bias, lack of identity-conscious support, and stereotypes of ability shape intersectional oppression in introductory physics courses. They described how professors seemed to lack consciousness about the racialized nature of their experiences as Black students.

The stereotype of "asociality," attributed to physics by of Leyva et al., is frequently noted in literature on LGBTQIA+ students in STEM. Cech, in (2013b) refers to this phenomenon in engineering as "depolitization" and Jennings et al. in (2020), refer to this theme in STEM research as the technical/social dualism. The technical/social dualism conveys the idea that STEM is constructed, through its day-to-day practices, as a purely technical domain, objective and neutral, in contrast to social fields of study that are based in subjectivity. As will be

discussed next, the technical/social dualism, when investigated in research, has been found to have uniquely harmful impacts on LGBTQIA+ and TGNC students.

Technical/Social Dualism

In (2013a), Cech et al. explore how depoliticization operates to veil issues of lesbian, gay, bisexual and transgender (LGBT) equality within engineering, and makes it more difficult to discuss and address the inequities this population may experience. The authors define the ideology of depoliticization within the culture of engineering as the belief that "social" issues should be walled off from the more "technical" aspects of engineering. The article reports on findings from interviews with 15 engineers in academia, five lesbian women, nine gay men, and one Trans woman. The authors found that the ideology of depoliticization codes issues of equality, justice and power as outside of concern to the work of engineers. Thus, depoliticization results in LGBT issues being of low priority within the profession, and the very discussion of LGBT equality issues is considered irrelevant to "real" engineering education and engineering work. The authors highlight how depoliticization has a unique impact on the LGBTQIA+ population as their sexual and gender identity cannot be "read off of them" in the same way that race and gender categories are not possible to ignore for BIPOC and cisgender people. For many transgender individuals who are "stealth," that is living seamlessly within a single gender category, that they are trans is not necessarily discernable to others. The authors argue that the "don't ask, don't tell" spirit of depoliticization in engineering designate LGBTQIA+ identity and LGBT+ inequality issues as "political," and therefore outside of the sphere of engineering. Furthermore, they find that due to the implicit heteronormativity in engineering, this ideology is "deployed *selectively*" and in a hypocritical manner, whereby discussion of heterosexual relationships and families are expected and encouraged. They conclude that depoliticization is

inherent in the ideological and cultural fabric of engineering and is reinforced through day-to-day practices and interactions. Consequently, engineering spaces need not overtly espouse anti-LGBTQIA+ ideology or sentiments to be harmful to LGBTQIA+ students. The ideology and day-to-day practices of depoliticization erases LGBT identity, silences the voices of LGBT engineering students, and the voices of their allies, who may quietly support LGBT identity and equality.

In (2019), an autoethnography reflecting on two students' experiences in engineering, Haverkamp et al. describes how because of depoliticization and asociality, TGNC students in particular, feel that their identities, deemed as inherently political, don't belong in engineering education spaces. One participant in the study found that hiding her LGBTQIA+ identity became a part of her strategy to find belonging and acceptance in engineering spaces. Haverkamp points out that LGBTQIA+ individuals in engineering are found to "closet," i.e. hide or downplay their identity at a rate that is higher than other STEM fields (2019). She further notes that for many TGNC individuals, their very existence is framed within political rhetoric and advocacy. She references research showing that transgender students in higher education are "more likely to discuss politics and share political opinions and that they claim liberal or far left political identity at well above the national student average" (Stolzenberg & Hughes, 2017). Haverkamp points to evidence that engineering is one of the most politically conservative academic disciplines in higher education (Mraz, 2012), noting a study that reveals "liberal- left views to be the far less prevalent in engineering faculty (23%) when compared to social sciences (59%) or humanities (54%)" (Rothman et al., 2005).

An assessment that computing is, similarly to engineering, steeped in ideology of depoliticization, objectivity, neutrality, and meritocracy, has been forwarded by critical

computing scholars (Benjamin, 2023; Erete et al., 2021). This area of research demonstrates that computing and its enactment via the technology industry promote an ideology of tech's neutrality and apoliticism meanwhile shirking responsibility for societal harm and actively fighting against oversight and regulation, both facets of conservative ideology: shunning government overreach and consumer protection. Even though at times tech corporations get involved in politics, for example objecting to former president Trump's Muslim ban and anti-immigrant rhetoric, they do so from the perspective of protecting their employment base. At the same time, these corporations promote the ideology of meritocracy, the notion that one's identity (marginalized or otherwise) is irrelevant to one's success in tech/computing. Given the current barrage of concerted efforts from the conservative right to politicize and delegitimize TGNC identity, TGNC students day-to-day being and making visible of their identity is, intentionally or not, of political significance and thus in tension/conflict with the insistence that CS is and must remain neutral and apolitical. According to Haverkemp's participants, TGNC engineering/computing students are more likely to be aware of and involved in advocacy and efforts against their own systemic marginalization. That is, some of them are involved in efforts to dismantle cis-hetero-patriarchy, transphobia, homophobia, etc. This part of their lives and identity is incompatible with the meritocracy and depoliticized ideologies ascribed to engineering/computing identity, forcing them to compartmentalize/split their identity in two.

To summarize, existing research reveals that due to the ideology and day to day practices that uphold depoliticization and asociality in STEM, engineering, and CS education, LGBTQIA+, and specifically, TGNC students, find that their identities, deemed as inherently political, don't belong in these spaces.

Belonging

As identified in previous segments, a lens used to understand the impact of a chilly climate, intersectionality/interlocking systems of oppression, and the technical/social dualism on LGBTQIA+ students in STEM is that of **belonging**. Described as the need to "form and maintain at least a minimum quantity of lasting, positive, and significant interpersonal relationships," psychologists Baumeister and Leary (1995, p. 497) theorized that a sense of belonging is a fundamental, and universal motivator to human behavior, informed by an individual's assessment of their social environment and motivated by the need for emotional and physical well-being. One way that belonging has been conceptualized in research is that it is "general inference, drawn from cues, events, experiences, and relationships, about the quality of fit or potential fit between oneself and a setting" (Walton & Brady, 2017, p. 272). This approach relies on measuring whether students see themselves as legitimate members of an academic context, for example, based on their individual sense of competence and a sense of being able to succeed – thus, locating belonging within an individual student. Another way of conceptualizing belonging, is that it is a set of cues, events, experiences, and relationships, embedded in the culture of a particular context, that communicate and demonstrate to students that they are understood/known, valued, and matter. This approach locates belonging within the sociocultural domain of a particular educational space and is more pertinent to my study.

Belonging in education

In education, belonging has been defined as "students' sense of being accepted, valued, included, and encouraged by others (teachers and peers) in the academic classroom setting and feeling oneself to be an important part of the life and activity of the class" (Goodenow, 1993).

According to Strayhorn and colleagues (2012a), a sense of belonging is a basic human need and this need drives both academic behavior and outcomes. In postsecondary education, the degree to which this need is fulfilled/fulfillable impacts all aspects of academic outcomes: selecting a major, performance in class, persisting in a major, staying in college, pursuing a particular career, etc. Within the higher education literature, sense of belonging has been shown to predict success and retention in college (e.g., Freeman et al. 2007; Pittman and Richmond 2008; Strayhorn 2012b). In contrast, the literature on belonging has found that students from underrepresented groups tend to have a lower sense of belonging than their counterparts from majority groups and thus face additional obstacles and barriers to their success and retention in college (Hurtado and Carter 1997; Johnson et al. 2007; Strayhorn 2012b).

Belonging in STEM/CS

A sense of belonging has been shown in research to predict academic success in STEM disciplines (Espinosa 2011; Good et al., 2012; Johnson 2012; Wilson et al., 2015). Studies find that women and marginalized students perceive a lack of fit between their identities and/or values and a pursuit of STEM (Diekman et al. 2010; Smith et al. 2014), which signals that they may not belong. The work of Thoman and colleagues (2014), suggests that a low sense of belonging works to push women out of STEM fields. Espinosa (2011) found that a sense of belonging was significantly related to the retention of women of color in STEM. In the field of computing, students from marginalized groups have been found to experience more uncertainty about their belonging and fit when compared to non-marginalized groups (Barker et al. 2010; Cohoon 2006; Margolis and Fisher 2002).

Belonging in education, including STEM education, has been conceptualized as both an individual's assessment of their fit within a context and as the impact of a context's sociocultural

practices on a person's sense of fit. Furthermore, even within these two understandings of belonging, research has identified different types of belonging, such as social and academic, as well as a variety of cues that signal belonging, such as alignment of goals/values, representation in numbers, stereotype fit, etc.

In (2020), Mooney et al., examine the relationship between undergraduate Computer Science students' participation in networking, outreach, and mentoring activities and their sense of belonging. They found lower levels of sense of belonging in women and self-identified minorities. However, they observed a higher sense of belonging in female students who participated in networking, outreach, and mentoring activities. In "Putting Belonging in Context: Communal Affordances Signal Belonging in STEM," Belanger and colleagues investigated whether STEM students who see their major as fulfilling goals of helping or working with others, perceive greater belonging in their majors. They found that for college students in STEM, perceptions that their major provided opportunities to pursue communal goals, such as altruism or collaboration predicted increased belonging in their major. Furthermore, greater belonging predicted more positive attitudes toward one's career path one year later. This was found to be true for both male and female participants.

In (2013), Smith and colleagues report findings that indicate women use effort expenditure perceptions to assess their fit in STEM. The research reveals that women in STEM fields perceive that they must exert greater amounts of effort than others to succeed. Even though they equaled in ability, women's feelings of belonging and motivation to pursue STEM fields varied in relation to their concerns about effort expenditure. The perception of STEM fields as male dominated activated worry about increased effort expenditure and reduced motivation for women but not for men. The authors theorize that women interpret the numerical

underrepresentation of women in a field as a cue that they will have to exert more effort than others to succeed. The above studies, focus on belonging as a phenomenon residing within the individual and make recommendations that locate fixes within students. For example, Smith et al. point out that women inaccurately predict that they will have to exert more effort in STEM education and posit that their sense of belonging may change if this misperception is corrected. In (2020), Belanger recommends that students be made more aware of the communal affordances of STEM to address the lack of sense of belonging. However, the study does not address the fact that students may rightfully assess that STEM fields do not prioritizes communal values/concerns or communal values relevant to them.

A number of studies in CS education examine the sociocultural impacts on sense of belonging. In "Cultural Stereotypes and Sense of Belonging Contribute to Gender Gaps in STEM," Master and colleagues argue that social factors, such as stereotypes and self-representations about "belonging," are powerful contributors to observed gender differences in STEM interest and academic outcomes. Cultural stereotypes specific to STEM contribute to gender gaps by negatively impacting interest and academic outcomes. In computing education, Cheryan and colleagues. focused on the impacts of environmental cues within CS education spaces on the sense of belonging for secondary and postsecondary females. They show that "when an environment stereotypically associated with computer science— containing video games, Star Trek memorabilia, and the like—was made salient, women were consistently less interested in joining the domain than men." On the other hand, women were more interested in taking a CS class if the environment was described as not stereotypical. The stereotypical vs non-stereotypical environment did not have a significant impact on men. Furthermore, the study shows that for women, belonging remained a mediator of the gender differences in interest in the

computer science course with a stereotypical environment. “When computer science stereotypes were evident, girls felt lower belonging in the course than boys, and this lower belonging predicted their reduced interest. Moreover, belonging predicted interest in computer science even after controlling for girls’ expectations of success and the value they placed on computer science.”

In “Measuring Students’ Sense of Belonging in Introductory CS Courses,” Moudgalya and colleagues found that for minoritized students in particular, the interest to learn and pursue CS courses was more correlated with their sense of belonging. The result was especially true for introductory CS courses that employed Process Oriented Guided Inquiry Learning (POGIL). Students in POGIL classes had a higher sense of belonging than those in non-POGIL classes, suggesting that the sociocultural practices in PPGIL classes positively impact students’ sense of belonging. In (2023), Perlmutter et al., found that Teaching Assistants’ (TAs) office hour interactions have significant influence on student sense of belonging. The authors report that student and TA conceptions of belonging included, among others, the following components: relatedness, and attentiveness to needs for safety and access. They offer examples of TA behavior that according to both the TAs and students fostered belonging, which include help with understanding the material, treating students with empathy, helping them see peers positively, and helping them to own their own success.”

An Intersectionality framework has been used to examine belonging/fit in STEM for students with multiple marginalized identities. In “Race and gender differences in how sense of belonging influences decisions to major in STEM,” Rainey et al. found that white men were most likely to report a sense of belonging whereas women of color were the least likely and that students from underrepresented groups are less likely to feel that they belong in computing

education. The authors found four key factors that contribute to sense of belonging for all students interviewed: interpersonal relationships, perceived competence, personal interest, and science identity. Sax et al. (2018), conducted a study investigating sense of belonging in CS of women and underrepresented minorities (URM), using a large data set, which included students from fifteen universities throughout the US. The study looked at student's incoming sense of belonging in a introductory computing class, sense of belonging at the end of the class, and characteristics that predict sense of belonging. They compared results by gender and URM status. Findings demonstrate that women started with a lower sense of belonging in CS and that all students' sense of belonging diminished over the length of the course, with women experiencing a higher decline. Finally, the study reveals that being supported by the department and by peers in computing were both positive predictors of students' sense of belonging. The students indicated that their sense of belonging is improved "when they feel that other computing students are available to hang out with them, to be a trusted ally, and to provide help understanding course material" (Sax, 2018). The current study includes questions that probe TGNC students' sense of belonging in CS with a focus on departmental and peer support.

It is notable that in the above studies on belonging, women and gender are almost exclusively theorized as binary categories. Sax et al. explicitly exclude TGNC students from their findings, stating that: "due to small numbers of non-binary students, they are excluded from these analyses and gender was recoded as a dichotomous measure (0 = male; 1 = female). Furthermore, even though some of the studies report TGNC students in their demographics, TGNC students' data are not desegregated and thus their experiences are for the most part missing from the literature.

Belonging LGBTQIA+ in STEM/CS

A handful of studies did employ the lens of belonging to examine the experience of LGBTQIA+ students in STEM and CS. In "Lesbian, gay, bisexual, transgender, and queer students' sense of belonging in computing: An Intersectional approach," Stout & Wright, investigated the relationship between thoughts about leaving computing and sense of belonging, comparing LGBTQIA+ and heterosexual undergraduate and graduate students. They found that LGBTQIA+ students were more likely to think about leaving CS due to a low sense of belonging than their heterosexual counterparts. Additionally, employing intersectional analysis, they found that LGBTQIA+ women had the lowest sense of belonging in CS and were significantly more likely than their peers to report thinking about leaving due to a low sense of belonging. The authors report that their participants included one person who identified as transgender and three that identified as Queer. However, the study does not offer any specific results for these uniquely positioned participants.

In, "Sexual and Gender Minority Undergraduates' Relationships and Strategies for Managing Fit in STEM," Campbell-Montalvo and collogues found that LGBTQIA+ students vary in their feelings of fit in STEM, depending on whether they identify as sexual or gender minority. In this study, transgender students are examined as a separate and unique demographic. The authors report that TGNC students (gender minority identity) experience more frequent and more severe microaggressions than students with sexual minority identities. They further find that students with racial minority identities report compounding issues related to their multiple identities. Finally, this study demonstrates that Sexual and Gender Minority (SGM) students with social capital (a network of people who can offer support and resources), believe that they fit in better in STEM than those without such capital. The study reveals that SGM students use

defenses against discrimination, including, what they term micro-defenses, wherein they select how they present themselves to avoid microaggressions and/or surround themselves with accepting/supportive people. Such actions are categorized in the literature as coping strategies and will be further examined in a later segment.

Belonging TGNC in STEM

A small number of studies focus specifically on TGNC students in STEM and engineering education. These include Haverkemp's previously mentioned autoethnographic study (2019), reporting on the experiences of two transgender queer women in engineering and a dissertation study by the same author (2021), which presents findings on data collected from nearly three hundred undergraduate engineering students. Maloy's study investigates factors that impact the retention of TGNC students in undergraduate STEM majors (2022). Two additional dissertation studies exist, one focusing on five TGNC students in engineering and one focusing on three TGNC students in STEM.

Haverkemp's autoethnographic research (2019) identifies a number of themes related to TGNC belonging that resonate across all four studies: (1) TGNC engineering students encounter misgendering and discrimination, (2) engineering and trans culture are separate, (3) TGNC engineering students lack support inside engineering education spaces but do find it outside of class. Haverkemp's participants share that there is an absence of TGNC identity in engineering spaces, including online engineering spaces, and an absence of engineering in TGNC spaces. They write of living in two different worlds: engineering, where they encountered discrimination, misgendering, a lack of acknowledgement, and various social support networks, where they encountered inclusive language, understanding of trans identity, and engagement with political issues significant to trans people.

In the dissertation study, “Transgender and Gender Nonconforming Undergraduate Engineering Students: Perspectives, Resiliency, and Suggestions for Improving Engineering Education,” Haverkemp (2021) employs an online questionnaire, follow-up interviews, and virtual community input to record and examine the experiences of a large number of TGNC undergraduate engineering students. She finds that TGNC engineering experiences are perceived by participants as different than that of cisgender peers. There are unique gender navigations that TGNC students face, such as concerns over pronouns, misuse of deadnames, varying degrees of being affirmed in cis students’ social circles, and varying levels of comfort with engineering codes of professional dress. Discomfort with gendered standards of professional dress in engineering is found particularly significant for nonbinary and transgender women. The study reveals high effect size relationships between gender and experiences of belonging and support in engineering, particularly for nonbinary students. The participants share that binary gendered spaces, such as male dominated engineering spaces or women’s groups in engineering, present inherent barriers towards the inclusion of TGNC people, whose very existence undermines the taken for granted essentialism of two genders and the boundary that divides them. Finally, Haverkemp highlights that participants in her study form supportive communities outside of engineering contexts which elevated and reinforced their success in engineering.

In the dissertation study, “The Water We Were Swimming In: Transgender And Gender Nonconforming Students’ Lived Experiences In Engineering**,”** Oliner (2022) employs Critical Trans Politics (Spade, 2015) and narrative inquiry to explore the lived experiences of five TGNC students in postsecondary engineering programs. The study findings convey that participants experience TGNC oppression at their universities, build LGBTQIA+ and TGNC communities, and describe more welcoming climates in non-engineering spaces compared to engineering.

Specifically, the findings reveal the following perceptions of the engineering climate: underrepresentation of TGNC identities, erasure of TGNC identities in curricular contexts, oppressive binary gender dynamics, isolation, a culture of impersonality/depoliticization, lack of support in their program. Furthermore, participants described challenges they had with mental health as they progressed through their program. In relation to the engineering industry, participants shared their anxieties about potentially having to navigate their identities in an unwelcoming or oppressive company. Finally, participants highlighted strengths they used in negotiating their identities and persisting through their engineering program including "self-preservation and building a supportive community of people with whom they could decompress and validate one another."

In the dissertation study, "Refracting Gender: Experiences Of Transgender Students In Postsecondary Stem Education" (2018), the author employs narrative inquiry and the gender-complex lens (Rands, 2009), to examine how the experiences of postsecondary transgender students in STEM education vary with their gender presentation and how their experiences with mathematics compare with other STEM fields. Study findings reveal that more feminine presentation in STEM typically results in less respect and lower expectations of one's abilities. Additionally, applying intersectional analysis, the author demonstrates that the following identity facets impacted TGNC students experiences: religion, sexuality, socioeconomic status, ethnicity, neurodivergence, physical appearance, mental health.

Maloy et al (2022), investigate the impact of STEM climate on retention of transgender and gender nonconforming students in undergraduate STEM majors. "The only significant predictor of STEM attrition for TGNC students in [the] model was whether they sought personal counseling; TGNC students who more frequently sought personal counseling were 21% less

likely to remain in STEM majors." They speculate that students who sought counseling left STEM in an attempt to prioritize their mental health over the unsupportive STEM climate.

In summary, very few studies focus on TGNC postsecondary students' sense of belonging in STEM. The few studies that do exist demonstrate that TGNC students struggle to belong/fit in STEM education spaces. All four studies highlight that TGNC students face discrimination, challenges around pronoun and correct name use, rigidly binary gendered spaces and curriculum, isolation, and a sense of living in two worlds: STEM contexts, where they are not acknowledged/supported and the social/cultural LGBTQIA+/TGNC contexts, where they are included and seen. Of note, to date, there are no studies that focus on TGNC students in CS education specifically.

Coping Strategies

A frequent theme in literature on LGBTQIA+/TGNC students in STEM education highlight their resilience and effective coping strategies. The framing of coping falls along two main lines of conceptualizing: surviving and thriving. The approaches that fall into surviving strategies include *covering*, that is, downplaying TGNC identity so as not to befall discrimination/harm. Some studies note that TGNC students resort to covering to persist and point to the extra labor that such efforts require (Cech, 2018; Yoder and Mattheis, 2016). In contrast, several scholars theorize that students use covering strategically and understand this behavior as agential: students reveal or don't reveal their TGNC identity when it is of benefit to them (Leyva, 2022c; Haverkamp, 2021). In (2022c), Leyva and colleagues investigated the agency that Black queer students employ to manage invisibility in the white, cisheteropatriarchal STEM space. The researchers intentionally sought to resist "deficit-oriented inquiry that

positions Black queer students as hepless victims and maintained recognition of participants' disruptive support and agency" (Levya, 2022c).

A parallel theme that can be found in the discussion of TGNC students' coping in STEM is that of not surviving, in other words, leaving the field. This is frequently presented as (1) a result of students being negatively impacted by the chilly culture of STEM, lack of fit/belonging and lack of support and (2) giving up. However, Maloy and Haverkamp argue that leaving can be understood as TGNC students' asserting agency and resistance, choosing more positive and fulfilling endeavors rather than remaining in the inhospitable and oppressive STEM education spaces. In (2021), Maloy and colleagues investigated possible factors that influence TGNC students' decision to remain in undergraduate STEM majors. They found that in their model, which included factors such as academic ability, participation in academic research, and studying with other students, the factor that predicted retention was whether a TGNC student sought personal counseling. In the study, TGNC students were 9.7% less likely to continue in STEM than their cis gender peers, a figure similar to findings on other marginalized groups and LGBTQIA+ students specifically. TGNC students who sought personal counseling were 20.8% more likely to leave STEM than those who did not do so. The authors state that "[a]t first glance, seeking counseling may be an indicator of poorer mental health, which can result from adjusting to the demands of college (and a STEM major specifically); trauma inflicted on upon TGNC students by a cisheteropatriarchical society, reflected in interactions with instructors, peers, and mentors on campus; or a combination of the two". However, they note that "seeking counseling can also be viewed as a proactive step toward tending to one's mental health, a form of agency students can maintain, that can potentially impact their retention." From this perspective, TGNC

students who seek personal counseling, and as a result leave STEM, are advocating for themselves and prioritizing their mental health and well-being.

Another frequently identified coping strategy in the literature is TGNC students persevering in STEM by finding communities and support of TGNC and ally peers. The supportive communities are found to be especially pertinent to students' surviving and thriving due to STEM's culture of depolitization and asociality, which forces students to cope by compartmentalizing their TGNC identity. Several studies reveal that students find LGBTQIA+ centered communities where they are seen and supported. "Many of the queer students in these studies found strength and resilience in queer communities […]. In general, those who were more gender-nonconforming felt a greater need for community with other queer people." (Kersey, 2021). Some of these provide opportunities for the students to be involved in political activism and fighting for their rights and liberation. The theme of TGNC students being politically aware and active is also identified in several studies. In "Resistance and community-building in LGBTQIA+ engineering students," Yang and colleagues report findings that capture how TGNC students "resist the dominant narratives of engineering culture by creating new spaces of existence and support, gaining power in the engineering department, and finding and building communities of marginalized students, thereby becoming agents of change in their engineering spaces (2021).

Conclusion

The literature that informs this study is comprised of several vast areas of inquiry. TGNC students in postsecondary CS education are situated within research on historically excluded and marginalized students in STEM, such as women, BIPOC, and those with disabilities. They are also situated within research on LGBTQIA+ students in STEM. Finally, they are situated within

research that uses an intersectional lens to highlight the impact of overlapping challenges experienced by LGBTQIA+ students with multiple marginalized identities in STEM education spaces. These literatures reveal that LGBTQIA+ students, similarly to other marginalized students, experience a chilly climate in STEM education. Many studies reviewed highlight that LGBTQIA+ students navigate a Venn diagram of outside and within STEM microclimates, which complicate their experience within STEM studies. Common themes in the literature on LGBTQIA+ students in STEM in general, and TGNC students specifically is navigating the following: discrimination and microaggression, white cisheteronormativity, erasure of their identity, and STEM being undergirded by an ideology of apoliticism, objectivity, and meritocracy,

Students cope with these challenges by strategically "covering" or revealing their identity, seeking out supportive communities, including ones online, and involvement in social justice activism. The studies reviewed examine LGBTQIA+ and TGNC students in STEM education in general, not making a distinction between STEM subjects, and in specific areas of STEM, such as physics, chemistry, and mathematics. To the best of my knowledge, to date, there are no studies that examine the experience of TGNC students specifically in postsecondary CS education. In (2021b), Haverkamp notes that each field of study has its own ideology and culture and creates a unique context for students to navigate. Employing queer/trans theory and the lens of intersectional analysis, this dissertation study is designed to examines how TGNC students navigate the uniquely constructed and constrained spaces of postsecondary CS education.

Chapter 3: Methodology

> There is not one "truth" out there but multiple stories… (Karp, 1996)
>
> Gender is like a lens through which we've not yet learned to see. Or more accurately, like glasses worn from childhood, it's like a lens through which we've always seen and can't remember how the world looked before. And this lens is strictly bifocal. […] there may certainly be more than two genders, but two genders is all we've named, all we know, and all we'll see. (Wilchins, 2002)
>
> Nothing for us without us. (Charlton, 2000)

Introduction

There is a growing effort in CS education to increase participation and retention of groups marginalized along the lines of race, gender, disability, and class. TGNC students constitute a marginalized group, are underrepresented in CS education, and have been found to leave the field at greater rates than their cisgender counterparts (Freeman, 2020; Maloy 2022). While there exists a growing corpus of literature and interventions addressing the experiences of marginalized students in CS education, especially that of women, there is a dearth of research that centers the experiences and voices of TGNC postsecondary students.

One goal of this study is to address the gap in the literature by examining the experiences of postsecondary TGNC students in CS education (RQ1). Additionally, researchers have pointed out that marginalized groups, including TGNC people, are frequently represented in literature as a monolith, leaving out experiences of diverse members within a group (Jennings, 2020). In response, this study was designed to engage a broad range of TGNC voices: those who experience a spectrum of expansive gender as well as those with additional marginalized identities. The study employs the lens of intersectional analysis to examine how expansive gender combines with other marginalized identities, such as race, ethnicity, disability status, class, etc., resulting in unique experiences and challenges for TGNC people in CS education

(RQ2). Finally, this study seeks to make contributions to shift CS education spaces to be more inclusive and supportive of TGNC students. Thus, the project engaged TGNC students in thinking together and sharing recommendations for how CS education can be improved to be more inclusive and supportive of expansive gender (RQ3). The last phase of the study is undergirded by a transformative paradigm, beliefs that research should be produced in the service of social justice, that is research should serve to improve living conditions and increase equity and justice (Hurtado, 2015; Martens 2017).

To achieve the goals of the study, a qualitatively driven explanatory sequential mixed methods design was chosen (Bowen, 2017; Ivankova, 2006) The choice of the research methodology was informed by the constellation of the following theoretical frameworks: feminist standpoint, queer, trans, and crip theories. The frameworks listed, share a core commitment to centering the voices of those who are marginalized and experience oppression (Johnson, 2014). In line with qualitatively driven design, the study included a qualitative component at every stage of the process. Members of the LGBTQIA+ community were consulted in the design of every phase of the study. Data collection activities took place between May and October of 2021. IRB approval for the study was obtained on 5/28/21, with extensions approved on 6/14/22 and 5/15/23.

Positionality and Role of the Researcher

One of the core frameworks employed in this study is feminist standpoint. At the heart of standpoint theory is the belief that those who live on the margins of validity, bodily autonomy, worthiness, and safety, are better positioned as knowers and narrators of oppression and how it operates (Harding, 2004; Hartsock, 1987). As relayed in the Introduction Chapter, I am person with lived experience of being transgender, having been a postsecondary student in CS, and

having multiple marginalized identities. Following the tenets of standpoint theory, I am well positioned to design and conduct this study. The writer and theorist, Gloria Anzaldúa, in *Borderlands/La Frontera*, points to how borders, physical and abstract ones, create the conditions for elevating (humanizing) some and devaluing (dehumanizing) others. She positions hybrid identities, those who live on the borders, straddling in and out of power locales, as significant and necessary sights of analysis and resistance to the bordered ideology that underlies contemporary systems of oppression (Anzaldúa, 1987). TGNC students navigate the legibility and illegibility of their gender, as well as legitimacy and illegitimacy of who they are in CS education. As a person who lives in the liminal spaces of gender and has experience negotiating nonnormative gender within the context of CS education, standpoint theory grants me the needed perspective to conduct this research, collaborate with the TGNC study participants, and interpret the collected data.

I am a white, male-identified, male-passing, transgender, queer, Jewish, immigrant. I hold a Master of Science degree in CS and have over a decade of work experience in the tech industry. Currently I teach CS at a public alternative high school. I am positioned inside and outside of the TGNC community, and specifically the subset of TGNC people who are the subjects of this study. As a transgender man with experience in CS education, I am an insider. In 2000-2006, I was a graduate student in a Computer Science department at a large public university in the PNW. At that time, I lived in a liminal space of having legal status as a woman, exploring my own expansive gender, and frequently passing and/or being perceived as a man. However, being white and male passing, having access to higher education, housing, and financial stability, I am aware that I hold more privilege than many of the study participants and am an outsider. Because I lack the perspective of TGNC people with lived experience outside of

my own, the study focused on bringing in voices of students with diverse identities. This aligns with the tenets of standpoint theory that center the importance of hearing from multiple and diverse perspectives of those who are oppressed to offer a deeper analysis of the conditions that produce and maintain power imbalance and harm.

I am a community organizer and activist, focused on issues impacting the TGNC community. This research has implications for the well-being of my community. For this reason, I engaged members of the LGBTQIA+ community, to include their voices, experiences, and expertise throughout the research process. Although, I aspired for this study to be more participatory and collaborative, the COVID 19 pandemic posed many challenges in establishing and sustaining a frequent schedule of engagement with participants, especially in-person engagement. I designed the three phases of the study, conducted the interviews, facilitated the focus group, and conducted the data analysis in part because I did not want to add to the workload of the participants during the already demanding time of the pandemic. However, members of the LGBTQIA+ community were consulted for input, suggestions, and revisions at every stage of the design process. In particular, members of the LGBTQIA+ community, which included University faculty, scholars and researchers, prior and current postsecondary students, and prior and current employees in computing, contributed to the design of the survey and interview questions, and the choice of Networked Improvement Community design for the focus group.

I have been involved in activism and advocacy work focused on uplifting the experiences of TGNC people for over a decade. I have participated in building and sustaining grassroots organizations centering LGBTQIA+ and TGNC people and have publicly advocated for and supported TGNC students in secondary and postsecondary education. I am committed to

improving the lives of and possibilities for TGNC people and this research is part of the work. My position and role on this project are not that of a neutral observer of a phenomenon, but rather as embodying and embodied in the phenomenon.

Ontology

People live lives where gender, sexuality, race, ethnicity, disability matter. That is people live in the skin, the language, food, customs, histories, stories that shape who they are and also shape how others treat them. What is real is the lived experiences of the study participant.

Epistemology

Knowledge and reality are subjectively constructed. Reality is multifaceted and nuanced, as are humans and human experiences. Better knowledge of the world is constructed by taking into account the voices of people with diverse lived experiences. All knowledge is constructed through interpretation of reality. Those who are oppressed should be at the forefront of generating knowledge about their experiences and charging the efforts for change. Knowledge generated through this study is in the service of social justice and improving conditions for TGNC students in CS education. To generate change, those who are oppressed need to engage in envisioning and creating knowledge of a more just world. “To build a better world, we first have to imagine it.” (Flanders, 2023)

Axiology

The aim of this research is threefold. One, to increase what is known about the experience of TGNC students in postsecondary CS education. This includes investigating the relationship between having expansive gender, as well as additional marginalized identities, and a sense of belonging in CS. Two, engaging TGNC students in envisioning CS education activities that are inclusive and supportive of expansive gender. Three, contribute to and join the

actions/work in the broader community to expand the theorizing and operationalization of gender in CS education beyond the binary with the goal of making it a more inclusive and supportive space for TGNC people .

Theoretical Frameworks

The design of this study is grounded in a constellation of theoretical frameworks: feminist standpoint, intersectionality, queer, trans, and crip theories. The theories listed are historically connected and intertwined and have been utilized to both drive scholarly inquiry and to demand and marshal sociopolitical change. I am committed to both capabilities of the frameworks. In terms of scholarship, the constellation of theories, to a varying extent, challenge the essentialist construction of normed bodies, binary sex, gender, and heterosexuality (Mertens, 2008; Hall, 2017; McRuer, 2006; Nagoshi, 2010). Furthermore, queer, and even more so, trans theory tells us that gender identity is dynamic, always already becoming, and that people with expansive gender are the ones who have the knowledge and lived experience necessary to define their authentic gender identity and speak to the challenges and oppression they face (Stryker, 2013). To be clear, the meaning of *authentic gender* here is as that conceptualized within transgender theory: "a fluid self-embodiment and a self-construction of identity that would dynamically interact with this embodiment in the context of social expectations and lived experiences" (Nagoshi, 2010). Thus, gender realness/authenticity resides within the individual: "you are who you say you are, [...], and you are the expert on your own body and life's experience" (Breaux, 2021).

In using the concepts of more-than-normative and gender expansive, the study is grounding in trans theory and calling attention to gender experiences that fit normative gender categories (trans man, trans woman) and expands beyond those (nonbinary, gender

nonconforming, gender fluid, gender queer, etc.). I am extending queer and trans theories by situating the study participants as the experts in defining their expansive gender and how expansive gender operates within computing education spaces, spaces that are extensively binarily gendered.

Assumptions

The design of the study is grounded in the assumption that quantitative data is necessary and informative but insufficient to understand the experiences of TGNC people in CS education. Qualitative data is needed to allow TGNC people to provide more context for the numerical data. Furthermore, the study design assumes that the TGNC community is diverse and that multiple types of data (quant and qual) as well as multiple TGNC identities and voices are needed to capture the impact that having expansive gender has on students in CS education, as well as to forward recommendations for improvement. The assumption which grounds the interview data analysis is that meaningful and significant knowledge is produced from accounts of experiences from marginalized people (standpoint/intersectionality). The assumption that underlies the focus group and analysis is that knowledge production is a relational and dynamic doing (all the theories underpinning the study have pieces that contribute to this notion). Therefore, guidance/recommendation for CS ed research that supports expansive gender requires engagement of a group of first-hand situated knowers.

Data Set

Data for this study constitutes survey answers, interview transcripts, focus group transcripts, and digital posters that were produced by focus group participants.

Data Collection and Management

The survey was developed and distributed via Qualtrics. The interviews and focus group were conducted via Zoom and recorded/transcribed. The focus group participants collaborated to create digital collages/posters and text documents. This was done through the Google docs and Google slides web-based applications. All data was removed from the internet and stored securely in digital format, using the UO online storage platform. Names and any identifying information of participants was scrubbed from all the transcripts/artifacts and replaced with pseudonyms.

Methodology

Qualitatively Driven Design

A qualitatively driven methodology is one where the qualitative components of the research are utilized to contextualize and give deeper meaning to the quantitative findings. As Creswell et al. state, a qualitatively driven mixed-methods research design does not "push qualitative research to secondary or auxiliary status," rather "it gives priority to qualitative empirical materials and [...] drives the interpretation of mixed-methods research" (2006, p. 1). A qualitatively driven mixed-methods approach is one that focuses on the complexities of context, experience, and meanings but does not exclude other ways of knowing (Hesse-Biber, 2010). As previously mentioned, this study is grounded in a constellation of theoretical frameworks at the core of which is the assertion that the subjective knowledge of those who experience negative outcomes due to power imbalance, is necessary and valid. A qualitatively driven design was chosen for the study because this type of design embeds qualitative components and integrates qualitative analysis in all phases of the study. The qualitative analysis employed in the study assumes "that social reality is constructed, and that subjective meaning is a critical component of knowledge-building" (Hess-Biber et al., 2015). The qualitatively driven approach is in alignment

with the theoretical frameworks' goals to elevate the voices of the marginalized and the author's commitments to center TGNC people at the forefront of working to change CS education, prioritizing the subjective knowledge of those who experience oppression and harm. Qualitative components were included in all phases of the study. For example, free text questions were embedded in the survey to give a deeper explanatory dimension to the quantitative data, while the final stage of the study, a focus group, engaged TGNC postsecondary students in co-designing CS education activities inclusive of expansive gender.

Explanatory Sequential Mixed Methods

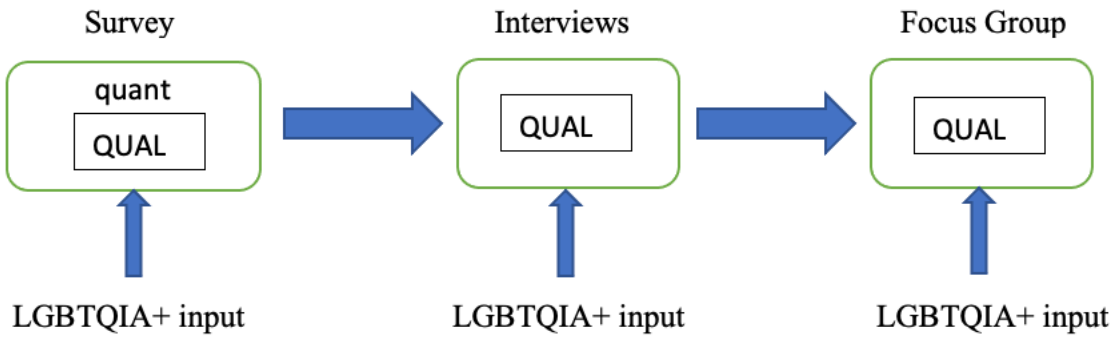
Explanatory sequential research method is a methodology which employs both quantitative and qualitative methods to more deeply examine an area of research. In the explanatory sequential method, quantitative data is collected first, followed by the collection of qualitative data. As previously stated, there is not much research focused on TGNC students in CS education. This is especially true of quantitative research. Large scale quantitative studies in CS education either present findings about TGNC as part of the LGBTQIA+ umbrella without disaggregating data or discard their data due to the statistical limitations of a small sample size (small N). The survey (QUANT) method was chosen in the hopes of reaching a numerous and diverse set of participants. Additionally, the survey method design choice was informed by a dissertation study that examined the experiences of TGNC undergraduate students in engineering, conducted by Dr. Haverkamp (2021b). This study used a survey and a set of questions investigating students' sense of belonging in engineering. I wanted to compare findings in that study to those situated in postsecondary CS education.

Qualitative studies of TGNC students in CS education are also rare and tend to examine the experiences of a few participants in a particular context, such as the same class, department

or University (Fitzgerald-Russell, 2022). To address the gap in quantitative and qualitative research investigating a broad population of TGNC postsecondary students in CS, an explanatory sequential mixed methods design was chosen. However, to the best knowledge of the author, this is the first study examining TGNC students in CS that uses the sequence of survey → interviews → focus group. This is also the first study to engage TGNC students in collectively generating CS education activities that are supportive of expansive gender, and thus providing recommendations to the broader CS community of how to include gender beyond binary in the field. See Figure 1, for a diagram capturing the sequential phases of the study.

Figure 1

Sequential Phase of the Study



Methods

Table 1

Methods Used in the Study

Method	**Type**	**Theoretical Framework**	**Data Analysis**
Survey – Expansive Gender in CS education	quant	Belonging Queer/Trans theories	Frequencies SPSS
Survey - demographics	quant	Intersectionality Queer/Trans theories	Frequencies SPSS
Embedded Survey Questions	QUAL	Feminism/Standpoint theory Queer/Trans theories	Thematic analysis, Excel
Semi- structured Interview	QUAL	Feminism/Standpoint theory Intersectionality Queer/Trans theories	Thematic analysis, Dedoose
Focus Group	QUAL	Crip Theory Networked Improvement Community Transformative Paradigm	Thematic analysis, Dedoose

Data Analysis

The quantitative portion of the survey was examined using the statistical software SPSS, version 28. The questions pertaining to belonging and the survey demographics data were examined though frequency distributions. The qualitative portion of the survey data, interview transcripts, focus group transcripts, and the digital posters produced in the focus group were all analyzed using thematic analysis. Braun and Clarke define thematic analysis as a "method for identifying, analyzing, and reporting patterns (themes) within data" (p6, 2006). Additionally, they state that thematic analysis "interprets various aspects of the research topic," (p6, 2006). Thematic analysis was chosen because it is a core analytic tool for qualitatively driven research, is independent of any particular theoretical framework and can be used across a constellation of

frameworks (Braun & Clarke, 2012). This analytic tool also aligns with the epistemology undergirding the research, namely that the researcher and the participants forward the answers to the questions posed by the study. Braun and Clarke point out that meaning conveyed through the data analysis comes both from the voices of the participants and the curation, interpretation, and meaning making of the researcher.

To situate the data and analysis in existing literature, codes and themes were identified using a combination of inductive and deductive analysis, that is the author used codes and themes informed by existing literature on LGBTQIA+ and TGNC students in postsecondary STEM education as well as generated unique codes that he observed in the data set. The data was examined using semantic analysis. The author only considered the explicitly stated meaning of statements and did not contemplate any latent (not explicitly communicated) meaning. The author followed the six phases of thematic analysis, as outlined by Braun and Clark (2006), for all three of the qualitative segments of the study. Braun and Clark propose six phases of thematic analysis:

Phase 1: familiarizing with data.

Phase 2: generating initial codes.

Phase 3: searching for themes.

Phase 4: reviewing themes.

Phase 5: defining and naming themes.

Phase 6: writing up the report. (Braun and Clark, 2006)

Research Study Phases

Survey Phase

To answer (RQ1), the survey included questions that ask participants how expansive gender impacts their experiences in a range of CS education settings, their sense of belonging, leaving a CS activity due to their gender, and their expectations about current and future success in classes and CS related employment. The survey method was chosen because it allowed for the possibility of reaching a substantial and diverse set of respondents, addressing a gap in quantitative research examining TGNC students in CS education. Additionally, the survey data was used to conduct a targeted recruitment of interview and focus group participants. The survey was created using the University of Oregon Qualtrics website and was active between May and October of the year 2021.

Survey Protocol and Design

The survey contained four main segments. The first segment contained questions that determined eligibility for the study. This included consent to participate, age, whether the participants identified as TGNC, and if they had computing education and/or employment experience. The second segment asked questions related to participants' experience in computing education. The third segment asked questions related to participants' experience in computing related employment. The fourth segment contained demographics questions. The questions in the computing education and employment segments of the survey were identical, other than the use of the words *education* and *employment* in the respective segments. Prior to distributing the survey, the researcher asked six TGNC colleagues to review the survey questions. The survey reviewers included two TGNC researchers and four TGNC community members. The reviewers had experience in computing education and/or employment. The researcher incorporated all feedback into the final version of the survey.

Belonging Instrument Segment

The belonging theoretical framework was incorporated into the design of survey questions to situate the experiences of study participants within preexisting and well understood frame of research on marginalized groups in STEM and computing education (Rainey, 2018; Sax, 2018, Stout, 2016). The framework is grounded in theorizing that belonging is an essential human need (Baumeister, 1995). In education research a positive/increased sense of belonging has been shown to improve persistence and academic outcomes (Freeman, 2007; Pittman, 2008; Strayhorn 2012). Belonging can be understood and investigated as a problem residing in the individual, that is, a person's sense of belonging is primarily dependent on their beliefs, attitudes, abilities, level of confidence, etc. From the understanding of belonging as a personal trouble an approach to changing one's sense of belonging would also focus on the individual. For example, interventions would focus on increasing one's sense of belonging by increasing one's skills or helping one see that there are people like them in a group. From this perspective, a negative sense of belonging, can be understood as an individual's deficiency, whereas it is the individual that needs to be fixed. This study assumes that belonging is a sociocultural phenomenon, and thus if TGNC students do experience a negative sense of belonging, it is not because they have failed to build up some belongingness muscle but rather that the reasons reside in the sociocultural dynamics of their CS education environments. From this perspective on belonging, a person's sense of belonging is dependent on the degree to which the person is accepted, valued, and supported by the group.

Because this research is focused on investigating TGNC students' sense of belonging in computing as a sociocultural phenomenon, the study asked questions about belonging within a sociocultural context, such as "Teachers and education staff in computing are supportive of my gender identity" and "There are positive representations of my gender identity in computing

education activities, such as in textbooks, lectures, assignment and project topics, etc." These questions investigate whether a TGNC student feels that they belong given the sociocultural reality of their CS educational spaces, such as, do these spaces have positive representations of people like them with respect to gender, are they able to engage with faculty and staff that are supportive of expansive gender? To address the underlying assumption that quantitative data paints an insufficient picture, the belonging instrument was supplemented with an opportunity to add open text responses to elaborate on their answers. The choice to embed this qualitative component was informed by the goal of gaining a deeper understanding of the experience of TGNC students and the impact of having expansive gender. Thus, a further choice was made to contextualize and situate the quantitative belongingness data within a qualitative explanatory set of data during the analysis phase.

The segments that asked about experiences in computing education and employment, began with nine 4-point (strongly agree, agree, disagree, and strongly disagree) Likert scale questions focused on belonging. The neutral point was not used. The questions were adapted from a study focused on TGNC undergraduate students in Engineering (Haverkemp, 2021). The belongingness questions were used for two reasons. First, belonging has been shown to be an indicator for recruitment, academic outcomes, and retention in CS education. Second, I was interested in comparing findings from this study to those of other studies on belonging and marginalized students in STEM education (Mooney, 2020; Sax, 2018, Stout, 2016). See Appendix A for the complete list of belongingness questions. The following are examples of questions from the belonging block of questions:

- I feel able to authentically express my gender in computing education spaces.
- Teachers and education staff in computing are supportive of my gender identity.

- I feel like I "fit in" with other computing education peers/students.

Questions with Free Text Options

The questions that asked about belonging were followed by four questions that included an option to provide additional details. See Appendix A for the complete list of open text questions. The following are examples of questions from that block:

- Has your gender identity ever caused you to doubt your belonging in computing education spaces? If you would like, please provide details/examples.
- Do you believe that your gender identity impacts your interest/willingness to pursue computing-related employment? If you would like, please provide details/examples.

The section about experiences in CS education was followed by a section about experiences in computing related employment, with identical questions, replacing the word *education* with *employment*. The final segment of the survey was demographics related questions.

Demographics Segment

Scholars, BIPOC, TGNC people and those with disabilities have critiqued the limiting ways that demographics information is collected and utilized in education research, including in CS education research (National Research Council, 2004; Thornton, 2020; Suen, 2020; Vincent, 2018). Race and ethnicity data that is collected is frequently aligned with categories established by the US census, which treat many racial and ethnic groups as monoliths. For example, African Americans can include people who were born in the US and are decedents of enslaved people as well as those whose parents were born in Africa and who immigrated to the US or came to the US as refugees. Furthermore, even when demographics data is collected it is used in reductive ways. There is extensive research that compares education outcomes for men and women without desegregating the data by race, or any other demographic markers. Another critique that has been forwarded is that the design and use of demographics information has been in the

service of "gap gazing" and deficit lens analysis of outcomes for marginalized groups. TGNC people have leveled a critique of how demographics data pertaining to gender is collected, where gender is either limited to binary options or captured in an option titled "other." There is a robust discussion in the TGNC community about effective ways to collect information about gender in research involving the general population, versus research that centers exclusively the TGNC population (Suen, 2020). The author did extensive research on survey demographics design, consulting a number of sources both academic articles and web sites specializing in survey design and supporting TGNC people, with the aim of addressing the aforementioned critiques.

The foremost goal of the demographics section in this study was to capture identity as multiplicity rather than to reduce and/or essentialize it. I aspired for the participants to feel "seen" as they engaged with the demographics questions and were offered extensive and multiple means to mark their identities. The demographics section included questions about race, ethnicity, gender, sexuality, immigration and refugee status, disability, etc. With respect to race and ethnicity, I decided to combine these into one question, allowing respondents to choose any designations that apply and add their own if they were not in the list. This choice was informed by a long-standing critique highlighting that race[27], a social invention to categorize all people on the African continent as "other" and inferior and to justify Europe's colonization projects in Africa, has no genetically or biologically determinable basis (Kendi, 2017). Moreover, the categories of race and ethnicity have a long history of being arbitrarily assigned to groups and used to deem people inferior and less worthy within sociopolitical systems where those in control of defining the "other" benefit from the resulting skewed and unjust entitlement to power (Kendi, 2017). The move to combine race and ethnicity into one category and to include an extensive list

[27] https://nmaahc.si.edu/learn/talking-about-race/topics/historical-foundations-race

of markers for each was also made to recognize that people live lives where race and ethnicity matter, that is they live in the skin, the language, food, customs, histories, stories that shape who they are and also shape how others treat them.

The demographics section was placed in the last segment of the survey in response to findings that placing demographics at the start added to "stereotype threat" and "survey fatigue." (McKay et al., 2003).

Survey Distribution

The survey was distributed via email. The researcher received a list of email addresses for Accreditation Board for Engineering and Technology (ABET, a nonprofit, ISO 9001 certified organization that accredits college and university programs in applied and natural science, computing, engineering and engineering technology) accredited postsecondary CS departments, which included community colleges and universities. The list was given to me by Dr. Haverkamp, the author of several studies on TGNC students in undergraduate engineering education (Haverkamp, 2019, Haverkamp, 2021). I additionally compiled a list of departments listed on the ABET website and cross-referenced with the list offered by Dr. Haverkamp. The following accredited programs were included in the list: computer science, computer engineering, information technology, etc.. The final list contained 600+ entries. In addition to emailing ABET accredited CS departments, I sent emails to LGBTQIA2S+ professional organizations in STEM and CS, the RESPECT conference, and peers and colleagues in my academic, professional, and social networks**.** The survey was also distributed using the snowball method by asking those in my circles and select participants to forward the recruitment email along their networks. Finally, the author contacted TGNC focused groups on social media. Some of these groups posted the recruitment announcement, while several refused to post the

announcement, with one group explicitly opposing being subjected to research recruitment announcements.

Survey Participant Eligibility. The following were eligibility criteria for participating in the study: consent, eighteen years old or above, identify as TGNC, have CS education and/or employment experience. Any "No" answers to the eligibility questions, automatically took respondents to the end of the survey. The survey received 300 responses from valid IP addresses and one response designated by the Qualtrics application as SPAM. Of the 300, 269 respondents gave consent to participate, and of those 267 were 18 or older. One hundred forty-nine respondents (n=149) answered 'Yes' to identifying as TGNC ('No' answers were filtered out of the study: N=114), of these 142 answered 'Yes' to having educational/employment experience. After filtering out ineligible respondents, the number of valid records was one hundred forty-two (N=142). As mentioned above, the survey included questions about K-12 through postsecondary education and employment experiences in CS. For the scope of this study, data was limited to participants who indicated that they had postsecondary experience in CS, resulting in a final set of ninety-nine (N=99) records included in the data analysis.

Survey Participant Demographics. The study drew a diverse set of respondents along race, ethnicity, age, disability status, expansive gender, sexuality, geographic location, and level of postsecondary education. The following is a summary of participants' demographics information. Demographics TABLE!

Table 2

Survey Participant Demographics

Demographic	n	(%)
Non-white		
Latinx		

Data Analysis

The examination of the survey data took place in two stages. During the first stage, quantitative data was imported into the statistical software application SPSS, version 28. The application was used to generate frequencies tables. The frequencies tables captured the numbers and percentages of strongly agree, agree, disagree, and strongly disagree answers to the 4-point Likert questions as well as four questions that used yes/no and other scales of answers. During the second stage, the qualitative data collected via the embedded free text questions, was loaded into Excel spreadsheets, and analyzed using deductive and inductive thematic analysis. I performed data analysis in rounds, over several months, each time reviewing the entire data set and refining the list of identified codes. The six phases of thematic analysis developed by Braun and Clark were used for this process (2006). I read all the responses to a single open-ended question, assigning codes that were a combination of prior research findings and unique instances. Codes were pulled from research that examined LGBTQIA+ and TGNC students belonging in CS and STEM education (Haverkamp, 2021; Stout & Wright, 2016). The identification of codes was also informed by Queer and Trans theoretical frameworks. Specifically, these frameworks establish that authentic gender is an individual's subjective knowing and that sociocultural forces act to affirm or invalidate one's gender (Hall, 2017; Nagoshi, 2010). I paid attention to how participants experienced this in their CS educational

spaces. The data analysis resulted in a table of codes and corresponding participant quotes. I then aggregated the codes into overarching themes.

Themes were determined by both how often participants spoke about, and the significance that they attributed to, a particular experience. According to Braun & Clarke (2006, p12), a "theme captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set." For example, participants frequently mentioned that they struggled to have their expansive gender recognized. Codes for this experience included being misgendered, being treated as one's gender assigned at birth, regardless of pronouns used, and being uncomfortable correcting faculty, staff, and teaching assistants (TAs) regarding pronoun use. The set of codes related to negative experiences with expansive gender recognition was aggregated into a theme of "gender identity disclosure, passing, and covering." This theme was also significant as it reflected a different degree of struggle for nonbinary students the those who passed as their authentic gender. See Chapter 4 for more details. After reviewing the themes, I identified quotes from participants that were illustrative of the corresponding theme.

Interview Phase

Participants who self-identified as having marginalized identities alongside race, ethnicity, sexuality, disability, etc. were emailed and invited to be interviewed. Eleven respondents agreed to be interviewed. Of those, seven were currently postsecondary students in CS. Interviews took place over Zoom and were recorded and transcribed. The interviews took place in July and August of 2021.

Interview Protocol and Design

The interview was semi-structured. To enable spontaneity of responses, the participants were not given the questions ahead of time. Interview questions were designed with an aim to

dig deeper into the relationship between expansive gender and CS education. According to (Seidman, 2006), a semi-structured interview is a suitable qualitative tool to gain deeper understanding of a phenomena from the perspective of those affected by it. Employing the standpoint theoretical framework interview participants were positioned as the knowers of how expansive gender impacts their participation in CS education. The questions were divided into segments by themes related to the research questions central to the study: childhood through adulthood experiences with gender, computing, and computing education, intersectional experiences in CS education, recommendations for improving CS ed for TGNC students. The interview included a question about the availability and impact of mentors and role models. This question was brought in as there is a body of literature that finds that availability and access to mentors and role models improves outcomes for marginalized groups in CS education (Garcia et al., 2019; Lee, 2019). For a complete list of Interview questions see Appendix B. The interviews took place over Zoom, each lasting from an hour to an hour and a half. The interviews were recorded and later transcribed, using a transcription service.

Interview Recruitment

Forty-three respondents (N=43) replied "yes" to participating in an interview when taking the survey. Potential interviewees were recruited via email, prioritizing those with multiple marginalized identities, in particular students of color and those with a disability. Recruitment took place in July of 2021. Interview participants emailed a completed consent form prior to the day of the interview. After completing the interview, each participant received a $50 Amazon gift card.

Interview Participants

Eleven participants were scheduled to be interviewed. Of those, seven were current postsecondary students and their data were included for the study. The participants ranged in

diversity of race/ethnicity, gender, sexuality, age, year in CS program, location where they are attending school, disability and immigration status. See Table 3 for a summary of demographics information for the interview participants.

Table 3

Interview Participants' Demographics

Name	Gender	Race/Ethnicity	Other Identities	Place of Birth	Postsecondary Level	School location
Clara	trans woman	East Asian, Chinese	Person of Color, International student, Homoromantic	China	Undergrad	US, South
Sasha	non-binary	White	Disability, Queer	California	Undergrad	US, West Coast
Jay	non-binary	Southeast Asian, Thai	Person of Color, Disability, Bisexual	Michigan	Grad/PhD	US, Midwest
Steph	trans man	Black	Person of Color, Gay	Ohio	Undergrad	US, Midwest
Andi	non-binary	East Asian, Both parents from South Korea	Person of Color, Bisexual, Disability	New Jersey	Undergrad	US, East Coast
Bo	non-binary	East Asian, Chinese	Person of Color, Bisexual	China	Grad/PhD	US, West Coast
Dayne	trans man	East Asian, Chinese, Bi-racial	Person of Color, Queer	East Coast	Undergrad	US, Midwest

The following section will offer a brief sketch of each of the seven interview participants to foreground their voices, humanity, textures of experiences with gender expansiveness and CS education.

Ciara. Clara is a transgender woman. She is an international student from Beijing, China, studying CS at a university in the South of the US. After a year of studies at the university, she returned to Beijing due to struggles with mental health. While back in China, she came out to her parents as transgender. Her parents were in part supportive, and with their agreement Clara started to see a therapist. Although her parents were against this, she began hormone treatment as well. She then returned to the US to continue her studies. She has one year remaining to complete her undergraduate degree. Clara shared that she enjoys playing the online version of "Magic the Gathering," a popular deck building game. Additionally, she participates in online communities of TGNC people some related to computing and others not. She talked about having difficulties in her living situation related to her gender and a disrespectful housemate. She conveyed that she does not have strong friendships outside of the online groups. Clara said that she does not participate in programming focused on women in computing, because she is worried that she will not be seen by some as a real woman. She also talked about how she does not know where she belongs in terms of being a Chinese transgender woman. She said:

> *There's a lot of students from China in our university […]. I don't know, but the whole community are not super, are not basically Chinese community. The Chinese community are not super friendly to LGBTs.*

In this passage, Clara is describing how as a Chinese student she does not fit in because the CS community is "not […] Chinese", and as a transgender person she does not fit in the Chinese community, because they are not "friendly to LGBTs." Clara also shared that she is concerned

about her employment options and what her life might be like as a transgender woman in computing employment in China.

Sasha. Sasha is a white, non-binary/gender-queer undergraduate student, who is in the process of finishing a CS degree at a University in the Pacific Northwest. Sasha had access to computing education in high school and enjoyed taking classes from a faculty they perceived as a mentor. They also enjoy juggling and are very committed to social justice. Sasha grew up in a conservative town in the US. They struggled to find support for their expansive gender as a young person. Sasha shared that they have not felt safe to tell their parents about being non-binary and queer, because Sasha is currently financially dependent on them. Sasha struggled with anxiety, depression, and a "drug problem," and shared that a lot of these got resolved once they started hormone treatment, a year ago. They shared that if they could express their authentic gender in CS education spaces that they would *"wear more makeup, feel comfortable dressing fem […] and would just be more comfortable talking about their gender, and gender experiences."* Sasha shared that they do not feel comfortable in CS classroom spaces or in spaces focused on women in CS. They said:

> *…the one WIX event that I went to, I was yes, it felt very comfortable. Yes. I don't know. I feel like what's hard for me is being in the classes and like being surrounded by all these CIS guys. I don't really feel like, 'I have any connection to you,' but then like, 'I'm also not a girl, so I can't go over to the girls and be like, lets be friends, lets us be friends.' I feel intimidated and out of place by that one too. Just feel like in this really in-between space constantly.*

Andi. Andi is a non-binary person. They were born in South Korea and moved to the US with their parents when they were two years old. They shared that they have been interested in

Greek mythology from an early age. They also had an interest in computing starting in elementary school but did not have an opportunity to study CS until college. They are a Junior studying classics and minoring in CS at a university on the East Coast of the US. They were encouraged to study CS by a faculty who taught an Intro to CS class that they took. The faculty offered Andi an undergrad research position in his lab, combining the fields of classics and computing.

Andi started to explore their gender identity recently and shared that they struggle with identifying as non-binary because they do not experience facets that have become mainstreamed as the necessary characteristics of transness. They conveyed:

> *I think that my gender journey hasn't really been that long in the sense that like, I started using, she/they, not that long ago. I didn't really realize that it was normal, or it wasn't normal to feel not exactly like a woman, but I don't have dysphoria, that's the thing. For the longest time, I was just like, 'Oh, but I don't have dysphoria, so I must not be trans or non-binary.' It was only more recently that I learned about you don't necessarily have to have gender dysphoria to be considered trans or non-binary, and so that was really freeing for me because I think just growing up, […] I never considered myself, like, 'Yes, I'm a girl.' I just constantly felt this disconnect from the identity of being a woman. It's only been really recently that I've acknowledged that. […] I think people are more familiar with trans people, in the sense that people who started using he/him go to she/her, she/her goes to he/him. They don't really consider that maybe there's an in-between. I'm a little hesitant to talk about it with other people if I don't know for sure that they can provide a safe space for me.*

Steph. Steph is a Black transgender undergraduate CS student at a Midwestern University. Steph started University in his authentic gender and considers himself a stealth man. His interest in computing started during his Junior year of high school, when he took a Java class, and continued with CS ever since. He also enjoys "tinkering" with spreadsheets. His first year in the university CS program was virtual due to the Covid-19 pandemic. He had limited in-person contact with classmates and peers. However, he got to live in "gender-inclusive housing" during that year, which he shared was a great experience. Steph has an on-campus job in food services, where he feels his gender is less respected and supported. He also participates in SHADES, a campus group for "queer people of color." He wants to study and specialize in artificial intelligence.

Steph shared that he has had positive experiences as a TGNC student in CS, which he attributes to being able to pass as his authentic gender and being stealth. He stated:

> *Me being stealth is mostly, so that I can avoid being the recipient of transphobia or other forms of bigotry. […] I feel pretty supported just in general. I know that it has a lot to do with me, both being binary and also passing because I know my trans friends in their respective engineering fields don't really experience that same privilege of not being questioned all of the time.*

Dayne. Dayne is a transgender man who identifies as mixed race. One of his parents is Chinese. He is going into his second year as an undergraduate in CS at a Midwestern University. Dayne started in CS in fifth grade and has been involved in computing related classes and activities throughout their secondary schooling. He had a computing teacher who was supportive of his gender and who he saw as a mentor. In high school, Dayne was involved in theater and robotics. He shared that he really enjoys the play Pygmalion, poetry, art, and dressing femme.

Dayne also started their postsecondary CS education during the Covid-19 pandemic, with mostly remote class experiences. Like Steph, he got to live in a gender-inclusive dorm and found the experience highly valuable and affirming. The following two statements summarize how Dayne struggles with being a transman and being femme and how living in a gender-inclusive dorm provided a glimpse of what it might be like to be accepted and celebrated as one's authentic self:

> *There's all these sides. Everybody has different sides of themselves. Now I understand that that's all just me, but I used to feel weirder about it, I guess. The main part, I guess, any part of my identity, that's just my sense of style, I have a lot of skirts, I have dresses that I like to wear, and that I didn't wear for five years. [chuckles] For five years, really, I would not in public wear because I just didn't want people to be like, 'Oh, you're not trans anymore,' and have that taken away from me.*
>
> *Actually, being around other trans people who, we had days where we just all wear a skirt, just for fun. I could speak, however, I could do whatever, I could behave in whatever silly way I wanted, be any side of my own personality. I wouldn't get misgendered, I wouldn't get disrespected. It's such a simple thing, but it's an experience, I think a lot of trans people never get. To just have that unconditional, you will be gendered correctly.*

Bo. Bo is an international student from China. They identify as non-binary and not heterosexual/straight. Bo has been interested in computing from an early age and wrote their first computer game when they were an early teen. This game had a gay character. They also have a passion for writing, mythology and art. At 14, they won the national championship in essay writing. Bo said that they discovered Alan Turing and Ada Lovelace when they were younger (still living in China) and that these historical figures inspired them to study computer science. In

undergraduate studies, they double majored in English language literature and CS. They are currently a PhD student at a university on the West Coast, studying Artificial Intelligence (AI). They shared that they struggle with being visible in their CS department and that they choose to wear a pin from the LGBTQIA+ center at their university that has a rainbow on it. They said that they sometimes take the pin off if they do not feel that they will be safe and supported. Bo shared that they started exploring their expansive gender after they moved to the US, at age eighteen and are still in the process of this exploration. They said:

> *About that time, I learned that gender is an identity that you can shape yourself. This is largely due to, I moved to California and it's very liberal. I never thought about it before I arrived in California, but after I arrived and I got exposed to those ideas, and suddenly what I saw before, like the documentaries and the mythology, and my own confusion, all makes sense. That's when I decided that I think I'm not a binary person. Actually, I am still very not decided what I am…*

Jay. Jay is a non-binary PhD student at a Midwestern University. Their parents are from Thailand. Jay became interested in computing and computer games in late elementary years. They spent a lot of time playing NeoPets and taught themselves how to program so that they could customize the game. Jay's dad has a PhD in CS. During high school, their dad attempted to help prepare them for the AP CS exam. They recall their dad being a terrible teacher even though he had 20 years of software engineering experience. Jay has completed an undergraduate degree in CS and is currently a graduate student in a combined CS and Psychology program. At the time of the interview, they were doing an internship at a large tech company which has an active online community for TGNC employees. They have been enjoying this space. Jay shared that even though they were very successful in undergrad CS studies they were seen as arrogant and

not sufficiently helpful. Jay speculated that this was because they were coded as a woman by their peers. They shared:

> *It was graduating class of 13 people in computer science, but I was the only one, of course, who wasn't a guy. It was something because I had a really good GPA in undergrad, like 3.95. They had Summa cum laude and like, all of that. My thesis, it was the co-winner of the Distinguished Thesis Award. I also got a President Medal, so I had three different things. It was good. It was nice to walk down with all these different medals […] but I felt like people didn't like me for it. I felt like I still had a reputation in the computer science department. I think my reputation was that I'm very smart, but I'm arrogant and I'm smart but I wouldn't help people.*

As can be seen from the descriptions of the interview participants, they are a diverse group with varied experiences of lived gender, upbringing, culture, race, ethnicity, sexuality, disability, and educational and extracurricular interests. It is the intention of the author to contextualize the study findings not only within the landscape of the binarily gendered field of computing but also within the rich and complex realities of these living beings.

Data Analysis

Data analysis of interview transcripts was conducted with the help of the Dedoose software. The interview transcripts were loaded into the software application and a combination of coding and identifying themes took place in rounds. The previously described six phase approach to thematic analysis was used to interpret the interview data (Braun, 2006). I first read all the transcripts several times to become familiar with the content. Second, I read through the transcripts assigning codes. As in the previous qualitative step, coding was informed by a combination of prior research findings and unique instances. In the interest of limiting the dissertation scope and space, data analysis was constricted to the topic of intersectionality and

intersectional analysis. Intersectionality was chosen as a focal point of analysis as there is a growing body of research that points to the need to acknowledge and address the overlapping structural sights of oppression experienced by those who live at the intersection of multiple marginalized identities (Mooney, 2020; Moradi, 2017; Warner, 2021). Intersectionality has been examined in CS education in the analysis of the experiences of black women and girls (Ashcraft, 2017; Rankin, 2020).

Codes were pulled from research that examines intersectionality in the context of CS and STEM education (Haverkamp, 2021b; Leyva, 2022b; Linley, 2018). The identification of codes was also informed by Queer and Trans theoretical frameworks, again paying close attention to how expansive gender comes into tension/conflict with normative gender structures. I paid careful attention to how participants experienced overlapping sights of struggles and harm in their CS educational spaces. The data analysis resulted in a table of codes and corresponding participant quotes. I then aggregated the codes into overarching themes and identified interview excerpts that were illustrative of the theme. For example, participants talked about struggles with mental health and lack of support from faculty. This resulted in several codes pertaining to challenges around mental health: lack of support from faculty, afraid to disclose difficulties/emotions, being misgendered due to disclosing a mental health struggle. This set of codes was aggregated into the following theme: intersection of expansive gender and mental health related disability. Three overarching themes were identified for analysis in the findings: intersection of TGNC and race, intersection of TGNC and sexuality, and intersection of TGNC and disability.

Focus Group Phase

Interview participants were invited to engage in a focus group, where they had an opportunity to codesign a computer science education activity, inclusive and supportive of students with expansive gender. The focus group took place in September of 2021, over Zoom and was recorded and transcribed.

Session Design and Protocol. The design of the focus group session was informed by the Network Improvement Community (NIC) methodology. A NIC is a group of intentionally selected stakeholders and experts with a "focus on one specific, agreed upon issue and together identifies problem-solving plans, implements those plans and solutions, measure the results of implementation, and adjusts strategies based on data that is gathered throughout the process" (Feygin, 2015 p.2) The elements of a NIC that were employed in the focus group design were as follows: a focus on a well specified common aim, guided by a deep understanding of the problem and the system that produces it, and a working theory to improve it. The NIC methodology emerged from the field of implementation science (Bryk, 2011). Its core components are coming up with a plan that is actionable and is tied to measurable outcomes. The methodology is iterative in that once a plan is implemented, the NIC monitors the outcomes measurements and revises/updates the plan if needed, continuing this process as many times as needed to reach an acceptable resolution to the problem. The NIC methodology was chosen as it is in alignment with my intention to center TGNC students as the experts and stakeholders in changing CS education to be more inclusive and supportive of expansive gender. For this reason, the focus group participants were asked to co-design an education activity that they felt was inclusive of expansive gender. For various reasons, such as lack of time and feasibility, the

phases of a NIC methodology pertaining to actual implementation of the education activity, coming up with measurable outcomes, monitoring and revising the activity, were omitted.

The first part of the session was introductions by the participants, which asked them to talk about their involvement in computing as well as what they enjoy about CS. This was followed by a presentation, prepared by the author, covering a number of interventions that aim to broaden the participation of women in CS. After the presentation and a discussion, the participants were divided into two breakout rooms. Each group was given a link to a Google document for taking notes during their work session, which included the prompts for their activity. The prompt asked them to design an educational activity inclusive of expansive gender and create an artifact, such as a digital poster, to advertise the activity. Each group was also given a link to a copy of a Google slides deck. The slide deck included the presentation of interventions aiming to broaden women's participation in CS and included editable slides that were reserved for the production of artifacts created during the work session. Each group had 30 minutes to design their activity and produce the artifact(s). Each group presented their design and artifact to the entire group. A brief discussion followed. The entire session took two and a half hours. See Appendix C for the collaborative activity prompt.

Recruitment. The eleven interviewees were invited to participate in the focus group. The recruitment took place in September. Seven participants confirmed that they would attend. Of those, five attended the session. Focus group participants emailed a completed consent form prior to the day of the group meeting. After the completion of focus group, each received a $50 Amazon gift card.

Participants. Sasha, Dayne, Jay, Andi, and Bo attended the focus group. All five are postsecondary students in CS.

Data Analysis. The focus group transcript was analyzed using thematic analysis and following the previously described six step process. I read the focus group transcript multiple times, applying codes inductively and deductively. The codes were informed by prior research which forwarded recommendations for increasing participation of marginalized groups and specifically that of TGNC people (Jennings, 2020; Linley, 2015). Additionally, codes were informed by the data analysis of the survey and interview data. The author reviewed the codes and aggregated them into overarching themes. The author analyzed the digital posters produced by the participants identifying participants' design decisions that could be interpreted as recommendations for improving CS education activities. The author looked for excerpts from the focus group transcripts that supported his interpretation and theme/recommendation selections. A table was made, summarizing the recommendations and the corresponding excerpts were included in the findings chapter.

Conclusion

TGNC students are seldom included in research on marginalized groups in CS education, even though they have been shown to be underrepresented and, the few findings that do exist, suggest that they face substantial challenges. Furthermore, when included, TGNC students are frequently treated as a monolithic 'T' under the LGBTQIA+ umbrella. To address the gap in CS education literature, this study was designed to engage a broad range of TGNC voices: those who experience a spectrum of expansive gender as well as those with additional marginalized identities. Specifically, intersectional analysis was used to examine how expansive gender combines with other marginalized identities, such as race, ethnicity, disability status, class, etc., resulting in unique experiences and challenges for TGNC people in CS education. Although the study design drew from research which examined the experiences of undergraduate students in

engineering, it offers unique contributions (Haverkamp, 2019). The novel contributions are as follows: a belonging instrument tailored for postsecondary CS education, a demographics section, containing a broad range of gender, sexuality, race, and ethnicity markers, interview questions that explicitly investigate intersectional experiences in CS education, and a focus group to engage TGNC students in co-designing inclusive CS education activities.

This study, which took up the ethos of, "nothing for us without us," consulted and engaged members of the LGBTQIA+ community in the design of every phase.

Chapter 4: Findings

"As a nonbinary person, I feel that I never see myself represented in CS or STEM in general." (Study participant)

Introduction

TGNC students in general and in computing specifically, are members of a marginalized group. There is evidence that they are underrepresented in computing and leave the field at higher rates than their cisgender counterparts (Linley, 2015; Maloy, 2022; Trenshaw, 2018). Extensive research on other underrepresented groups in computing, such as women, people of color, and students with disabilities has interrogated this underrepresentation using belonging theory. As previously discussed in Chapter 2, belonging theory is grounded in the idea that humans have an inherent need to feel that they are a valued member of a group (Baumeister and Leary, 1995). In education research, belonging has been shown to predict better academic outcomes and persistence (Goodenow, 1993). This framework has also been widely used to demonstrate that an increased sense of belonging has a positive impact on academic outcomes and persistence in computing for minoritized groups, in particular women and students of color (Sax et al., 2018). Belonging has been used to examine the experience of LGBTQIA+ computing students and TGNC students in engineering (Stout & Wright, 2016; Haverkamp, 2021b). For the most part, belonging has been examined while employing quantitative instruments and resulting data used to predict outcomes (Sax et al., 2018; Walton & Cohen, 2011). The findings in this study illustrate TGNC students' sense of belonging in computing through frequency measures and situate their sense of belonging within layers of experiences in postsecondary education. Unlike studies that employ belonging data to predict academic outcomes or persistence, here,

belonging data is used to better understand the relationship between a sense of belonging and the various contexts and experiences navigated by TGNC students in computing.

The first section of this chapter reports on findings from the survey component of the study and answers the first research question (RQ1): *How does having expansive gender influence TGNC students in postsecondary CS education, with respect to belonging, persistence, leaving, etc.?* The next section presents findings from the interview data, and answers the second research question (RQ2): *How does having multiple marginalized identities result in unique experiences and challenges for TGNC students in CS education?* The third section will present findings from the focus group and answer the last research question (RQ3): *What recommendations do TGNC students give for making CS Ed an inclusive space for people who experience gender beyond the binary?* The last section will summarize the study findings and identify themes that will be further discussed in the discussion chapter.

RQ1: The Impact of Having Expansive Gender on TGNC Students in CS Education

One way that scholars examine minoritized and historically excluded groups in computing, is through the belongingness lens. This framework is grounded in theorizing that minoritized groups feel a lesser sense of belonging due to their minoritized status. For example, research has shown that students of color have a lesser sense of belonging (fit) in computing than their white counterparts (Sax et al, 2018). Scholarship has shown that an increase in the sense of belonging improves participation, academic outcomes, and retention in STEM in general and computing in particular for LGBTQIA+ students (Stout & Wright, 2016). The survey part of the study focused on TGNC student's sense of belonging in computing. It contained nine 4-point Likert scale questions that were adapted from a belongingness instrument in a study on TGNC undergraduate students in engineering (Haverkamp, 2021b). The questions explored three areas

related to belonging. One group of questions probed the extent to which students are supported by faculty and staff in their department, encounter representation of their gender and feel that they fit in. Another group of questions focused on participation in educational experiences in and out of classroom settings and comfortability to join social activities with cisgender peers outside of class. The final group of questions, focused on feelings about current and future attainment of success in computing education.

Examination of the response data using frequencies revealed several distinct patterns:

- lack of support and representation
- confidence in CS academic abilities and that they can be successful in CS
- comfort participating in CS activities outside of class
- worry about a future in CS

On questions relating to their gender identity being supported in postsecondary CS education, 43% of respondents reported that they do not feel able to express their gender authentically and 37% reported that they do not feel supported by faculty and staff in their departments. In response to questions that relate to representation and a sense of "fit," 81% reported that there are no positive representations of their gender in their computing education spaces and 50% reported that they do not feel like they "fit in". Taken together, these results indicate that a substantial number of TGNC participants do not feel supported in their postsecondary computing education. Furthermore, on a question that asked about belonging specifically, 44% reported that they Frequently/Moderately doubt belonging in CS education.

Questions regarding participation in educational experiences in and out of classroom settings had a higher rate of positive responses: 81% feel comfortable participating in computing classes, 68% feel comfortable participating in computing-related activities outside of class, and

67% feel comfortable socializing with cis-gender computing peers outside of class. While these numbers are more positive than those regarding being supported and fitting in, 20%-33% of participants report not feeling comfortable in computing educational spaces. Furthermore, on the question that asked directly about leaving a computing education activity because their gender identity was not supported, nearly one in five respondents reported that they had left an activity.

Questions regarding success in computing had the highest rate of positive responses: 85% of respondents feel that they will be able to have the same level of success in computing education as their cis-gender peers, 79% feel that they will be able to achieve the same level of success in future computing-related endeavors as their cis-gender peers. However, 66% of respondents answered "yes/somewhat" that gender identity impacts their interest/willingness to pursue computing-related employment. Even though a high number of participants feel that they can and will succeed in their computing education endeavors, one in three participants report that their gender impacts whether they are willing to pursue employment in computing. This indicates that respondents feel concern that their gender identity will have a negative impact on their computing employment event though, they are as competent and skilled in the subject as their cisgender peers. This should be troubling as there is research that demonstrates that confidence in being able to succeed in future employment has a positive effect on persistence and academic outcomes for minoritized students in CS (Hansen et al, 2023). See table below for a summary of Strongly Agree/Agree responses to the belonging-related survey questions.

Table 4

Results for Belonging Questions with % of Strongly Agree/Agree Responses

Survey Questions	n	Strongly Agree	Agree	Disagree	Strongly Disagree
I feel able to authentically express my gender in computing education spaces	86	17%	40%.		
Teachers and education staff in computing are supportive of my gender identity	91	22%	41%		
There are positive representations of my gender identity in computing education activities, such as in textbooks, lectures, assignments, and project topics, etc.	69	12%	7%		
I feel comfortable participating in the same computing education activities as my cis-gender peers	98	37%	44%		
I feel comfortable participating in the same computing-related activities outside of class as my cis-gender peers	94	35%	33%		
I feel comfortable socializing with cis-gender peers in my computing education activities outside of class	93	24%	43%		
I feel like I "fit in" with other computing education peers/students	89	15%	35%		
While participating in computing education activities, I feel that I will be able to have the same level of success as my cis-gender peers	92	46%	39%		
While participating in computing education activities, I feel that I will be able to achieve the same level of success in future computing-related endeavors as my cis-gender peers	88	39%	40%		

Table 5

Do you believe that your gender identity has impacted your computing educational experiences?

	N	**(%)**
Yes	38	40%
No	18	20%
I'm not sure	36	40%
Total	92	100%

Table 6

Has your gender identity ever caused you to doubt your belonging in computing ed. spaces?

	N	**(%)**
Frequently	11	12%
Moderately	29	32%
Seldomly	24	24%
Never	28	32%
Total	92	100%

Table 7

Have you ever left a computing ed. activity because your gender identity was not supported?

	N	**(%)**
Yes	15	18%
No	77	82%
Total	92	100%

Table 8

Do you believe that your gender identity impacts your interest/willingness to pursue computing-related employment?

	N	(%)
Yes	26	28%
Somewhat	35	38%
No	31	34%
Total	92	100%

What Impacts a Sense of Belonging in CS Education for TGNC Students?

Several of the survey questions had open-ended follow up questions that asked for additional details. These answers were analyzed using the strategy of thematic analysis. The themes identified in the open-ended answers offer concrete details and a better picture of participants' sense of belonging in computing education. The analysis included several broad areas of impact on outcomes and persistence that have been identified by prior research for LGBTQIA+ people in STEM and engineering. These include climate, discrimination and microaggression, stereotypes, culture of impersonality and apoliticism, pressure to stay in the closet. Additional themes were identified that fell along several categories identified in prior research specifically on TGNC people in STEM. These categories include pervasive treatment of gender as binary (genderism), lack of support and representation, lack of fit due to stereotypes in computing.

In addition to themes already identified in prior research, the following facets of belonging, specifically pertaining to being TGNC in CS education, emerged from the data analysis: challenges navigating a male dominated field, sexism and misogyny, and discomfort taking part in interventions aiming to increase participation of women in CS. The latter themes

have not, to the best knowledge of the author, been identified and examined in research literature on TGNC postsecondary students' experiences in CS education. The analysis of open-ended question data revealed that TGNC students in CS Ed navigate a complex interplay of the field's culture of impersonality and apoliticism, treatment of gender as binary, gendered interventions to increase participation of women, and stereotypes which frequently elevate men and devalue women. Participants shared that this caused them to feel erased, invisible, isolated, and not able to find where they belong in CS Ed. Finally, the geographic location of the educational institution they attend, the attitudes towards TGNC people at a particular institution, and attitudes of a CS department faculty and peers had further impact on TGNC students' sense of belonging in CS Ed.

Unsafe and Unwelcoming Climates and Microclimates. As discussed in Chapter 2, the US has vastly different realities for TGNC people depending on where in the country they are. This section will use the term microclimates. introduced in Chapter 2, to show how many overlapping contexts impact the experiences of TGNC postsecondary students in CS Ed. Whereas, for some marginalized identities, for example sexual minorities, it has been shown that CS and engineering departments present a "chilly" climate, TGNC students' existences are additionally negatively impacted by the political, legal, and cultural geographical contexts where they study. With respect to the current US landscape, four hundred forty six anti-trans bills have been introduced across forty states. Survey responses demonstrate that the sociopolitical climate of the location where TGNC students attend school has an impact on their sense of belonging. For example, the excerpt below demonstrates how the experience of coming out in a CS department in a rural school was so difficult that the student switched their major.

> *When I did manage to come out in education, I was often shunned or rejected. I went to an 'engineering' school in a rural area, and stereotypes about trans- people were*

> *abound, let alone the EXTREMELY misogynistic nature of the school. It was a nightmare. So, I switched to study Discrete Mathematics, where I learned the elements that make computer science, without being in a computer science program.*

Another respondent shared that they are concerned about future employment possibilities, as they will not work in states where the "trans panic defense" is legal. Trans panic defense is a legal strategy, permissible in several US states, by which a defendant accused of physical violence or murder of a TGNC person can request a not guilty verdict due to the duress experienced in discovering that they were interacting with a not cisgender person.

> *At some point, I'll need to find work, and, at minimum, I don't feel comfortable working in states where the trans panic defense is still legal. Lots of other issues too, depending on how progressive the space that I'm part of is.*

These excepts demonstrate that TGNC students in CS must navigate the political, legal, and cultural treatment of TGNC people in the geographic location where they are studying or seeking to work in addition to the attitudes and policies towards TGNC people in their respective CS department. As can be seen in the above quotes, participants expressed concerns for their physical safety and experience rejection if they do disrupt gender norms by being "out in [CS] education". The two quotes also demonstrate how for TGNC students, the sociopolitical contexts of a geographic location and computing spaces are always already **entwined**. Another respondent wrote about the overlapping microclimates of a particular location and white male CS students' attitudes and behaviors:

> *CS majors just are pretty transphobic a lot of the time. Like I'm not sure if it's cause I'm in Texas or just cause computer science is like 90% white guys who've never consciously interacted with a queer person but there's a lot of punching down in their humor, or eye rolling when you tell them that those jokes make you uncomfortable. It's really not a great atmosphere and it makes it extremely hard to feel comfy interacting with at least male cs majors.*

This statement demonstrates the way that several interwoven layers can negatively impact TGNC students and their sense of belonging in CS Ed. The layers include location, overrepresentation

of males, overrepresentation of whiteness, negative attitudes of peers and make it hard for TGNC students to "feel comfy" in CS Ed. Taken together, the three statements illustrate how TGNC students are not just confronting the microclimate of their CS departments/classes, but rather the interweaving of multiple sociocultural and sociopolitical contexts. They are at once navigating the legal, political and cultural viability of their expansive gender identity at the state and urban, suburban, or rural locality levels. Survey participants reveal that these sociocultural and sociopolitical contexts impact where TGNC students feel safe to attend school and seek employment. These contexts further permeate postsecondary institutions and can result in schools where the culture is 'EXTREMELY misogynistic' and 'stereotypes about trans- people [are] abound', further diminishing a sense of belonging. As one participant noted, the combination of coming out at an engineering focused school in a rural area and a CS department with negative attitudes towards TGNC people caused them to leave the CS department all together. Thus, for TGNC students in computing education, belonging cannot be examined at the departmental or classroom level, it must be understood as always already existing in the concentric sociocultural and sociopolitical realities of the state, locality, and the postsecondary institution they are attending.

Male Dominated Field. When responding to questions about belonging and the impact of gender on their CS education, many students talked about CS being a male dominated field and their computing education spaces being "boys' clubs." The overrepresentation of men in CS Ed, particularly white men, results in a culture/climate that centers and elevates white men (Camp, 2012; Cheryan et al, 2017). There is a large body of research that finds women are negatively impacted by the male-dominated culture/climate of CS Ed. Additionally, research demonstrates that the overrepresentation of white people in CS Ed has a negative impact on

black, brown, and Indigenous students' sense of belonging. The excerpt below conveys how the interaction of computing being a male dominated space, where women are present in much smaller numbers, and are often subjected to misogyny and discrimination, forces this student to have to choose between passing as a cis man and "muting" their nonbinary identity or experiencing discomfort if they display their gender nonconformity and present their "feminine side".

> *CS is ubiquitously a male dominated space, and I feel as if having any gender identity other than that definitely has an effect on one's experience. I've had classmates, team members, and professors misgender me. I feel like my fellow students aren't sure how to address me, and sometimes will willingly ignore my gender nonconformity. However, I feel like my input is usually valued, but I also present looking like a cis man despite my nonbinary identity. I don't always feel comfortable leaning into my feminine side and will mute my personality around my classmates.*

One participant expanded that CS departments are not only "cis-het male dominated," but compared to other academic departments, there is no engagement with gender identities beyond the binary.

> *In general, CS spaces feel cis-het male dominated, and male students are sometimes condescending or not inclusive of non-male classmates. While I have had a couple trans and non-binary classmates, the majority of them have not been, and in comparison to the attention and space given for queer and trans identities in some humanities classes I've taken, my CS classes often feel like they are not spaces made with these people in mind.*

The excerpts above demonstrate how the male dominated microclimate of CS and relational microclimates, that is interactions with faculty, classmates, and project teammates, produce a limited set of options for TGNC students. Taken together, these students show that they are navigating CS education within a male-dominated culture/microclimate where they feel that their choices are to "mute" to fit/belong or be themselves at the risk of discomfort. Additionally, the above example shows that TGNC students experience CS departments as less acknowledging of expansive gender (and sexuality) than departments in the liberal arts and humanities. Thus, even

if they encounter more accepting microclimates while taking classes in other departments, they do not feel that there is space for their gender identity in CS.

Culture of Impersonality, Apoliticism, and Meritocracy. One way to understand the difference between the treatment of expansive gender in CS compared to other academic departments is to recognize that the ideology undergirding CS education is steeped in notions of apoliticism and impersonality, which limits what topics are deemed pertinent to acknowledge and discuss in computing spaces. This has been examined in research on LGBT in STEM showing that LGB individuals stay closeted at higher rates than people in non-STEM fields (Yoder and Mattheis, 2016). In addition, computing is steeped in ideals of meritocracy, which claims that all one needs to do well and advance in the field is competence and a strong work ethic. Two survey participants made this evident in their responses to the question of whether their gender has had an impact on their computing education experience. One offered the following: "Gender doesn't matter. Merit matters." Another participant, provided a more detailed example of how the CS ideology of apoliticism, impersonality, and meritocracy limit even the possibility that one's gender can have impact on their experience in CS ed:

> *There were no problems as my gender identity is really irrelevant to what I do in computing. Just as it is irrelevant to my what my cis-gender peers do in their bedrooms. Anyone who can get the job done is welcome. Anyone who is competent, willing to work, put forward their best effort is just as welcome as anyone else. You just have to do a good job, be courteous to other people, and people will be well disposed toward you. At my job, my job performance is important. At school, my school performance is important. The workplace is not set up for socializing. I am not expecting my work or school to act as my therapists. A work or school it is meant to accomplish a goal or task, and it has very little to do with what a person does with their family in their own time. Computing is computing, no matter what the person looks or feels like.*

This participant offered the following to the question of their sense of belonging in CS ed spaces:

> *It's refreshing to work with hardware: the circuit board does not care about what a person "feels like" at any given moment: it just does what it does. The people who are drawn to the field of computing are methodical, goal oriented, and work with others*

> *based on KNOWLEDGE not personality, or any other trait. Just what you know, what you can bring to the table, that's what matters. The work place or school is not a social club. If I want to "express myself" I can find places outside of school and work environment. At school or at work, I am there to learn, or to accomplish a goal. It's really pretty simple.*

These responses demonstrate how the notion of CS as being impersonal, "*the circuit board does not care about what a person 'feels like,'"* and that the only thing that matters in CS is a person's knowledge of the CS subject and the quality of work they produce. The statement delineates the CS education or work space as a place where feelings, expressions of identity, socializing, emotional support do not belong. The statement, which hypothesizes what kind of people are drawn to computing, "*methodical, goal oriented, and work with others based on KNOWLEDGE not personality*," further illustrates how stereotypes of who belongs in computing intertwine with the notion that CS is apolitical, impersonal and meritocratic. Several participants conveyed how this trifecta of conditions combined with the gendered nature of CS ed spaces impacted their decisions to disclose or not disclose their gender expansiveness. Disclosing expansive gender or disrupting binary norms of gender was experienced by some as breaking the rules of impersonality, apoliticism, and meritocracy. These findings will be discussed in the next section.

Gender Identity Disclosure, Passing, and Covering. A pertinent theme identified in research on TGNC students in STEM relates to disclosure of trans identity. To disclose or not is a complex set of decisions and students experience a variety of pressures and challenges when evaluating how much of their expansive gender identity to reveal. Research has shown that the inability to disclose one's LGBTQIA+ identity leads to poorer mental health and professional outcomes (Pachankis et al., 2020; Ragins & Cornwell, 2001). Several participants reported that they opted not to disclose their gender identity:

> *Most of when I was studying CS, I wasn't out as trans. CS encouraged me to completely ignore my body, making it easier to stay in the closet, but so much harder to find myself.*

> *I do not openly express my feelings and representations of my gender identity, so while I don't always feel comfortable around my classmates and fellow work employees, I've never really been singled out for my gender identity, because no one ever knows it.*
>
> *I do not express my gender identity to my peers. I am AMAB, but I am feminine leaning non-binary.*
>
> *In my junior project class, the professor segregated our groups by gender based on the perceived gender of our names. A group of women went to the department head to complain, but I wasn't out and couldn't really talk about how this behavior was additionally transmisic nor did I feel comfortable speaking up with the women.*

These statements demonstrate that TGNC students, especially nonbinary students, choose not to disclose their trans identity because the culture/microclimate of CS Ed does not provide visibility/legibility, safety, and support of more than binary gender identities. They also show how the choice to not disclose provides reprieve from being negatively impacted and at the same time causes discomfort and a disconnection from self. One way that nonbinary students experienced the struggle with disclosure is in wanting to be seen/known but not being legible to their faculty, TAs, and peers, even if they did disclose their identity. Another way this manifested is in them choosing not to disclose because they fear being negatively impacted:

> *It's difficult to be perceived in most groups of people where the general field is considered to be a male-driven field. Most people see me as my birth gender (female) and I've been spoonfed information from peers, but not professors at least. I feel that if they were more aware of my gender that most of my peers would probably stay away from me/argue with me more/ignore me.*

This statement reveals how being gendered as a female, results in the student being treated as intellectually inferior and needing to be "spoonfed information." At the same time, the student is worried that if they take actions to make their expansive gender more known, they will experience negative reactions from others, including rejection. Additionally, participants shared that even if they did disclose, faculty and peers disregarded their chosen names and the pronouns that they use. For example, the following statement shows how a person's identity is "coded" no

matter how they identify, such as “I'm often coded as a woman, even if I'm AFAB but gender non-conforming” and “A lot of people don't understand and/or don't respect my transness and treat me like I'm basically a woman.”

The following two responses show how TGNC students’ expansive identities are made invisible, even if they do disclose their identities by asking to be referred to by their chosen name and correct pronouns: “I use my preferred name in class and people use it but they still treat me like my assigned gender at birth by using gendered terms and pronouns.” And “I feel like I'm still in the closet even though I'm out and proud.”

Taken together, these excerpts demonstrate how TGNC students’ gender identities are erased, regardless of whether they chose to disclose or not. Students whose expansive gender is not readily legible confront making a choice between disclosing and facing interactions with people who “don’t understand and/or respect [their] transness" or not disclosing and not being able to advocate for themselves as TGNC people. TGNC students feel the pressure to not disclose and frequently cover their identity, resulting in being coded as the binary gender they were assigned at birth, they do not “feel comfortable speaking up with” or that they belong in these groups. The lack of legibility and space made for them further complicates their sense of belonging, specifically, with whom do they belong?

For respondents who struggled with disclosure and who experienced being “coded” as women, they relayed that they had to additionally contend with sexism and misogyny, even though they do not identify as women. On the other hand, several trans men who are read as cis men, reported that their experience in computing education either improved or their gender no longer felt relevant. The following two statements demonstrate a different experience of gender for TGNC students who are read as cis men:

> *In computing education after transitioning I was treated differently than before I transitioned. My new school only knew of me as male and I was questioned much less about my knowledge and given the benefit of doubt much more.*
>
> *I am a somewhat stealth transgender man. My gender identity is male. Since others see me as male, it's no more relevant than a cisgender man's gender identity.*

Transgender women and transfeminine students reported similar challenges as nonbinary students, in terms of their gender not being legible and being misgendered. One participant shared that, while she identifies as a transgender woman, her voice is read by others as masculine, and she is misgendered by peers. She shared the following:

> *I am a transgender woman, but I have not done any work toward feminizing my voice. This has led to people referring to me with he/him pronouns during conversations which makes me incredibly uncomfortable while speaking. This has occurred while working in a group of only 5 people that I knew fairly well. This makes it really hard to not just feel like another guy in the computer science department, and that is a miserable feeling for me.*

Another participant wrote:

> *I'm a trans girl, who is, to quote POSE, 'burgeoning.' I use they/them pronouns, which no one ever gets right. I dress like I'm in either The Girl With The Dragon Tattoo or The Sound of Music, depending on the day, and at minimum make people in any room I walk into uncomfortable.*

Taken together above examples demonstrate the complex challenges that TGNC students encounter as they navigate whether to disclose or not disclose their expansive gender identity in computing education spaces. The findings further demonstrate significant differences between the experiences and challenges faced by students who are nonbinary and those whose transgender presentation more closely aligns with binary gender. While both groups of students run into the binary gender machinery that operates in computing education spaces, nonbinary students, more so, experience that their gender is invisible, illegible and invalid. Some nonbinary participants in the survey shared that they opt not to disclose their gender due to being afraid of harassment or discrimination. Other participants relayed that even after disclosing that they are

nonbinary, they are still "coded" as the gender they were assigned at birth. A few participants talked about how the extra energy required to continually correct faculty, TAs, and classmates, is exhausting, and so they decided to not push for their gender being recognized, in other words they decided to cover their genuine gender identity.

One participant noted that they chose to disclose specifically because of the lack of representation of nonbinary people in computing, stating, *"*I wanted to be the first nonbinary in computing since I had never seen of my gender in the tech industry until then." This remark demonstrates how the pressure to not disclose expansive gender identity can lead to gender expansive people not "seeing" others of their gender in computing education spaces. As respondents reveal, disclosing expansive identity runs the risk of negative consequences, such as discrimination or microaggression, or one's identity not being legible, acknowledged, or respected, leading to fewer TGNC students being "out". Therefore, they often experience being the only one in the space.

While many respondents reported a lack of visibility and representation of gender other than binary in computing education spaces, one participant offered a different experience: "[my gender] has allowed me to find other genderqueer people in CS at my school and relate to them, but has certainly made me feel outside the general cis male population". This excerpt demonstrates that TGNC students do find each other in CS while at the same time feel as outsiders in the general "cis male population." Research has demonstrated that finding community is important for TGNC students' mental health, academic outcomes, and persistence in postsecondary education (Kersey & Voigt, 2021; Yang et al, 2021). However, being a part of TGNC community in the department is insufficient. As this student points out, they still feel "outside the general cis male population." This can be connected to what participants shared as

the lack of visibility of gender outside the binary inside computing spaces, due to the lack of the following: visibly discernable TGNC students, class discussions that consider gender beyond binary, inclusion of expansive gender identities in CS Ed curriculum, as well as programming and resources that specifically acknowledge and center TGNC students. Taken together these findings reveal a negative feedback loop in CS Ed spaces, where the culture of impersonality and apoliticism restrict discussion of gender beyond the binary, which contributes to the illegibility and invisibility of TGNC students.

Disclosing and not being legible, or not disclosing and covering, additionally impacts how TGNC students are confronted with stereotypes about women in computing:

> *I'm perceived as a woman although I don't necessarily identify purely as a woman, and it makes me worried that if I ask for help, I'll build up stereotypes of 'women can't code, they're less technologically inclined than men, etc.'*

> *I actually went to my academic advisor to talk about how having depression impacted my ability to perform in all of my classes, and she implied that maybe I wasn't meant for CS, since it was 'too hard.' I'm really not sure if she would have said the same thing, had she perceived me as any gender other than female*

The above excerpts demonstrate how gender nonconforming students encounter "stereotype threat" of being identified with "women can't code, they're less technologically inclined than men," even though they do not identify as women. The first excerpt shows how being categorized as a cisgender woman leads a student whose identity is not binary, to fear that they are contributing to stereotypes of women being technologically inferior if they ask for academic help. The second excerpt shows how a nonbinary student, who asked for support around mental health, is left wondering if they are seen as less capable in computing because they are "perceived" as a female and speculating that if they were read as any other gender, perhaps their mental health concerns would be affirmed and addressed. Taken together, the passages highlight that for nonbinary students, being illegible contributes to being negatively impacted by

stereotypes about women in computing and undermines their ability to ask for assistance, be it academic or related to mental health. (cite paper on LGBTQIA+ minority threat and findings).

Interventions to Increase Participation of Women in CS Education. Survey respondents conveyed various ways that organizations and programming aimed to increase participation of women in computing, create further challenges and harm to TGNC students by essentializing and cementing binary gender in spaces adjacent to computing classrooms. They reveal how programs that promote "women in tech" force TGNC students to have to cover their gender to fit in. The struggle to embody their authentic gender and to be seen in the contexts of such programming was especially noted by nonbinary students. One student reported that participating in activities which "push for more women in STEM" left them feeling dysphoric and lead to them withdrawing from participating in extracurricular computing activities. They shared:

> *I'm transmasc/nonbinary butch and AFAB (though only recently out, and not at all out or even questioning -- due to lack of knowledge -- during undergrad). I always felt kind of off in 'women in tech' spaces e.g. clubs, conferences, which I thought was initially due to imposter syndrome but looking back turned out to be dysphoria. This stopped me from attending a lot of those extracurriculars. I was also held up a lot as a 'successful woman' in CS (you know how programs like to showcase their ~diversity~), which made me uncomfortable even though I didn't have the words to express why yet. I felt like I was just faking being a woman in tech. It was very strange to ID more on the masc side of things, yet constantly be celebrated for being assumed to be femme. It made me stop trying to excel as much as I had previously, because I didn't want the attention turned on me and my gender.*

This passage illustrates how the binary definition of gender that undergirds programs for "women in tech" leads nonbinary students to feelings of being an "imposter", "faking" a gender, and dysphoria. Even though, the student above identifies "more on the masc side of things" they feel that they are "celebrated for being assumed to be femme," by which their authentic gender is disregarded and erased. Furthermore, the focus on promoting and celebrating academic

achievement of women in computing and the lack of acknowledgement of trans and nonbinary gender resulted in this student deciding to stop trying to excel in computing because they do not want to continue to receive attention for a gender with which they don't identify.

Another student also reported that their nonbinary gender is disregarded in "women in STEM" spaces. They shared the following:

> *My gender identity has impacted my computing educational experience in an odd way; I am AFAB and am frequently gendered as such by others despite attempts to present androgynously. The push for more women in STEM oftentimes leaves me feeling weirdly alienated, as I feel as if I am being singled out as a representative of a group I am not even a part of. While it is well intentioned and I am sure helps those who actually identify as women and are in STEM, it leaves me in the position of benefiting (scholarship-wise, as well as socially from individuals who are attempting to uplift women in STEM) from a false perception of myself that I am too afraid to correct.*

This statement reveals that participating in "women in STEM programming," designed to support one binary gender option, leaves a nonbinary student feeling "alienated" and being "singled out" for support "as a representative of a group [they are] not even a part of." Even though this student tries to present "androgynously" they are categorized as female, effectively erasing their authentic gender. Furthermore, the excerpt demonstrates how a nonbinary student feels that they can only receive social and financial support offered by gendered programming in STEM if they participate under a "false perception" of being a female, that they are "afraid to correct." It indicates that nonbinary students are forced to hide their expensive gender out of fear that their authentic identity will not qualify them for support. Several participants in the study reported that they want access to support for being a gender minority in computing because they are TGNC. However, they repeatedly shared that programs for women in computing are not spaces that they experience as supportive because these spaces do not treat gender as anything other than binary, and do not consider the experiences and needs of TGNC people.

Imagining a Future in CS. Two survey questions asked participants to reflect on their future in computing. One question asked if TGNC students anticipate achieving the same level of success in their future computing endeavors as their cisgender peers. Seventy nine percent (79%) of participants had a positive outlook (strongly agree/agree) in response to this question. However, a later question asked specifically if expansive gender impacts participants' interest and willingness to pursue employment in computing - 66% responded with yes or somewhat to this question. An optional open-ended question, asking for more details, supplemented the question. Participants reported concern about the following with respect to a future in computing employment: fitting in as their authentic gender, being visible/legible, and whether their gender identity would be supported. Several participants reported that they anticipate staying "in the closet" or not disclosing their gender expansive identity while employed. One responded stated:

> *I know I'll stay closeted, because I've come to terms with this over the years. It would probably be a different story if I were transgender instead of nonbinary, but as of now my gender dysphoria isn't stronger than my need for a job.*

The above passage demonstrates that nonbinary students worry about their expansive gender being legible and supported in computing employment. The student shares that if they were transgender, rather than nonbinary, they anticipate not being closeted, implying that if their gender were legible or if they could pass as their real gender, they would be "out" at work. Furthermore, the response reveals how a TGNC person is forced to opt for computing employment and securing financial compensation necessary for survival, at the expense of suffering gender dysphoria and having to cover their authentic gender. Another responded elaborated that even if there were employers who advertise that they "commit to creating a workplace environment that respects transgender employees," they would not be certain if the

commitment was “just an empty gesture toward diversity” and if nonbinary people would, in actuality, be acknowledged and supported. They stated:

> *I feel as if my gender identity somewhat limits the amount of employers I can work for. I try to seek out internship opportunities that at least on paper, commit to creating a workplace environment that respects transgender employees, but I worry about how much of that is actually true and how much of that is just an empty gesture towards diversity without any real backing behind it. Furthermore, even if they do recognize transgender employees, I worry about employers and coworkers only recognizing binary trans individuals and erasing my identity as a nonbinary person.*

Taken together, the two excerpts show that nonbinary students worry that their expansive identity will not be recognized or supported in computing workspaces. Respondents shared that they expect having to cover their gender, staying “closeted”, and having a limited number of employers to choose from. One participant reported that they anticipate being an “outcast” while employed in a tech company due to not wanting to participate in the “boys club” culture. They shared:

> *The very strong experiences I have had in computer science, gaming, engineering in general, lead me to think that computer companies are a nexus of "boys club" culture, and I have a strong aversion to those roles. At the same time I have deep skills and talent. This leads me to be somewhat an outcast, and seek autonomous roles at best, curbing my opportunity for leadership and advancement.*

The statement demonstrates that not only does the participant expect being alienated because of their gender identity and not conforming to expected gender norms for “boys,” but additionally, because they are “deeply skilled and talented”, implying that this is not the expected combination for a TGNC person. Despite being skilled and talented, the participant is expecting to have limited opportunity for “leadership and advancement.” According to the survey data, a high number of survey participants feel that they can and will succeed in their computing education endeavors, and several open-ended question respondents stated that they are good at and passionate about computing. However, quantitative data showed that 66% of participants are

concerned that their expansive gender will impact their employment in computing. The following is an illustrative example of how a student who is confident in their skills is worried about their future in a CS career:

> *I started coding when I was 10 but never felt welcome in tech spaces. Even in tech camp as a kid I felt out of place even when I loved making little website at home on the computer. I realized as a college kid that I loved to code and rediscovered that passion for tech but I really struggled with the idea of going back into male-dominated spaces as a female-coded person.*

This passage reveals how a TGNC student is concerned about being employed in CS not because they lack skills and passion but because they are worried about their authentic gender being illegible and having to cope with being misgendered, coded as a female, in a male-dominated space.

To recap, survey respondents report that they are "skilled and talented" in computing and on the open-ended questions they shared that they enjoy the field and various computing related activities, such as problem solving, working on projects, and coding. According to research that employs the expectancy value theory in STEM, placing a high value on computing-related tasks and a high level of expectation to succeed in computing should result in students' increased persistence in the field, including continuing to employment in CS (Eccles, 1983; Lehman et al, 2023). However, data discussed in this section shows that TGNC students who report being good at and highly valuing CS activities, have doubts about pursuing employment in CS because they anticipate encountering unsupportive and harmful environments. Several participants stated that they have decided not to pursue a career in CS. This finding is significant, as research shows that TGNC people leave CS at higher rates than their cisgender counterparts (Maloy et al., 2022; Trenshaw, 2018). The findings related to students leaving CS will be further discussed in the next section.

Leaving. When answering the open-ended question that directly asked about leaving a CS education activity, survey participants shared that they have left class sessions, an entire course, and a program of study in CS. As noted in the prior section, students also expressed uncertainty about pursuing a career in CS after finishing their degree. Respondents talked about leaving due to microaggressions, disrespect, sexism, and transphobia - challenges they frequently attributed to CS being a male-dominated field. Respondents also gave examples of how the lack of inclusion of trans- and nonbinary genders in curricular materials and pedagogy caused them to leave CS education activities. One student shared:

> *Literally every course i took in anything beside library science was mostly cis men. besides the fact that i was born in a majorly feminine body and had to deal with sexism in every class/homework assignment, i also had to deal with transphobia and homophobia. literally switched from comp sci to info tech/data science because of this.*

This passage demonstrates how a student encounters sexism, transphobia, and homophobia in class and in "homework assignment[s]," pointing out that they experience harm not only at the level of classroom culture but also within the class curriculum. They convey that assignments in CS classes did not affirm their expansive gender, were transphobic and sexist, and that this caused them to leave CS for a different program of study. Another student provided a concrete example of how the lack of inclusion of expansive gender in CS curriculum and pedagogy, results in them leaving an entire course. They stated:

> *In college, my databases professor told us in the first few weeks of class that gender could be represented as a single bit to save space in database applications. I honestly stopped listening to lecture for the rest of the class.*

This student recounts how a professor in their database course, a foundational topic in computing education, reduced gender to binary options, by telling students that gender can be represented by a single bit. By definition, a single bit can be used to represent exactly two distinct states or items of information. Thus, the consequence of using a single bit to represent gender is that only

two values for gender are made possible: 1 or 0, M or F, male or female. This curricular and pedagogical move not only teaches students that no other gender options exist, but that this is acceptable, and more so, efficient/favorable treatment of gender in the field of computing. The student states that they "stopped listening to lecture for the rest of the class," which can be understood as an act of "leaving" a class where a faculty actively communicated that they don't exist, that they do not fit in, and that it is acceptable to erase them.

In addition to leaving computing courses and programs, participants reported leaving CS activities outside of these spaces. One respondent shared the following:

> *Other than the above case of leaving an entire program behind, I have often found myself unable to participate in extra-curricular computing activities, e.g. a game dev club where the sexism wins. Being outed by someone I spoke to in confidence, in a horrible way... when offering a suggestion on how the project could go, I was told 'go make us sandwiches, woman'.... the rest laughed at what they thought might have been average hazing, but the person who said it knew exactly how deep it cut. I never participated in anything having to do with the CS program again after that too.*

The above passage demonstrates how spaces that are less formal than classrooms leave a student exposed to "hazing," sexist remarks, being outed and having their authentic gender identity invalidated and devalued. The student, who does not identify as a cisgender female, is coded as a woman by a peer, erasing their actual gender, and at the same time, they are put in a subservient position by being told to "go make [...] sandwiches" for their classmates. This double "cut" leads the student to leave "anything having to do with the CS program. It is not clear from the passage if the student continues to take courses but abandons all out of classroom CS activities or leaves the CS program of study entirely. Significantly, students reported that the inability to participate in out of classroom CS activities resulted in limiting their access to working on team projects, receiving help with assignments in study groups, and networking opportunities. According to research, participation on team projects and in study groups increases opportunities for

networking, which increases academics outcomes and persistence in STEM (Estrada et al., 2011; Lichtenstein & Greenhill, 2018). Another respondent gave examples of the harm they experienced while attempting to study in "computer science lounges." They stated:

> *Class environments and adjacent studying environments are different in tone and the types of jokes that students make. As a mostly closeted person, I've never had any significant problems in regular classes in computer science, but the studying spaces for CS students was a different experience. Most of the CS studying spaces were only young men with no adult authority, so the jokes they made became more crass and purposefully 'offensive.' I originally intended to study in the computer science lounges in my college, but there were so many 'airplane' jokes and other cliches targeted at transgender people that I felt it was too distracting to study there. Even studying with other people who I knew from class would make jokes about 'tr*nnies' when in private. Studying or spending time became like a ticking time bomb waiting for an offensive thing to be said that I would have to control my response to, and so I decided to just avoid most social studying events and activities with students in my CS classes. It was just too exhausting.*

This comment demonstrates how being "closeted" shelters the student from "problems in regular classes in computer science," however, when they are in study spaces, they are exposed to harmful jokes from mostly male peers, including classmates. The environment is so distressful that the student reports deciding "to just avoid most social studying events and activities with students in my CS classes." Leaving study spaces, where one can engage with classmates and departmental peers, not only eliminates the possibility of getting help with classwork, but additionally limits the extent to which this student can build social relationships and networks which have been shown to increase a sense of belonging and persistence in CS (Hurtado et al., 2010; Strayhorn, 2008).

These comments convey that TGNC students leave CS education spaces not because they are doubting their abilities but because they experience disrespect, microaggression, and harm. Both students demonstrate that they are committed to CS school work, one student participating in an extra-curricular group project, and the other prioritizing spending time in study spaces to

work on assignments. Another survey respondent expressed that for them "being good at [CS] schoolwork" is an insufficient condition for staying in CS. They shared:

> *I am going to get a CS job not in CS industry, seriously this culture is so toxic and sometimes I want to switch out of my degree despite being good at schoolwork because I just, can't put up with it you know?*

Taken together, the excerpts discussed in this section highlight that TGNC postsecondary students in CS have confidence in their computing skills, are passionate about and enjoy activities core to the field of computing. However, they report leaving CS education spaces and the field of CS due to only binary options for gender and a lack of possibility, legibility and affirmation of their expansive gender.

Summary of Survey Findings

This section addressed the first research question: *In what ways does expansive gender impact TGNC students in the context of postsecondary CS education?* Examination of the quantitative and qualitative portions of the survey reveals that TGNC students feel positive about their CS education abilities and retain a sense that they can be successful in CS, despite reported lack of support, representation, and feeling that they do not fit in. Digging deeper into the qualitative data reveals that there is a great deal of nuance in the experience of TGNC CS students, highlighting textures of experience, struggles, and perseverance. The findings in this study align with those in (Haverkamp, 2021b; Linley et al., 2018) which show that despite unsupportive and hostile environments, TGNS CS students manage to persist and persevere. However, a high rate (66%) of TGNC students report that gender identity impacts their interest and willingness to pursue computing-related employment. TGNC students report a significant difference in their experience in CS based on whether they are nonbinary, their gender presentation aligns with a binary gender, they are read by others as their correct gender (passing),

they disclose their gender identity but are still "coded" as their gender assigned at birth and they stop correcting others (covering), or they are "out" as TGNC. Being "out" is reported to be particularly difficult for nonbinary students and those who are not able to "pass" as their correct gender. This struggle to be seen and acknowledged impacts TGNC students' sense of belonging/fit in computing, how comfortable they feel to engage with faculty and peers, which spaces they feel are for them, including programming and resources which target women in STEM and computing. Overrepresentation of males and lack of representation of gender other than binary was reported frequently, as well as lack of representation of identities that are not cis- and/or hetero-normative.

RQ2: Overlapping Challenges for TGNC Students with Multiple Marginalized Identities

The survey demographics section was used to conduct a targeted recruitment of students who reported having multiple marginalized identities, such as race, ethnicity, sexuality, and disability, to participate in an interview. The interview data was analyzed using thematic analysis. The interview data revealed additional layers of complexity and challenges experienced in computing education by TGNC students with multiple marginalized identities. This section will present findings that answer the second research question (RQ2): *How does expansive gender combine with other marginalized identities, such as race, ethnicity, disability status, class, etc., resulting in unique experiences and challenges for TGNC people in CS education*? The interview participants shared many of the themes identified in the survey portion of the study such as challenges being a gender other than cis male in a male-dominated field, lack of legibility and visibility, microaggression, sexism and misogyny. Significantly, they offered insights into harm and challenges that exist at the intersection of multiple marginalized identities in postsecondary CS education spaces.

As discussed in Chaprter 2, intersectionality is a theoretical framework, developed by the African American legal scholar, Kimberlee Crenshaw (1991a), which makes visible how people with multiple marginalized identities experience overlapping and compounded effects of oppression and power imbalances. The seven interview participants, Clara, Sasha, Andi, Steph, Dayne, Bo, and Jay, introduced in Chapter 3, shared that having multiple marginalized identities added challenges and complicated their sense of belonging in CS education. Thematic analysis of interview data revealed a recurrence of negative outcomes resulting from the intersection of TGNC identity and the following: race, sexuality, and disability. Four interviews were selected for reporting findings as these exemplified experiences across the full set of interviews.

Intersection of TGNC Identity and Race

As previously noted, CS departments are embedded in sociopolitical and cultural contexts of educational institutions, cities, and states, that vary with respect to legal protections, policies, and attitudes toward TGNC people. Additionally, US geographies vary regarding levels of racism, the size, diversity, and segregation of the non-white populations, as well as historical relationships to race and racism. Two interview participants reported that they experienced racism on and off campus while studying CS. Jay, an Asian-American non-binary student, whose parents were born in Thailand, recounted experiencing racism and transphobia at the University where they started their CS undergraduate studies. They shared:

> *In Milwaukee, honestly, not a coincidence in Milwaukee. If you're a person of color, honestly, there's still a lot of racism, and coupled with just the environment of the school's very conservative, so there were racist jokes. I did get harassed for being transgender. My first semester of college there, and the administration wasn't very satisfactory, handling it and I felt very isolated, but it wasn't a good environment. That is why I transferred.*

The above statement shows how the interaction of racism and transphobia creates an unlivable CS education environment for a TGNC student of color. Furthermore, Jay noted that the school

administration did not address the harassment they experienced for being transgender in a "satisfactory" manner. The two sources of oppression (race and expansive gender) combined with an unresponsive administration left Jay feeling "very isolated" and resulted in their decision to transfer to a different university. Steph, an African American sophomore at a Midwestern university, recounted his experience with racism and how he felt scared to be outside of his dorm as students were holding "White supremacist rallies." He shared:

> *I'm Black. A lot of people think I'm Mexican or something, but it gets scary especially when there's White supremacist rallies around the area by other students. Mostly people from the other side of campus from me, but it's scary. Especially when it was election season going outside of my dorm without my White friends. They're still employing the police department that has frequently been perpetrators of police brutality and murdering people in their own homes, pepper spraying Black Lives Matter protesters last summer. Even though the student body and the student government right now, even though they want to cut ties with that police department, they don't want to. Though they have their own university police department, which is very frustrating. I don't think the administration cares to look out for any of its minority groups. It does ask us to come there with scholarship programs offered up to queer people and people of color. I feel like that's all just to get the diversity points and be like, 'Hey, we're so diverse. You should come to our school and give us money.'*

The above passage conveys how a black TGNC student is impacted by racism that is occurring at his university: students holding White supremacist rallies and the university employing the city's police department, which has a history of police brutality against people of color and "pepper spraying Black Lives Matter protesters." Furthermore, Steph points out that universities and specific departments purposefully recruit and offer scholarships to "queer people and people of color." However, he notes that the administration does not actually "look out for any of its minority groups," and that instead they use the diverse student population for self-promotion and "to get the diversity points." Taken together, Jay's and Steph's experiences highlight how TGNC students of color in CS navigate both racism and transphobia. When the harm, resulting from racism and transphobia, is not addressed by administration, TGNC students of color experience a

sense of isolation and that the university and the CS department doesn't care about them. This is especially concerning as more computing education efforts focus on increasing the participation of people of color and LGBTQIA+ people in CS, resulting in an increased presence of TGNC students of color in CS programs, without structures and practices to actively support them (Brown, 2016).

Steph offered another example of harm that he experienced due to his race and expansive gender. The university, where he studies CS, offers gender-inclusive housing. Steph shared that he appreciated having gender affirming housing and not having to worry about transphobia in his living space. However, he shared that he did experience racism in that space. He said:

> *Most of the people that were on my floor though, for the gender-inclusive housing, they were all White. I experienced some racism from them, which was not fun, but I did make friends with the trans people of color that were also on my floor, which made it easier.*

The passage illustrates that, on one hand, Steph benefitted from a living space where he was safe from transphobia and was able to meet other trans students of color. On the other hand, this space did not have guardrails to protect him from racism. Steph additionally noted that the gender inclusive housing was run by a cisgender woman. He shared:

> *For gender-inclusive housing, it's run by one person and she's a cis woman. She frequently outs people's deadnames to their potential roommates. She'll reject trans people to live on campus because there's no more spots or she'll have them live with their assigned gender at birth with no in-between. Our school doesn't have a queer center. It's the only [...] school that doesn't.*

This passage reveals that TGNC postsecondary students in CS face challenges in securing living spaces where their expansive gender is supported. They navigate administrative staff, such as people in charge of gender-inclusive housing, who are not able to effectively assist TGNC students with safe housing, including inappropriately sharing names they no longer use with roommates and placing them in housing designated for the wrong gender. Finally, Steph pointed

out that in addition to not providing safe housing for TGNC students, the university lacks an LGBTQIA+ center, a place where TGNC students can find community, resources, and support. The presence of LGBTQIA+ centered spaces signal to TGNC students that the University is prioritizing resources for supporting sexuality and gender minority students. Taken together, Jay and Steph describe ways in which TGNC students of color in CS Ed experience challenges and harm when universities and CS departments do not commit to supporting students along the lines of race and expansive gender.

As previously discussed, the field of computing and CS Ed are steeped in ideology of meritocracy. This ideology asserts that, in the field of computing, the only characteristics that people in the field are judged by are how hard they work and how good they are at computing. Several study participants relayed that computing is a challenging subject, that it has a culture of competition, and that not knowing answers or asking questions is unacceptable. Jay shared:

> *It's more related to that, I think, to that culture more than anything else. That culture of saying you can't ask for help and you have to pretend everything is-- You're the smartest person in the world and if you ask for help it's bad and you can't show vulnerability. That was toxic for a lot of people and for me too.*

Dayne, a sophomore at a Midwestern University, stated that as a transgender student, he feels extra pressure to excel in computing. He further reported that as an Asian-American he has encountered racist statements that diminish his academic effort and accomplishments. He said:

> *[…] people will look at me and think that I'm smart without thinking that I work hard, which is it's really, really frustrating. […] I have people say to my face like, "Oh, well, you're Asian, of course, you're smart. It's just easier for you," which is so unbelievably racist, and it happens, it happens a lot. […] It's not good. I feel like I don't really ever get credit for the intelligence that I have. It gives me a bit of imposter syndrome where I'm like, 'No, I'm not really smart. No, I never work hard. No, I can't possibly have burnout because there's no way I'm working hard.'*

When discussing how his expansive gender impacts his CS studies, Dayne offered the following:

> *I absolutely feel like I have something to prove going into this. I keep hearing from people who care about me, 'Hey, you have nothing to prove, just do your best.' I feel absolutely like I have something to prove. I want to be the best because I feel like that's when I'm going to get the respect that I need is when I can outperform people. […] I believe that when you become one of those people that gets the respect that they deserve because of your performance, that you force other people to be more open-minded because then once they see it, and they're like, "Oh, not only do trans people exist, but they can be really good at what they do that." […] Having that kind of experience, especially because there's this huge stereotype around queer people as being very artistic, and not doing well in the STEM regions.*

This passage demonstrates how Dayne is navigating racism, in the form of the model minority stereotype (Walton & Truong, 2023), which leaves him doubting his academic abilities and experiencing impostor syndrome, all the while striving to prove that as a TGNC person he does not merely exist in the CS ed space, he and other TGNC people excel at computing. Jay and Dayne expose how the meritocratic and competitive culture of CS drive TGNC students of color to gain visibility, respect, and acceptance via the avenue that meritocracy makes available, namely working hard, not asking questions, and pushing through burnout. At the same time, Asian-American TGNC students confront the model-minority stereotype which ascribes their success in CS education to a genetic advantage and natural ability in STEM, which as Dayne points out, downplays their academic effort and commitment.

The culture of meritocracy and neutrality adds an additional layer to the intersection of race and expansive gender. When discussing the possibility of being out as TGNC in computing spaces, especially employment, Steph shared that he would remain stealth at work. He talked about how this reality, that he would not disclose his transness, did not bother him and that it's how he understood computing employment spaces to work. He said:

> *I know that's pretty much how everybody is to some degree, having them put on a mask for your peers as to not seem unprofessional. I figured it would probably just be another facet of that trying to avoid any forms of bigotry, to avoid causing any workplace issues. Or having to deal with taking people to HR, filing a complaint.*

He further said that he wasn't sure whether co-workers would treat him differently if he did disclose being a transgender man, but that he *"would rather not take the risk of people being awful."* When asked if avoiding the risk of being mistreated was compounded by his race, Steph shared the following:

> *Probably. I know that Black people, in general, are told by their parents and friends to be more professional than your White peers, so that you don't get called aggressive or have them try to cause issues with you. That's something that I also grew up learning. I think that's probably why I try to avoid any kind of situation where there might be confrontation.*

When asked to recall what his mom told him about being more professional, he reported the following: "Always have a better attitude. Always work harder, just so that they don't have an excuse to try to tell you off."

The three passages above demonstrate how a black TGNC student navigates the intersection of expansive gender and race. Steph opts not to disclose his transness and remains stealth to stay away from harm, the harm that he can avoid. He mentioned multiple times that having passing privilege and being stealth has kept him from facing negative experiences in CS because of his gender. However, Steph does not have the same options for avoiding racism, he cannot hide his race. He has been forewarned by "family and friends" to tamper his behavior, "be more professional," appear "less aggressive," in response to racism. Steph further normalizes the choice to conceal his gender at work by saying that it's "pretty much how everybody is to some degree." The statement that concealing one's transness is like putting on "a mask for your peers as to not seem unprofessional," demonstrates how Steph understands that being out as a TGNC person is less than, or outside of, being *professional*, and thus outside of the norm. He further notes that as a black person, he feels additional pressure to be seen as professional. Steph's decision to not disclose his gender because it may be perceived as "unprofessional" combines

with the pressure he feels as a black person, to be more professional, work harder, and have a better attitude.

Both Steph and Dayne feel pressure to work hard in their CS studies, although they experience this for different reasons, in both cases the reasons stem from racism. Additionally, they both enact strategies to combat transphobia in CS Ed spaces. Steph opts to stay stealth, and not disclose his authentic gender, while Dayne commits to being the best and outperforming his peers. Jay's experience demonstrates that the competitive culture of CS to always be better, not to ask questions, and not to ask for help further makes it difficult for TGNC students of color to get the support that they need with respect to race and being transgender. Taken together, Jay, Dayne and Steph demonstrate how TGNC students of color encounter challenges and harm stemming from racism, lack of acknowledgement and support for expansive gender, and transphobia. TGNC students of color report that they do not feel supported or protected by university and CS department administration, leaving them feeling tokenized, vulnerable, and isolated. Furthermore, they navigate CS ed's culture of meritocracy and neutrality which designates issues of racism and transphobia as outside the scope of CS, making it more difficult for TGNC students of color to receive support from their departments.

Intersection of TGNC Identity and Sexuality

Several interview respondents shared their struggles in navigating the cis- and heteronormative space of CS education. Bo and Steph gave examples of how their sexuality is not affirmed or accepted in CS ed spaces. Bo noted that they feel doubly invisible and invalidated regarding their gender and sexuality. They shared:

> *Many men in the department just assume I was a heterosexual female, and then they asked me out, and I had to politely declined them, and some of them became really salty after that. They didn't believe in me when I told them I'm not a heterosexual female. They*

> *thought I'm just trying to reject them in a very mean way. That is one thing that's complicated my existence. I hated that.*

The statement demonstrates that when Bo declines to date a male classmate, offering "I'm not a heterosexual female" as the reason, the classmate rejects this as a valid reason, therefore questioning Bo's gender identity and sexuality. In this case, a TGNC student cannot embody their authentic gender and sexuality as these aspects of their identity are invalidated and erased. Bo further conveyed that there is a double standard with respect to what is acceptable to talk about in CS ed spaces. They shared:

> *For example, I can't strike a conversation with my lab mate saying, "I met this girl and she's really attractive, I want to date her." This is impossible, but if I was a heterosexual guy, then this is a normal conversation to have. I can't be my authentic self because if I do that, then the other party's going to be stunned. Not necessarily disgusted or reacted negatively, but they will be stunned by not knowing what to say. It's a conversation stopper, so no, I can't be my authentic self just for the awkwardness sake.*

In the passage above, Bo points out that they cannot talk about an attraction outside of a heteronormative one with a peer, because it would be a "conversation stopper." On the other hand, it would be normal and acceptable for the same peer to talk about his attraction to an opposite sex person. Bo's experience demonstrates how the norms of cis gender and heterosexuality in CS education spaces results in confronting a situation where their gender and sexuality are invalidated and erased. The double standard of what is and is not acceptable to talk about in CS Ed spaces is especially troublesome for TGNC students who are not straight as both their gender and sexuality identities place them outside of norms and outside of belonging.

Steph, who identifies as gay, shared how this identity impacts his CS education experiences. He relayed that his CS classmates and peers do not accept his being gay as something that is normal. He said:

> *I talk about having a boyfriend sometimes, being like, "Oh yes, my partner is making dinner today. He says it's going to be really good." Like, "You're dating a guy? Crazy.*

> *[…] They always seem really surprised anytime I would bring up being in a relationship with a guy.*

The passage above conveys that when Steph shares information about being in relationship with a same sex partner, his peers respond with expressions of surprise, thus communicating that his choice of partner is out of the norm. Additionally, when he brings up common activities that couples engage in, such as cooking for each other or sharing a meal, his peers assess the behaviors in the context of Steph dating a guy and deem it "crazy." Again, signaling that he is doing something out of the norm. Steph further shared that for him, being gay has been more of a source of negative experiences then having expansive gender. However, he pointed out that this is the result of him being able to pass as a binary gender. He shared that he knew of other students who had more negative experiences due to being both TGNC and not straight. He stated:

> *I feel pretty supported just in general. I know that it has a lot to do with me, both being binary and also passing because I know my trans friends in their respective engineering fields don't really experience that same privilege of not being questioned all of the time.*
>
> *[…] I'll probably have an easier time than somebody who's openly trans or not passing.*

This passage demonstrates that queer TNGC students in CS Ed who openly disclose their gender or do not pass, in addition to having their sexuality negatively judged, experience the validity of their gender questioned, thus receiving additional signals that they are outside the norm and do not belong. Taken together, Bo's and Steph's experience in CS education spaces demonstrate that TGNC students, who are not heterosexual, in addition to homophobia and transphobia, experience their gender and sexuality being erased and invalidated because their gender and sexuality are outside of the cisgender and heterosexual norms of CS culture.

Intersection of TGNC Identity and Disability

TGNC students with disabilities shared that having a gender expansive identity and a disability resulted in increased and more complex challenges in CS Ed. Specifically, CS being a space where it is not acceptable to ask for help, or show vulnerability, students shared that they had difficulties asking for and receiving support for their disabilities. Jay recounted an incident where the lack of support for hearing impairment limited their ability to participate in a CS Ed conference. They stated:

> *I am hard of hearing, I am disabled because of that. That has definitely impacted the way my identities go. I consider being disabled as part of my identity. That goes along with my work and how I experience it because even the little things like going to conference. […] You're aware of the [...] Conference, that happened last May. […] They tried to do the auto caption, but the auto caption was so bad, I couldn't look at them and understand what was going on. At the same time, I asked for accommodation for cards, so essentially somebody would transcribe, do this thing in real-time, and the card people were very uncooperative, they were like, 'Well, you already have the captions, you don't need us.' I'm like, 'Look, these are unusable, please, do your job. You were paid to do this, so please, do it.' That kind of thing. I felt like that adds another layer of the hoops to jump through in order to even access that network of researchers in the CS community as well.*

This passage demonstrates that the lack of attention paid to accessibility in a CS education space creates an additional "layer of the hoops to jump through." Conferences are places where students are introduced to new research and have opportunities to network with peers and faculty. The passage illustrates how a TGNC student who is hard of hearing cannot access research content due to the ineffectiveness of auto captions. Furthermore, the student was not able to access the "network of researchers in the CS community," because the conference organizers did not attend to the student's hearing impairment, leaving the student to have to fend for themselves and outside of the conference community. TGNC students face many challenges to belonging in CS education spaces. When their TGNC identity is combined with having a disability, they face the additional hardship of having to demand access to class and conference

content and support. They are effectively doubly excluded from the CS community, for having a gender identity outside of the norm and for needing support due to having a disability.

Jay provided an example of a CS education space where both his transness and disability were affirmed and supported. He shared the following:

> *My main experience is the CRA URMD. They have changed the name now it's The Computer Research Association's cohort for Under-Represented Minorities and people with Disabilities. The workshop, I think it is a three-day workshop, [...] it was really good for me because you meet other people who are disabled and people that are trans. It was eye-opening because after I came back, I also felt very angry that nobody had told me that before, that this community existed, and I felt like I had wasted a lot of time, just being alone when I didn't have to be. Even being this person with disability, I didn't even know that quite existed. […] because the disability office didn't talk about it, never talked about it, and so I have suffered through four years of just constant headache after class. I was sitting in the front and just concentrating on what the professor is saying. I wouldn't want to miss anything to the point where I would get headaches every day because of that. Knowing that was hard, and that was an option, it was also what made me feel angry that, "Why didn't nobody tell me about this?*

Although, this passage reflects a positive experience for a TGNC student in a CS education space, it also demonstrates that disability is not consistently addressed in all CS spaces. The conference that Jay attended, currently named, Grad Cohort Workshop for Inclusion, Diversity, Equity, Accessibility, and Leadership Skills (IDEALS), is in existence precisely because there is recognition that disability has been largely excluded from computing and BPC efforts. Jay's experience of meeting other TGNC people with disabilities was transformative in that it led him to find a community of people with similar life experiences and thus not feel alone. However, it also left him with feelings of anger as he noted that "nobody" told him about this conference, including the university's "disability office" and the CS department. It can be understood from the passage that had Jay known about the conference and attended it earlier in their studies, they would have learned that there is a community of people with disabilities in CS and that this community includes TGNC people, and that they are not alone. Furthermore, the passage shows

how a TGNC student, feeling that they are the only one with challenges around a disability, does not ask for help, and thus suffers years of "headaches" and hardships. Taken together, Jay's experiences reveal that for TGNC students with disabilities it is challenging to have a sense that they belong in computing education due to the following: their expansive gender is outside of binary gender norms and when their disability is not supported, they are left outside of CS content, classrooms, and community.

The findings regarding intersectional struggles in CS reveal that TGNC students experience an overlapping and compounding threat to their sense of belonging in CS education at the intersections of transness, race, sexuality, and disability. The intersection of expansive identity and race exposes TGNC students to racism and transphobia. TGNC students of color confront pressures to hide their authentic gender to lower the risk of encountering discrimination due to both transphobia and racism. They face pressure to work harder than their cisgender white peers because they feel that being good at CS will give them visibility and validity. Asian American TGNC students are additionally confronting the model minority stereotype by which their success in CS education is attributed to a natural predisposition to STEM based on their race, devaluing their academic work and commitment. TGNC students who are not heterosexual experience a double sense of not belonging in CS education due to their gender and sexuality being outside of the cultural norms of CS. They further experience their authentic gender and sexuality invalidated and erased. TGNC students with disabilities confront barriers to accessing content in and out of CE education spaces.

RQ3: Recommendations from Focus Group Participants

As previously noted, little CS education research centers the lived experiences and voices of TGNC students. Furthermore, TGNC students are rarely positioned as experts in discussions

on inclusion in CS ed research. The third phase of the study sought to address this gap in the literature. Specifically, this part of the research gave TGNC students an opportunity to inform the greater CS ed community about their educational experiences and needs. Interview participants from the second phase of the study were invited to engage in a focus group where they were asked to co-design a CS educational activity inclusive of TGNC students and expansive gender. The conversations and digital posters created during this activity were used to answer the third research questions (RQ3): *What are the recommendations that TGNC people give for making CS Ed an inclusive space for people who experience gender beyond the binary?*

Five participants, Sasha, Andi, Bo, Dayne, and Jay, attended the session, which was held online, via Zoom. The session began with a slide deck presentation, conducted by the author, which provided an overview of different types of CS education activities, specifically focusing on those that make gender salient, such as single sex programming for girls/women aimed at increasing participation in CS. A discussion of how gender is treated in computing education activities followed the presentation. After the presentation and discussion, the participants were split up into two breakout groups of three and two participants, respectively. Each group had thirty minutes to co-create a CS educational activity and produce a digital poster for it. The participants were invited to create their posters using Google slides. Each group was also given a Google doc for recording their process and discussion. The following are findings from the discussions and the digital posters created by each group. Going forward, each group will be referred to by a name that represents a significant theme that emerged during their activity. The names are as follows: *Representation* and *AI Bias*.

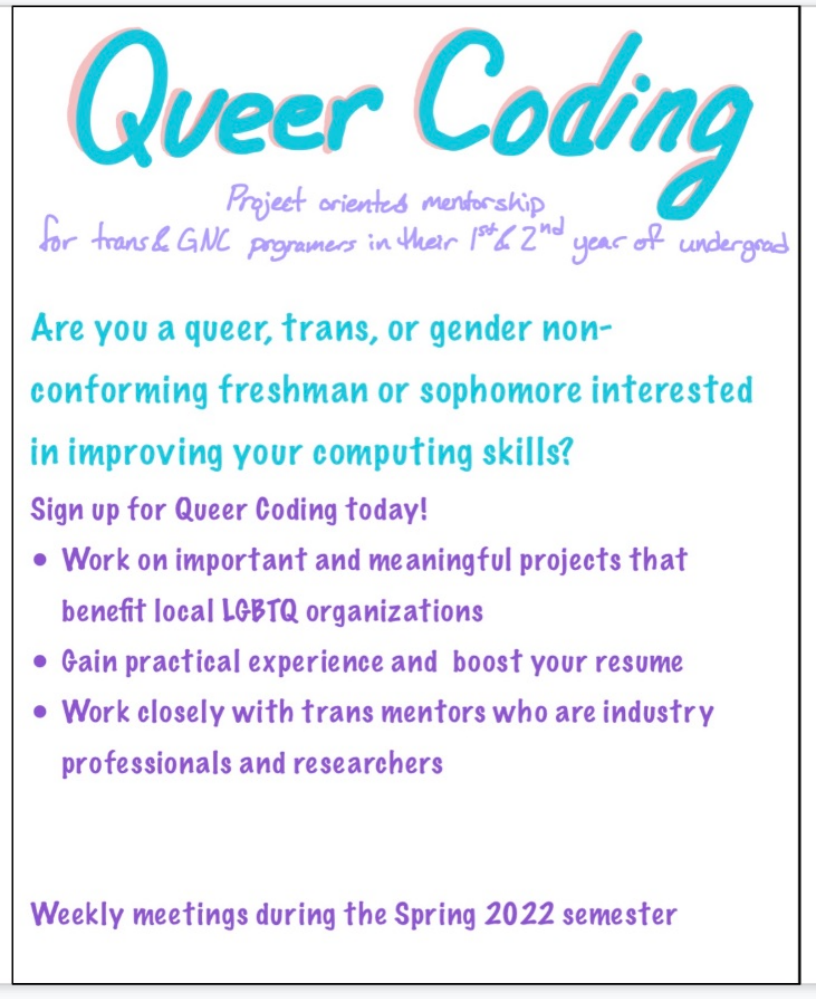
Group Representation: For TGNC by TGNC, Mentorship, Representation, and Relevance

Participants Jay, Dayne, and Sasha were in the group that will be referred to as *Representation*. The main themes that came up in their discussion and activity poster were as follows: representation and centering of TGNC students, relevance of activities, mentorship, support, and community. The activity they designed is a weekly project-based mentorship event focused on increasing computing skills and designated exclusively for TGNC students in CS. The digital poster is presented in Figure 2. The main attributes of the program, provided by the group members, can be found in Figure 3. Jay volunteered to give a description of the event:

> *Our idea was a project-based mentorship program for college students. It came out of my experience, my freshman, sophomore year of college, where so many people dropped out. […] because of the lack of, I guess, role models and also a lack of-- I guess, that attitude of, all of these guys are like, 'Oh, we know all about computing, we know everything about it. If you admit you don't know, then you don't belong here, you're not good enough.' I guess, the idea for this program is to try to prevent that from happening by helping queer and trans students be more confident in their computing skills, also providing mentorship and role models." We decided to make it project-oriented, project-based, to actually have people be able to increase their computing skills.*

Figure 2

Group Representation: Queer Coding Event Poster



The program designed by this group addresses a number of challenges experienced by TGNC students in CS education that were reported across interviews and survey responses. Many study participants shared that they rarely or never encountered people like themselves (in terms of expansive gender) in their CS studies and said that they would feel more included if there were more representation of their expansive gender among faculty, staff, and peers. The program designed by the group addresses this lack by creating a space that is specifically for TGNC

students in CS and bringing in mentors who are TGNC. Further, the program addresses the lack of support and community that TGNC students often feel within CS education spaces. Program components address TGNC student's lived experience of facing hardship early on in their studies, freshman and sophomore years. Jay is the student who transferred to a different university when he experienced racism and transphobia and lack of support from their university and CS department. Members of the group shared that a supportive community is important for TGNC students, especially early on in their studies. The design of the program also addresses the need for TGNC students to have a supportive space where they can be "more confident" and "increase" their computing skills. A number of participants in the study reported that they do not feel comfortable or supported to engage in extracurricular CS education spaces. Extracurricular programming provides students additional opportunities to increase their skills and network (Glassman et al., 2019; Tissenbaum et al.,2016). Group participants shared that they saw value in their program because it provided both a positive representation of a TGNC person who made it in CS and a "support system," which includes "having someone to talk to." They shared:

> *We have a mentorship program because I think, at least, having somebody to talk to both the mentor and also other people in a program creates a support system. Also, having mentors who are also trans and who have made it in the sense that they made it by working in the industry or even be like grad students or researchers, would be helpful to prove to other participants that, "Hey, we made it, so we can help you work through where you are.*

Another lack that the participants address in their program is curricular. TGNC students rarely encounter curricular content, such as lectures, assignments, and projects, that include topics relevant to them. Jay shared:

> *Also, the project I felt like should be meaningful because I've been in a lot of programs where we did something that was interesting enough, but it didn't feel really relevant. We wanted to have something meaningful that help the participants feel like they're benefiting other people.*

This statement relays that the participants sought to address this lack of opportunities to work on projects relevant and meaningful to TGNC students in their design. Sasha gave an example of one possible project that they thought could be offered within their program, which is an app that helps users locate gender neutral bathrooms. This shows that participants saw a need to offer TGNC students choices to work on projects that relate directly to their lives and that of members of their community.

Dayne pointed out that the group intentianally designed the program for TGNC students. The group discussed how activites to increase particpation of women or other historically marginalized groups might include TGNC students but that the inclusion comes across as peripheral. Dayne shared:

> *I think, kind of a way that our conversations started off, it was already very geared towards like, […] being trans and GNC in computer science, it's just like, when you do see that inclusion on any type of poster advertising for anything, that's being very much on the sides. […] then just already starting off in that direction of, 'Okay, we want this to be front and center,' and carrying that through it to make sure that-- Not to remedy it, but just the antithesis of being so sidelined and having something get so explicitly for trans and GNC people. […] and really advertising the mentorship thing was something that I thought was good because-- Yes, just that creating that sense of community and just the feeling less alone in your field is really important.*

This passage demonstrates that the participants of this group felt that it is important to have programming that centers TGNC students in CS, where they are the population that is being designed for, rather than added to programs designed for women, or other marginalized groups. This passage also highlights the importance of CS education spaces where TGNC students can feel that they are not alone, that they are in a community of peers, and that this includes their expansive gender.

A participant from group *AI Bias*, Andi, echoed the need for programming that offers TGNC students opportunities to be in community with other TGNC students in CS. They stated:

> *I think from my experience, till the other CS people who are also LGBTQIA+ that I've talked to, they felt very isolated, and they felt like they didn't belong. Like the majority of people in the CS classes are White straight males, White cishet males. I think it would be really cool to have something like this.*

This passage demonstrates that a number of TGNC students in CS education spaces can feel that they are the only ones whose gender is not male and/or is outside of the binary. As Andi points out, these students feel isolated and that they don't belong. This group's design offers the possibility for TGNC students to come together, see each other and those who have made it in the field, as well as be seen and supported, all while working with mentors on projects that are menaingful to them.

Figure 3

Group Representation. Description of the Event

Participants: queer trans gnc students, 1st and 2nd year undergraduate students

Partnering with some LGBT organizations for projects

Mentoring program, with one mentor for X students

Mentors can be trans industry professionals or grad students

1 semester, weekly meetings

Group AI Bias: Bias in Computing, Representation, Examination of Gender

The second group consisted of Andi and Bo. The themes that came up in their discussion and digital creations are as follows: lack of representation of expansive gender in curriculum, especially AI, machine learning, and game development, and lack of critical examinations of gender in computing education in general. To address this lack, they came up with an idea of a university-based summer program for high school-age students which includes multiple classes.

Andi and Bo designed two classes that they envisioned as part of this summer program. Figure 4 is the digital poster for the first class. Figure 5 is the digital poster for the second class. Bo described the first class:

> *I think we were thinking about a summer camp, which has a collection of courses. Then, we will teach them from many aspects, so that they will be more aware of how the identity of being a transgender or gender-nonconforming person can influence or affect the way they develop machine learning. […] The first course we came out with was machine learning and deep learning and social impact. As you can see on the right hand pictures, […]the idea behind that picture was that, in a facial recognition deep learning neural network, it is trained on a lot of data from White males, but not enough for Indian males or American Indian females. As a result, […] its accuracy is significantly worse when it's classifying images on American Indian female faces. What does this teach us or the kids, teenagers should know that, if we train a model that is on a data set, that's not diverse enough, then this model will be inherently biased.*

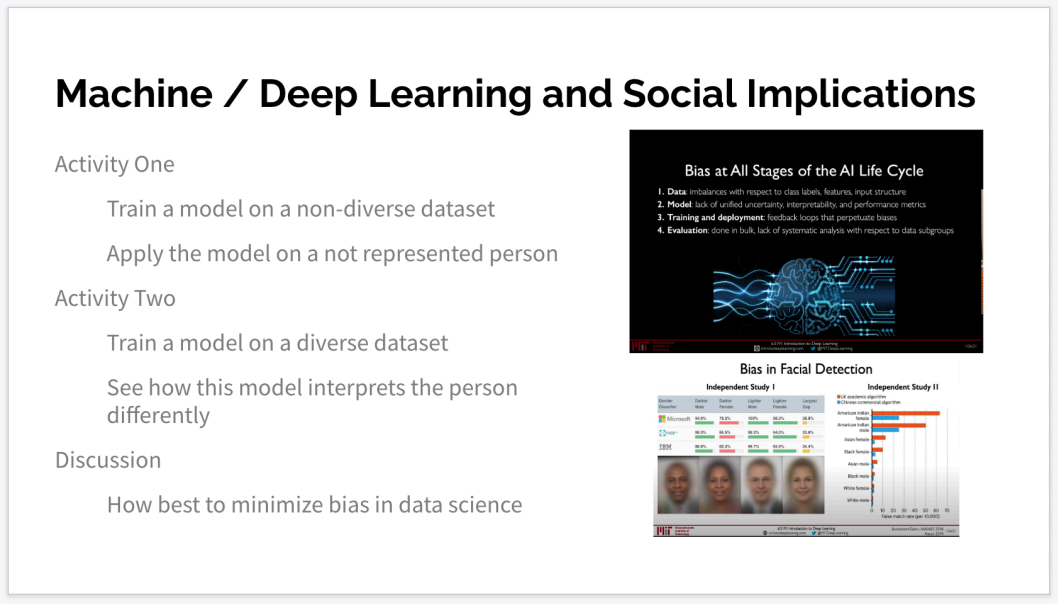
This passage conveys that Andi and Bo sought to address the lack of discussion in CS education about the negative impacts of using data sets with low representation of racial diversity to train machine learning programs. They designed their class/activity to engage students in thinking about how the lack of attention to diversity of race and gender can result in algorithmic bias. They further extended the exercise to the examination of expansive gender by asking students to think about what will happen if a model is trained on data sets containing only representations of binary gender. The program that Andi and Bo created is meant for any high school age student, relaying that they recommend this type of engagement for the broader population. Additionally, they connect the lack of examination of expansive gender and bias in algorithms, with negative impacts of computing on other marginalized groups, such as people of color and/or women. This move can be understood as a recommendation to situate the examination of expansive gender in computing within a broader examination of the negative impacts of computing on marginalized communities, while also expanding CS education curriculum by including discussion of expansive gender. Bo stated:

> *Then, so we will have a discussion to make them realize that if they want their identity to be represented and to not be biased, or discriminated against by the AI, it's important for them to voice what they're thinking and voice their identity.*

This passage conveys the recommendation that students whose identities are underrepresented, including TGNC students, should be encouraged to examine the way gender interacts with computing and to voice not only their thoughts but also their identity. One way to understand the phrase, "it's important for them to voice what they're thinking and voice their identity," is that in addition to providing space to think about bias and discrimination in algorithms/AI, students whose identities are underrepresented, should be given space to make their identities visible.

Figure 4

Group AI Bias. Description of Class #1



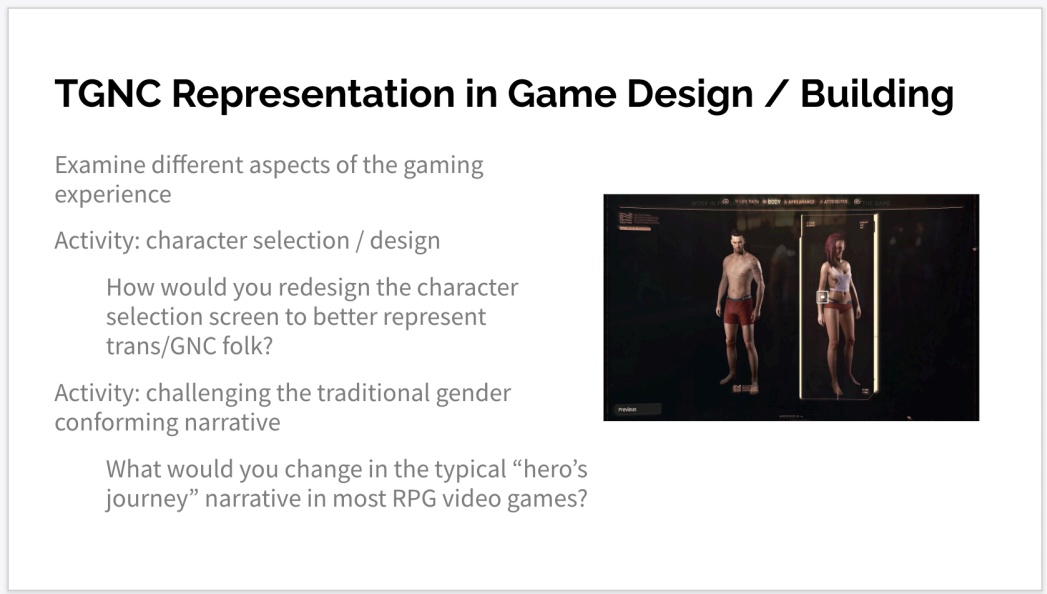
The second class was intended to examine gender in video games and videogame development. Andi and Bo designed the class to engage students in thinking about the treatment of gender with respect to the design of characters and in the types of stories that are commonly told through video games. Andi stated:

> *The second class that we thought about was trans and non-gender conforming representation in game design and game building. ...[one] picture was from Assassin's Creed Odyssey and you can choose to play as either a male or a female character, but unlike other games, they actually allow the male character to wear female outfits and*
>
> *stuff, whereas in other games it's usually limited. We wanted to examine different aspects of the gaming experience and how well trans and non-gender conforming people's experiences are presented. The first activity that we came up with was redesigning the character selection screen, because it's mainly usually like, do you want to play as a male character or a female character? It's very binary. It's usually very limited.*

The passage above captures the group's intention to address the lack of examination of gender beyond binary in videogame character design. Because gender is assumed to be binary, the menu of options for a character is limited. The activity asks students to think about gender expansively, including possibilities outside the binary, such as gender-nonconforming options, and experiment with recreating the character design panel of a video game to make room for expansive gender.

Figure 5

Group AI Bias. Description of Class #2



Andi went on:

> *We wanted to maybe ask students, […] how would you redesign the character selection screen to better represent trans people and gender-nonconforming people, like not*

> *having the gender matter at all, or not having to select one, et cetera and they would come up with their own ideas. The second activity was challenging the traditional gender conforming narrative of the hero's journey, which is really typical of most stories in video games. It's very focused on White male experiences, and so we want to talk to students, what would you change in the typical narrative in most RPG video games?*

Opportunity to take critical examination of video game content further, beyond only gender. Gender is just the starting point. Connect expansive gender to other groups who are not well represented in video games. Make room for many voices.

A participant from group *Representation*, Dayne, had a very positive response to the activity designed by Bo and Andi. He noted that the activity not only guided students to critically think about the impact of computing on gender, gender expansiveness, and other marginalized identities, but that it offered opportunities for students who have these identities to fight the bias, etc. Dayne shared:

> *I wanted to say, I really liked what you came up with. I would go to all those classes. I really like, because I think it's important, and we don't do it enough to teach young people coming into CS about all the kind of inherent-- Not inherent, but the way it is right now, really passive discrimination that goes on with these really racist and sexist algorithms. These very limited options in games and stuff, just […] the way all these ways these things are built-in. I like the idea of, as a way […] it would draw underrepresented people in CS to see the ways in which we can actively fight those things happening.*

Figure 6

Group AI Bias. Representation of expansive gender in a video game

The focus group participants provided recommendations for better support of TGNC students in CS education spaces by envisioning activities that they felt were more inclusive and supportive. Group *Representation* designed an activity that was specifically for TGNC students, focused on increasing confidence and computing skills through mentorship, culturally relevant projects, and the support of a community of peers. Group *AI Bias* focused on addressing the lack of curricular representation of TGNC people and expansive gender in computing, critical examination of gender and the impact of computing on gender and other marginalized identities. Group *AI Bias* prioritized the engagement of TGNC and cisgender high school-age students. See table 3 for a complete list of recommendation themes from both groups.

Table 9

Recommendations for Better support of TGNC Postsecondary Students in CS Education

Group	Recommendations
Representation	Center TGNC students in CS Ed programming/events Provide TGNC mentors and role models Peer support in CS Education spaces Opportunities to increase CS skills in supportive settings Relevant curriculum, including project topics
AI Bias	Representation of expansive gender and TGNC people in curriculum Critical examination of gender in AI, Machine Learning Critical examination of gender in game development Critical examination of the prevalence of the "hero's journey" in video games

Conclusion

The findings from the three phases of the study, survey, interviews, and focus group, reveal that TGNC students encounter obstacles to belonging in CS education. Data examination of the quantitative and qualitative portions of the survey reveals that 44% of study respondents feel that they do not belong in CS, even though 85% feel positive about their CS education abilities and 79% retain a sense that they can be successful in CS. A high rate (66%) of respondents report that gender identity impacts their interest and willingness to pursue computing-related employment. TGNC students report a significant difference in their experience in CS based on the following factors: they are nonbinary, their gender presentation aligns with a binary gender, they are read by others as their correct gender (passing), they disclose their gender identity but are still "coded" as their gender assigned at birth, they are *covering*, meaning they stop correcting others when they are misgendered, or they are "out" as TGNC. Being "out" is reported to be particularly difficult for nonbinary students and those who

are not able to "pass" as their correct gender. This struggle to be seen and acknowledged impacts TGNC students' sense of belonging/fit in computing, including programming and resources which target women in STEM and computing. Overrepresentation of males and the lack of representation of gender other than binary was reported frequently as a challenge to feeling that they belong, as well as lack of representation of identities that are not cis- and/or hetero-normative.

The findings regarding intersectional struggles in CS reveal that TGNC students experience an overlapping and compounding threat to their sense of belonging in CS education at the intersections of transness, race, sexuality, and disability. The intersection of expansive identity and race exposes TGNC students to racism and transphobia. TGNC students of color confront pressures to hide their authentic gender to lower the risk of encountering discrimination due to both transphobia and racism. They report feeling pressure to work harder than their cisgender white peers because they feel that being good at CS will give them visibility and validity. Asian American TGNC students are additionally confronting the model minority stereotype by which their success in CS education is attributed to a natural predisposition to STEM based on their race, devaluing their academic work and commitment. TGNC students who are not heterosexual experience a double sense of not belonging in CS education due to their gender and sexuality being outside of the cultural norms of CS. They further experience their authentic gender and sexuality invalidated and erased. TGNC students with disabilities confront barriers to accessing content in and out of CE education spaces.

Focus group participants provided recommendations for better support of TGNC students in CS education spaces by envisioning activities that they felt were more inclusive and supportive. Group *Representation* designed an activity that was specifically for TGNC students

and focused on increasing confidence and computing skills through mentorship, peer support, and culturally relevant projects. Group *AI Bias* focused on addressing the lack of curricular representation of TGNC people and expansive gender in computing, critical examination of gender and the impact of computing on gender and other marginalized identities. The group prioritized both TGNC and cisgender students in their programming.

Chapter 5: Discussion

> *I was introducing the binary number system to my high school CS class, and the students were giggling …and one student said: "I'm nonbinary." And I responded with: "Why do you need to talk about this? The binary number system is just zeroes and ones… just zeros and ones!" (A participant in a High School CS Professional Development session)*
>
> *In college, my databases professor told us in the first few weeks of class that gender could be represented as a single bit to save space in database applications. I honestly stopped listening to lecture for the rest of the class. (Study survey participant)*
>
> We argue that researchers should treat gender as fundamentally **multiplicitous**: as a concept with many meanings and relations to individuals and communities. These meanings vary depending on the type of research question, the places that work is undertaken, and the participants in those places. (Keyes, 2021)

This study contributes to the larger canon on participation disparities in computer science education, both in enhancing perspectives on overall issues of underrepresentation and by shining light on ways computer science education needs to shift to avoid oppressive practices and be intentionally inclusive for TGNC students. These findings are situated in discourse, research, and practice on participation gaps in computing for groups currently and historically marginalized along the lines of race, gender, and disability status. Beyond participation counts, there has been a growing sense in the CS education community that increasing and supporting the engagement of marginalized groups in CS is a matter of social justice and is in better alignment with the democratic ideals of this country. These democratic ideals can be seen through an increase in state policies marking CS as a key literacy through universal K—12 computer science education, with many schools now requiring computer science coursework as a high school graduation requirement.

The importance of considering the experiences of TGNC people is particularly urgent in a discipline marked by power and vast influence. Currently, technology increasingly impacts every area of our lives. It is thus imperative that the US population is knowledgeable in both how

technology is produced and its impact on our lives. Marginalized groups have been shown to be disproportionately harmed by computing technology (Benjamin, 2021; Noble, 2018). To safeguard these communities from continual negative impacts, it is important to increase their level of engagement and agency within the field of computing. Marginalized populations are consistently underrepresented in innovation and leadership roles and experience a gap in both earnings and wealth. It is well understood that CS education can offer entry into positions of innovation, leadership, and financial prosperity. This study adds to our understanding of the importance of including TGNC people to ensure that diverse and intersectional perspectives and backgrounds, particularly around gender, are embedded in the designs and employment of new technologies.

TGNC students, having a minority gender identity, are a marginalized group. In the current political climate, that aims to delegitimize and vilify this identity, they are a vulnerable population. According to the 2022 Transgender survey[28], TGNC people have high rates of negative outcomes in health and health care, education, employment, housing, physical safety, etc. They are also an underrepresented demographic in CS. They have been found to choose STEM majors and persist in them at lower rates than their cisgender counterparts (Maloy, 2022; White, 2023). Several organizations, such as the Computing Research Association's Committee on Widening Participation in Computing Research (CRA-WP[29]), The National Center for Women & Information Technology (NCWIT[30]) and Alliance for Identity-Inclusive Computing Education (AiiCE[31]), recognize on their respective websites, that TGNC students need increased

[28] https://ustranssurvey.org/
[29] https://cra.org/cra-wp/mission/
[30] https://ncwit.org/blog/why-does-broadening-participation-in-computing-matter-and-what-can-you-do-to-help/
[31] https://identityincs.org/resource/byte-sized-dei-j-pronouns/

support in computing. Notably, TGNC students are a vulnerable population and they experience similar negative outcomes in CS ed as other marginalized groups, dropping out of STEM/engineering majors at rates similar to BIPOC students and students with disabilities. Yet, TGNC students have very seldom been the subjects of studies investigating the experiences of marginalized. For example, the three above mentioned organizations list TGNC identities as those underrepresented and under supported in CS ed but offer almost no TGNC centered resources or programming.

The study presented here sought to fill the gap in the literature and increase the CS ed researchers' and practitioners' understanding of the unique challenges and harms faced by TGNC students in postsecondary CS education. To this end, the discussion will focus on the following three areas: the impact of expansive gender on experiences in CS education spaces, intersectionality, and recommendations for improvements.

Experiences of Students with Expansive Genders in CS Education

The survey findings reveal that TGNC students do not feel that they fit or belong in CS. A high percentage of respondents reported that they do not feel able to express their gender authentically, do not feel supported by faculty and staff in their departments, and do not feel comfortable in computing educational spaces. At the same time, survey results indicate that TGNC students feel positive about their CS academic abilities and retain a sense that they can be successful in CS: 85% of respondents feel that they will be able to have the same level of success in computing education and 79% feel that they will be able to achieve the same level of success in future computing-related endeavors as their cis-gender peers. The study also captured particular ways that TGNC described experiencing harm in computing spaces, including microaggressions, pronoun misuse and deadnaming, unsafe/unwelcome climates, male

dominated field, disclosure/erasure/invisibility, apoliticism, impersonality, meritocracy, BPC interventions theorize gender as binary, leaving, and worry about future employment.

While this novel survey illuminated many unique trends related to TGNC experiences in computing education, three findings were particularly alarming. First, even though the questions about confidence in CS ability and success drew the highest number of positive responses, two out of three respondents answered "yes/somewhat" that gender identity impacts their interest or willingness to pursue computing-related employment. Second, one out of five respondents reported leaving a CS education activity because their gender identity was not supported. Finally, 81% reported that there are no positive representations of their gender in their computing education spaces. Overall, the findings from the survey align with existing literature on experiences of TGNC students in STEM/engineering, demonstrating that TGNC students feel positive about their STEM/CS education abilities, retain a sense that they can be successful in STEM/CS majors, and that despite unsupportive and hostile climates, they manage to persist and persevere (Haverkamp 2019b, Kersey & Voigt, 2021).

Intersectionality

Much like underrepresentation, TGNC students are often not considered in discourse, practices, or policies around intersectionality in computing education. The interview phase of the study shed light on the experiences of TGNC students with multiple marginalized identities. The findings identified three intersectional identities with minority gender that were prevalent: race, sexuality, and disability.

This research revealed that TGNC students of color confront pressures to hide their authentic gender to lower the risk of encountering discrimination due to both transphobia and

racism. They face pressure to work harder than their cisgender white peers because they feel that being good at CS will give them visibility and validity.

TGNC students who are not heterosexual experience a double sense of not belonging in CS education due to their gender and sexuality being outside of the cultural norms of CS. They experience their authentic gender and sexuality invalidated and erased as topics outside of cisheteronormativity are deemed inappropriate for discussion. A study participant shared that a male classmate refused to accept that their reason for declining to go out on date with him was that they are not heterosexual. The person conveyed that in addition to not feeling that they are visible as a TGNC person, they were denied visibility as a sexuality minority person as well. They further stated that even the possibility of a conversation about them not being straight felt "impossible."

TGNC students with disabilities confront barriers to accessing content in and out of CS education spaces. One participant shared that they lacked support for their hearing disability in their CS classes, as well as, when they attended a prominent Computing Research conference. The student expressed frustration and upset that the disability office at their University did not connect them with an organization explicitly for LGBTQ+ students with disabilities in CS. They felt that had they been able to connect with other CS LGBTQ+ students with disabilities they would have felt more confident to ask their CS department for accommodations, instead, they suffered four years of headaches after attending classes.

In all three cases, TGNC students felt that they rarely found affirmation and support for their multiple identities, frequently having to choose which one to assert. The respondents with multiple marginalized identities reported compounded challenges, such that they…

Recommendations from study participants

This research study was intentionally designed to solicit recommendations from the participants in the TGNC community being researched. Thus, the third phase of the study, a focus group, asked participants to envision and design CS education activities that they felt were more inclusive and supportive TGNC students. The participants were placed into two subgroups. One subgroup designed an activity that was specifically for TGNC students, focused on increasing confidence and computing skills through mentorship, culturally relevant projects, and the support of a community of peers. The other subgroup, focused on addressing the lack of curricular representation of TGNC people and expansive gender in computing, critical examination of gender and the impact of computing on gender and other marginalized identities. Their activities were designed to engage with both TGNC and cisgender high school-age students.

Overall, the participants involved in this part of the study collectively identified the following core challenges for TGNC students in postsecondary CS: misgendering, deadnaming, misogyny, isolation, lack of acknowledgement and discussion of more than binary gender, lack of awareness of TGNC people's needs, lack of mentorship and community.

TransForming CS Education

Based on the study's findings, I propose a new paradigm, TransForm CS, a set of pillars to guide the inclusion of TGNC students in CS education. The goal of this paradigm is to TransForm each of the following core pillars: curriculum, pedagogy, policy, and the design/implementation of CS education research. The implications for each will be discussed next.

Implications for TransForming Curriculum and Content

Study participants, and existing research on LGBTQI+ in STEM/engineering, note that many challenges faced by TGNC students stem from the framing of gender as binary in curricular content. Additionally, as pointed out by respondents in this study, there is very little to no representation of TGNC people in CS education spaces. Curriculum designers/providers should attend to the following:

- Acknowledge and include discussion of more than binary gender[32]
- Include representations of TGNC computer scientists: historical figures as well as contemporary ones
- Include topics and concerns significant to TGNC people:
    - Application design that accounts for more than binary categories
    - Algorithmic bias (models trained on binary gender)
    - Ethical considerations of face/voice recognition and body scanning software
    - Acknowledge and link to existing research that does this (algorithmic justice league)

Implications for TransForming Pedagogy and Practice

Study participants shared that many of the faculty and teacher assistants they interacted with did not have much knowledge about TGNC identity or the sociocultural/historical context of TGNC people. In light of this finding, CS educators should:

[32] https://dceg.cancer.gov/about/diversity-inclusion/inclusivity-minute/2022/beyond-gender-binary#:~:text=The%20gender%20binary%20describes%20the,%2C%20non%2Dbinary%20or%20agender.
https://www.britannica.com/list/6-cultures-that-recognize-more-than-two-genders
https://www.scientificamerican.com/article/sex-redefined-the-idea-of-2-sexes-is-overly-simplistic1/

- Seek out and adopt curricula that includes discussion/representation of more than binary gender.
- Set up inclusive classroom culture that acknowledges and supports more than binary gender. Link to existing online resources to support this…
- Seek out professional development opportunities and educate oneself about TGNC history, challenges, and needs

Implications for TransForming Policy

Many of the study respondents noted that they did not feel supported by their CS departments. CS department administrators should include work to build institutional and structural supports of TGNC students in departmental policy. Such policy should include the following:

- An acknowledgement that there is gender beyond binary categories
- Include categories of beyond binary gender in department climate surveys
- An acknowledgment that students with beyond binary gender need affirmation and support
- Require professional development that informs about expansive gender for all faculty and teaching assistants.

Implications for TransForming CS Education Research

At the 2021 RESPECT conference, Meiner and colleagues presented a paper which makes a compelling case for the need to broaden gender in CS education research. Three years later, even though the words transgender and nonbinary are beginning to appear more frequently in CS education studies and in BPC initiatives, to date most research and initiative evaluation reporting continues to reduce gender to male/female categories. It is impossible to know how

expansive gender impacts students' experiences in CS education if TGNC students are not accounted for in demographic measurements. Additionally, the erasure of TGNC students in demographic measurements further contributes to and affirms their erasure in Computer Science education writ large. CS education researchers should:

- Count TGNC students as recognized/measured as a marginalized group.
- NSF, a major funder of CS education research, does not require reporting of gender outside of binary: point to examples.

Study Limitations

As mentioned previously, there is a dearth of research that examines the experience of TGNC students in CS education. Thus, a core limitation of this study was simply the absence of existing research to inform the design and implementation of this work. The recruitment for this study cast a wide net, reaching out to the bulk of ABET accredited CS departments. Supplemental recruitment used the snowball method and relied on my social and professional network, not necessarily yielding a representative sample. Overall, the study participants did represent a diverse population: undergraduate and graduate, both national and international, a diversity of expansive gender, a diversity of race, ethnicity, and disability status. However, the study had a small number of BIPOC, and, especially Indigenous, respondents, representing a limitation of this study.

Of note, the study primarily attracted responses from students who are actively involved in postsecondary CS education. Responses and experiences of those who left CS education are missing from the study. This information is necessary to have a fuller understanding of the experiences of TGNC people in postsecondary CS education. Additionally, the focus group likely drew the participation of students who are very invested in being a part of computing.

Again, missing are the voices of those students who are less engaged and who likely have a lot to add to our understanding of what TGNC students want/need to feel that they belong and are empowered in the field of computing.

Future Research Directions

There are a few studies that take up integrating more than binary gender within STEM and queering STEM subjects (Haverkamp et al., 2021a; Menier et al., 2021; Paré, 2021). These efforts focus on expanding STEM curricula and pedagogy to acknowledge and discuss gender beyond binary categories (Alexander et al., 2021; Bakka et al., 2021 Traxler et al., 2016). Future research should continue to focus on the following:

- Incorporate trans theory in CS ed research design
    - To inform how gender is operationalized
    - To include TGNC identity when looking at intersectionality
- Center TGNC student agency/activism when designing interventions to enact change in CS education. TGNC students have been shown in research to be more committed to political activism, social justice. They are more involved on politics and social justice organizations than their cisgender peers. This asset ought to be harnessed and channeled to improve the living conditions for TGNC students in CS education and to expand our understanding of gender which has the potential to improve the livability of gender for all!

Conclusion

Based in historic facts and evidenced by research, TGNC people participate in both CS and CS education. Lynn Conway, Danielle Bunten Berry, Edith Windsor, Sophie Wilson, all four

TGNC people, made great contributions[33] to the field of computing. More recently, Angelica Ross, Anna Anthropy, and Christine Love, have continued this legacy, all adding innovations to the field. However, they have been and continue to be a mostly invisible demographic. The erasure of TGNC people in computing education occurs at all levels: departmental policy and practices, curriculum, pedagogy, as well as research and research based interventions. This results in not having a strong sense of belonging. This study, building on prior results, demonstrates that TGNC people enjoy the field of computing, feel confident about their skills and abilities, however they worry about their future in CS and do leave at higher rates than their counterparts. The findings urge the need for a new paradigm in CS, a set of pillars to guide the transformation of curriculum, pedagogy, policy, and research design/implementation. This paradigm is grounded in centering trans theory and the agency/voices of TGNC people in the efforts to create CS education spaces where TGNC and other marginalized students are included and belong.

[33] https://reference.thecodingspace.com/blog/2022-03-01-six-trans-programmers-who-shattered-the-lavender-ceiling/#:~:text=Lynne%20Conway%20is%20an%20American,and%20fabrication%20of%20complex%20microchips.

APPENDICES

APPENDIX A. QUALTRICS SURVEY

Belonging instrument

Please answer on a scale of 1 to 4: 1 = “Strongly Disagree,” 2 = "Disagree," 3 = "Agree," 4 = “Strongly Agree”

	1 2 3 4
I feel able to authentically express my gender in computing education spaces ()	
Teachers and education staff in computing are supportive of my gender identity ()	
There are positive representations of my gender identity in computing education activities, such as in text books, lectures, assignment and project topics, etc. ()	
I feel comfortable participating in the same computing education activities as my cis-gender peers ()	
I feel comfortable participating in the same computing-related activities outside of class as my cis-gender peers ()	
I feel comfortable socializing with cis-gender peers in my computing education activities outside of class ()	
I feel like I "fit in" with other computing education peers/students ()	
While participating in computing education activities, I feel that I will be able to have the same level of success as my cis-gender peers. ()	
While participating in computing education activities, I feel that I will be able to achieve the same level of success in future computing-related endeavors as my cis-gender peers. ()	

Open text questions

Q3.6 Do you believe that your gender identity has impacted your computing educational experiences?

- ○ Yes (1)
- ○ I'm not sure (2)
- ○ No (3)
- ○ If you would like, please provide details/examples (4)

_____

Q3.7 Has your gender identity ever caused you to doubt your belonging in computing education spaces?

- ○ Frequently (1)
- ○ Moderately (2)
- ○ Seldomly (3)
- ○ Never (4)
- ○ If you would like, please provide details/examples (5)

_____

Q3.8 Have you ever left a computing education activity because your gender identity was not supported?

- ○ Yes (1)
- ○ No (2)

Q3.9 Do you believe that your gender identity impacts your interest/willingness to pursue computing-related employment?

- ○ Yes (1)
- ○ I'm not sure (2)
- ○ No (3)
- ○ If you would like, please provide details/examples (4) _____

Q4.1 **About your computing employment (example: software development, tech support, networks or system administration, web development, etc.)**

Q4.2 Did you or do you work in computing?

- ○ Yes (1)
- ○ No (2)
- ○ Other (3) _____

APPENDIX B. INTERVIEW PROTOCOL

The following are questions about your childhood:

- Where were you born/raised?
- During your childhood, did you have access to computing/technology?
- Were you interested in computing/technology as a child? If yes, can you recall any specific incidents related to your interest in computing/technology?
- Do you remember any specific/impactful encounters with computing/technology, positive, negative, or neutral?
- What were your experiences with regard to gender as a child? Can you recall specific incidents relating to gender?
- If you had experiences with computing/technology, did these also include an experience of gender?
- Describe any experience from your childhood when gender might have had an impact on how you engaged with computing/technology.
- Do you recall having thoughts about what kind of person might be a computer scientist? Were you aware of any stereotypes about who does computing?

The following are questions regarding your experience in computing:

- When and how did you become interested in computing, Computer Science?
- If you had experiences in computing education, can you tell me about these?
- If you didn't have computing education experience, why might that be? Why didn't you pursue computing education?
- Do you recall any people who inspired you or pulled you into computing? Can you tell me more about these experiences?
- Did you have any mentors during your schooling/employment? Did you have any mentors specifically in Computer Science? Who were they and what was that like?

These are questions about your gender transition journey. What I mean by the *gender transition journey* is the events and processes by which a person moves increasingly closer to living as their authentic self with respect to gender:

- How did you come to identify as a transgender/gender nonconforming person?
- If you are comfortable, tell me about your gender journey…
- In what ways did your gender impact you pursuing or not pursuing computing education?
- How have your gender journey and your gender identity impacted your computing career? How does your gender identity impact your day-to-day work experiences?

These questions are about Intersectionality

- How do other facets of your identity, such as race, class, ability, sexuality, etc. impact/impacted your computing education/career?
- In what ways do other aspects of your identity interact with or are in tension/conflict with your gender? How does this impact your career and your day-to-day work experiences?

These questions are about recommendations for improving CS Ed for TGNC people

- During your time in computing education/career, have you been aware of efforts to engage more women or any other previously excluded people from computing? Can you give an example of any such effort that you are aware of or were engaged in? What was your experience of this? What are your thoughts/feelings about such efforts?
- Gender diverse people are underrepresented in CS fields and CS educational programs. What changes do you think would result in more gender expansive students completing CS programs in school?

Would you like to add anything to your answers? Any thoughts related to gender and computing that came up while we were chatting? Are there any questions that you think I should have asked but didn't?

Do you have any questions for me?

APPENDIX C. FOCUS GROUP PROTOCOL

Focus group: small group activity setup

Activity set up and directions
- You will be randomly placed in a breakout group (3-4 participants)
- Each group has their own slide deck on which to create their poster
- Each group has their own Google doc on which to take notes, brainstorm
- Also, write recommendations that your group identified for supporting TGNC students in your activity
- You will have about 50 minutes for the activity
- Each group will share their poster and recommendations with the large group

Focus group: small group activity prompt

- Pretend that you are part of a team that is designing an educational intervention to increase participation in computing
  - This can be a camp, after school club, in-school class
  - The activity can be single-gender (i.e. for girl-identitfied and include trans/non-binary students) or mixed-gender
  - Your group will create a sketch of a poster for this activity
    - Include description of the activity
    - Who are intended participants
    - What are the goals of this activity
- On the Google doc, keep notes of anything noteworthy as you are designing this activity

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