Leveraging Networks: Nonbinary STEM graduate students and the power of identity-specific social capital

Mx. Cole Thompson, Purdue University at West Lafayette (COE)

Cole received their bachelor's degree in chemical engineering from The Ohio State University in 2021. They then worked in industry as a process engineer for one year before deciding to return to school to pursue graduate degrees. Cole is currently a PhD student in the School of Engineering Education and a master's student in the environmental and ecological engineering department at Purdue University. Their research interests include assessing the education experiences of nonbinary students and the alignment of nonbinary and engineering identity development.

Mx. Adrian Nat Gentry, Purdue University at West Lafayette (COE)

Adrian Nat Gentry is a Ph.D. candidate at Purdue University in Engineering Education. They completed their undergraduate degree in May 2020 and master's degree in December 2024 in Materials engineering from Purdue University. Adrian's research interests include assessing student supports in cooperative education programs and the social capital of nonbinary scientists. Adrian is involved with Purdue's Engineering Education Graduate Association and the oSTEM chapter at Purdue.

Dr. Kerrie A Douglas, Purdue University at West Lafayette (PWL) (COE)

Dr. Douglas is an Associate Professor in the Purdue School of Engineering Education. Her research is focused on improving methods of assessment in engineering learning environments and supporting engineering students.

Dr. Julie P Martin, University of Georgia

Julie P. Martin is the Director of the Engineering Education Transformations Institute at University of Georgia. Julie is a Fellow of ASEE, a member of ASEE's Hall of Fame. She is the editor-in-chief of Journal of Women and Minorities in Science and Engineering, where her mission to change the culture of academic publishing to one of constructive review.

Fio Bahr, Purdue University at West Lafayette (COE)

Introduction & Lit Rev

This critical theory paper promotes the understanding of nonbinary student experiences in science, technology, engineering, and math (STEM) and how they gain support to persist in STEM. Promoting inclusion of transgender, nonbinary and gender non-conforming (TNBGNC) students has been recognized by the National Academies of Science, Engineering, and Medicine (NASEM) as a growing area of change for the field of engineering (NASEM, 2018). In the 2022 cycle of the Common App, Jaschik reports that over 26,000 potential students (2.2%) of the 1.2 million applicants identified as TNBGNC and over 36,000 potential students (3%) identified as using they/them pronouns (Jaschik, 2023). These statistics are further mounting evidence that nonbinary students are a growing segment of higher education, with other reports finding that there are over 928,000 nonbinary individuals under the age of 30 in the United States (Wilson & Meyer, 2021) and 1.4% of the United States population between the ages of 13-17 identify as transgender, which is three times higher than those 18 and older (0.5%; Herman et al., 2022). With a rising number of TNBGNC students entering college, there is an increasing need for educators, administrators and staff in engineering and STEM education to understand the needs of, create inclusive spaces for, and support the professional formation of nonbinary students entering STEM fields.

Extant research focuses on nonbinary STEM undergraduate students' navigation of professional and academic spaces that lack recognition for their gender identities (Campbell-Montalvo et al., 2023; Gentry et al., 2024; Maloy et al., 2022). STEM students and faculty have shared that others have expected them to separate their racial, LGBTQ, and nonbinary identities from their purely technical identity, a perspective that reinforces the socio-technical divide in engineering and STEM more broadly (Kaufman-Ortiz & Rodriguez-Simmonds, 2022). This intolerance can manifest in a reductive understanding of gender and the erasure of nonbinary identities within STEM environments (Johnson et al., 2009; Stuhlsatz et al., 2020). Additionally, these spaces can lead to feelings of tokenization and added minority stress (Chow, 2024; Suárez et al., 2022; Williams et al., 2020). Understanding the lived experiences of nonbinary STEM graduate students and the challenges they must overcome is essential for developing best practices to support their academic and professional success.

Professional development and emotional support are key to the inclusion of STEM graduate students, yet relationships that support nonbinary STEM graduate students are incredibly nuanced and ill-understood. Research on TNBGNC and nonbinary inclusion in STEM has largely focused on addressing the experiences undergraduate students (Campbell-Montalvo et al., 2023; Gentry et al., 2024; Haverkamp, 2019). However, the needs of graduate students are distinctly different from undergraduates, as graduate education involves unique challenges in mentorship dynamics, professional development, and research expectations (Perkins et al., 2020; Wilkins-Yel et al., 2022). Research has shown how shared gender identities between mentors and mentees increases in both professional development and emotional supports the mentee receives (Blake-Beard et al., 2011; Li et al., 2018). However, for nonbinary graduate students, the lack of mentors who share their gender identity can create significant barriers to accessing these benefits. This lack of mentors stems from the underrepresentation of nonbinary individuals

in STEM fields, compounded by the fact that fewer older nonbinary individuals are present in academia and even fewer occupy positions of power or influence (Rosenberg & Tilley, 2021). As a result, nonbinary graduate students often face challenges in finding role models or mentors who can fully understand and affirm their experiences. Thus, it is important for us to understand the ways by which nonbinary STEM graduate students navigate their academic environments and access the supports they need to succeed in their studies.

The purpose of this study is to explore the experiences of nonbinary graduate students in STEM, focusing on the unique support systems they utilize within their academic and professional careers. The value of this research lies in its potential to inform increasingly effective methods for providing access to professional and emotional support and fostering inclusive research environments for nonbinary students, ultimately contributing to their success in STEM fields.

Project Background

Larger Study

In summer of 2022, a team of six nonbinary graduate students and early career faculty, with the support of two engineering education faculty, conducted a qualitative study on nonbinary STEM individuals' social capital. Participants were recruited from a variety of online STEM communities such as LGBTQ+ focused social media websites (e.g., Ace in Stem Discord, 500+ Queer Scientists Twitter's page and Pride in STEM Twitter's page), small and large professional LGBTQ+ STEM societies (e.g., International Society of Nonbinary Scientists Twitter and Slack, oSTEM global Discord, Trans and Gender Nonconforming Fieldwork Alliance) and email communities (e.g., Virtual Community of Practice email listserv through the American Society of Engineering Education). The research team found a large portion of participants were recruited through snowball sampling, specifically snowball recruiting from local oSTEM organizations at institutions across the U.S.

The research team collected participant interest and demographic information through an interest survey that asked participants to self-identify their gender, race/ethnicity, geographic location, work setting, current employment and career stage. They specified their work setting as (1) academia or education, (2) nonprofit, (3) industry, (4) government or military, (5) none of the above or (6) fill in the blank other. The team collected in-depth information on participants' work and employment as they wanted to have a representative sample across academia, since many of our recruitment settings were academia focused. In total, the study had 125 participants indicating interest in the project, ranging from undergraduates to mid-career industry and faculty individuals.

The study utilized Lin's social network theory of social capital (2002) as a guiding framework for developing the interview protocol and analyzing the data. The interview protocol used a social capital name generator—that is, a method of prompting participants to think of a person who supports them and then share information about their relationship and the supports—to explore nonbinary graduate students' social networks and their access to various types of emotional and professional supports. This method has been well established as a strong method for exploring the resources embedded in ones' strong ties (Lin, 1999; Martin et al., 2013).

Understanding that support comes from a variety of settings, the research team used a name generator to prompt the participants to share their experiences with individuals who support them in three settings: (1) workplace or academic institution, (2) local affinity groups (i.e., local identity or community-based organizations), and (3) online communities. By conducting the interviews using a semi-structured name generator, the team elicited rich descriptions of their participants' social networks and the supports they access, mobilize or wish to receive in addition to their experiences being nonbinary in their academic workplace.

The team selected 40 participants through purposeful sampling based on the demographics we collected. We purposely over-sampled nonbinary individuals that: (1) identified their race or ethnicity as Black/African American, East Asian, South Asian and South American; (2) identified their careers as outside of academia (e.g., industry, nonprofit, government); and (3) identified their career stage as mid-level career or above (e.g., Post Doctoral researchers and faculty). Consequently, out of the 40 participants interviewed, 14 participants identified their career stage as graduate students.

Current Study

The present study focuses on six of the 14 graduate student interviews. Specifically, we focus on the supports graduate students access in their academic workplace—as the supports accessed in these settings are most relevant to engineering education researchers, faculty and administrators. We ask the following research question (RQ 1), *how do nonbinary STEM graduate students receive supports from cisgender and transgender alters that witness and mirror them as nonbinary?*

Frameworks

We utilize Gentry et al.'s (2024) nonbinary social supports conceptual framework and Dolan and Garvey's (2024) nonbinary identity development model to guide our study. As nonbinary researchers, we found it crucial to model the use of asset-based frameworks specific to our nonbinary population.

Nonbinary Social Supports Conceptual Framework

We utilize Gentry et al.'s (2024) nonbinary social supports conceptual framework to explore the unique, queer-centered social networks of our nonbinary STEM participants. This framework was developed by Gentry and colleagues to explore how nonbinary engineering students receive gender-specific support from individuals with various gender identities in their network (see Figure 1). In their framework, Gentry and colleagues operationalize kinship networks using Lin's network theory of social capital (2002) and Devor's transgender identity development framework (2004). By using both frameworks, we are able to identify and communicate the subtle identity-specific supports that nonbinary individuals use to promote their wellbeing and persistence.
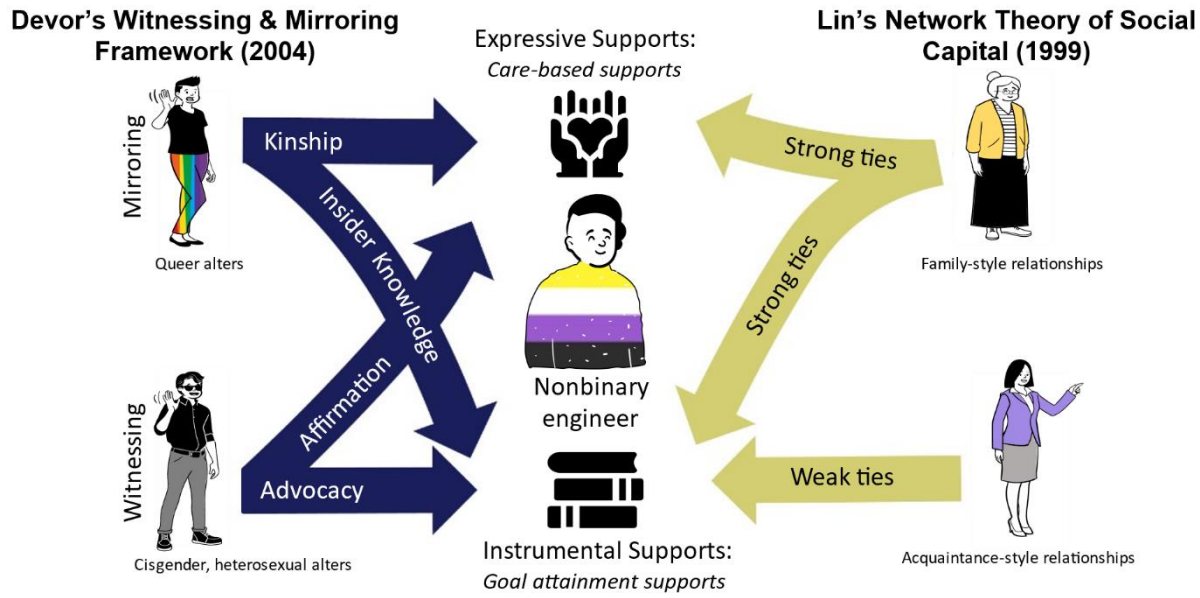
Lin's network theory of social capital (2001) defines social capital as the resources and support embedded in one's social relationship. The ego, in our case the nonbinary student, receives support from the alters, the individuals in their social network who support them. Lin (2001)

posits that support from one's social network is received in the form of either expressive supports (caring, emotional, supports focused on wellbeing), or instrumental (goal-attainment) supports. Expressive support is primarily provided by strong ties, or those with close and well-established relationships with the ego (in our case the nonbinary STEM graduate student). In contrast, instrumental support is provided by both strong ties and weak ties, connections which are more distant and infrequent (Granovetter, 1973).

In Devor's transgender identity development framework (2004), he describes an overarching framework of witnessing and mirroring—which we use to interpret Lin's framework for a transgender and nonbinary population. Devor defines two types of personnel, those who witness (cisgender alters) and those who mirror (transgender alters). In our study, witnesses are defined as someone who does not share the ego's nonbinary and thus can provide objective affirmations of the nonbinary ego's identity (witnessing supports). Gentry et al. define witnessing instrumental supports for nonbinary individuals as advocating supports (e.g., correcting others who incorrectly gender the student) and expressive supports as affirming supports (e.g., asking students how they would like to be referred to). Mirroring comes from those with similar identities to the ego (other nonbinary individuals) and can affirm the nonbinary ego as "in the community." Mirroring supports can be insider knowledge such as sharing what to wear to conferences as a nonbinary graduate student (instrumental supports) or kinship supports such as sharing experiences of being nonbinary in STEM (expressive supports). Witnessing (affirmation and advocacy) and mirroring supports (kinship and insider knowledge) only include supports that acknowledge the ego's nonbinary identity. When students receive expressive and instrumental supports that are not related to their nonbinary identity (e.g., providing a networking opportunity for all graduate students in a lab), we refer to them as simply "expressive" or "instrumental" supports.

Figure 1

Nonbinary Social Supports conceptual framework describing the supports available in the complex social networks of nonbinary engineering students. Adapted from Gentry et al. (2024).

Devor's Witnessing & Mirroring Framework (2004)

Mirroring — Queer alters

Witnessing — Cisgender, heterosexual alters

Kinship

Insider Knowledge

Affirmation

Advocacy

Expressive Supports: *Care-based supports*

Nonbinary engineer

Instrumental Supports: *Goal attainment supports*

Lin's Network Theory of Social Capital (1999)

Strong ties — Family-style relationships

Strong ties

Weak ties — Acquaintance-style relationships

Nonbinary Identity Development Model

We also utilize Dolan and Garvey's (2024) nonbinary identity development model to explore how nonbinary STEM graduate students navigate their identity development in STEM settings. In this emergent model developed using queer theory, queer of color critique, intersectional and student development theories, Dolan and Garvey outline six key concepts related to nonbinary identity development: kinship networks, navigating disclosure, embracing fluidity and ambiguity, witnessing and mirroring, worldmaking, and exploring transition.

As we began to analyze the six graduate student interviews, our team found that participants often shared complicated and nuanced experiences relating to their identity development that was not clearly modeled by Gentry et al.'s nonbinary social supports conceptual framework. Specifically, participants shared crucial experiences with alters in their social network and their STEM professional and academic environments related to how they developed their identity as nonbinary scientists. Thus, we pursued additive analysis using Dolan and Garvey's (2024) nonbinary identity development model; we added the following research question (RQ 2), *how do nonbinary STEM graduate students describe their nonbinary identity development in their social networks and STEM environments?*

We selected two aspects of nonbinary identity development that most aligned with the experiences our participants shared: embracing fluidity and ambiguity and worldmaking. Dolan and Garvey define embracing fluidity and ambiguity in two ways: fluidity and ambiguity in gender identity and expression, and fluidity beyond gender (i.e., politics and professionalism outside of the binary "good/bad" or "masc/fem"). First, nonbinary individuals may embrace the fluidity and ambiguity that comes with identifying somewhere between (e.g., nonbinary) the man to woman binary or outside of the rigid masculine and feminine binary spectrum altogether (e.g., those who do not identify with a gender on that spectrum—agender, nullgender, genderqueer). This outside-the-binary expression can extend to one's beliefs towards anything strictly binary or without nuance, for example, traditional beliefs that professionalism and professional dress are

strictly coded as masculine (e.g., expected to wear button ups, polos and suits and to have leadership skills) and feminine (e.g., expected to wear dresses and blouses and perform secretarial skills; Arthur & Guy, 2020; Faulkner, 2009). Unsurprisingly, those who identify as neither man nor woman also embrace the ambiguity and nuance in a complex, compulsory cisheternormative world.

Worldmaking is defined as nonbinary individuals' radical dreaming of a utopian, joyful, violence-free world; one that nonbinary individuals "have led movements to hope for, imagine and create new worlds and spaces for safety, joy and liberation" (Dolan & Garvey, 2024, p. 178). Practically speaking, this can be found when nonbinary students, especially those with other intersectional, marginalized identities, work together to create organizations or communities that center queer joy, anti-racism, and community driven dreaming of a better future.

Methods

Positionality

Our research team recognizes that our identities and experiences shape how we approach, interpret, and conduct research on the lived experiences of nonbinary scientists pursuing graduate degrees in STEM. The Mx. Thompson and Mx. Gentry are nonbinary PhD students in engineering education at a large Midwestern research-intensive (R1) university. One of the PhD students (Mx. Gentry) is a member of the research team who collected the data. Their personal experiences navigating graduate education as nonbinary individuals inform their understanding of the challenges faced by nonbinary STEM graduate students. These experiences provide a lens of lived expertise that allows them to engage with the complexities of dialogue with our nonbinary participants. The Dr. Douglas and Dr. Martin are tenured faculty members at R1 universities and served as advisors to the early career researchers on this project. Both Dr. Martin and Dr. Douglas are committed to fostering a diverse and equitable engineering field and aim to support research that amplifies the voices and experiences of underrepresented groups, demonstrated in their advising of the nonbinary research team who collected the 40 interviews. While not a member of the nonbinary community, their allyship and dedication to equitable practices help to contextualize this work within broader efforts to create inclusive academic environments. The Mr. Fio Bahr is a transgender undergraduate student pursuing a degree in civil engineering at a large, public R1 university in the Midwest. His lived experiences as a transgender engineering undergraduate help him understand the nuances of navigating trans and queer identity in STEM spaces, and provide a unique outside perspective on graduate students. Together, our collective positionalities contribute to a nuanced understanding of the issues at hand while also highlighting the need for intentional reflexivity to ensure our research remains rigorous, inclusive, and impactful.

Current Study Participants

For this study, we selected six of the 14 graduate student participants to analyze. We focused this study on graduate students as much of the current dialogue around LGBTQ+ STEM students focuses on the experiences of undergraduate students rather than graduate students who are more likely to have more robust social networks. We purposefully selected participants that were (1)

interviewed by Mx. Gentry and (2) equally representative of the geographic United States (i.e., two participants from each location: the south, the west coast and the Midwest). Participant demographic information is in Table 1.

Our six participants have complex, intersectional identities that were salient in our interviews. A majority of the participants identified their race as white, gender as nonbinary and pronouns as they/them/theirs. Many participants shared salient ethnicities, such as Latino (one participant) and Jewish (two participants). Some participants identified as identities within the nonbinary spectrum (e.g., agender, genderqueer, nullgender) and outside of the nonbinary umbrella (e.g., trans and transmasc). It is common for LGBTQ+ individuals to identify as multiple identities and potentially use multiple pronouns that represent their full range of gender identities. For example, Z identifies as genderqueer and uses both they/them/theirs and it/its as pronouns while Sky identifies as nonbinary and uses they/them/theirs and she/her/hers. While we did not collect information about ability/disability, a majority of our participants shared in the interviews that their disability or neurodivergent identity was influential on their STEM identity. Our participants identify as disabled (one participant) or neurodivergent (one participant identified as autistic, one participant identified as having ADHD and two participants identified as neurodivergent more broadly).

Table 1

Participant free response demographics from interest survey

Pseudonym	Pronouns	Gender	Ethnicity	Geographic Location	Degree
Z	They/It	Gender-queer	White/Jewish	Midwest	Climate and space sciences and engineering/ past engineer
Jules	They/ Them	Nonbinary/ Transmasc	Taiwanese/ Chinese and Ukrainian	Midwest	Microbiology
Sky	They/She	Nonbinary	White	South	Aquatic ecologist
Gili	They/ Them	Nonbinary	White	South	Bio-informations
Luz	They/ Them	Nonbinary, Trans	Biracial Latino and White	West Coast	Neuroscience
Cedar	They/ Them	Agender, Nonbinary, Nullgender	White, Ashkenazi Jewish	West Coast	Physics/ Astronomy

Data analysis

During our interviews, we were deliberate in encouraging participants to share about their intersectional identity as a nonbinary person and scientist. To prompt the participant to think of alters who support their intersectional nonbinary-scientist identity, we asked that participants "think of a person at your workplace or academic institution who has supported you as a nonbinary scientist" and then to describe their relationship with the alter, their "relationship to them." We then focused on the critical incidents when they were supported by their alters, asking "can you tell me about a specific time when they supported you?" and "what knowledge, opportunities and/or materials have you gotten through this person?" This section elicits the non-identity based expressive and instrumental supports (i.e., career attainment and emotional support unrelated to one's nonbinary identity) and identity-based supports from witnesses and mirrors (i.e., affirmation, advocacy, kinship, and insider knowledge), and demonstrates how nonbinary graduate students navigate worldmaking and fluidity and ambiguity in their workplace relationships. We followed each specific incident by asking how that support influenced their wellbeing and persistence in their career. We utilized follow up questions as needed, such as "what about someone from a previous workplace or academic institution?" to help a participant think of an alter or "when was a specific time when their support helped you persist?" to elicit more information. We concluded each setting by asking what supports they wish they had received and what the potential impact of that support would be on their persistence and wellbeing, "what support are you not getting from people in your workplace that could impact your happiness and desire to stay in your career?" This question allowed participants to share supports currently not available or not previously mentioned.

Once all interviews were transcribed and anonymized, six interviews were analyzed iteratively following Saldaña's (2013) approach to first and second cycle coding. Saldaña defines first cycle coding as encompassing a large variety of coding methods (e.g., process, in vivo, concept, and descriptive coding) where each serves a specific purpose and multiple can be utilized to segment data into meaningful subsections (2013). The purpose of second cycle coding is to group these subsections into larger, overarching themes which prevail across multiple interviews.

In our first coding cycle, we utilized a combination of descriptive, process and in vivo coding to capture the lived experiences of our nonbinary participants through our theoretical framework. Descriptions of these forms of first cycle coding as well as example excerpts are shown in table 2. To support the rigor of the study, Mx. Gentry and Mx. Thompson coded the first interview simultaneously and compared coding schemes to ensure alignment with our theoretical framework. First cycle coding was an iterative process. As we established codes for common themes across interviews, the research team reviewed previous interviews to ensure that code definitions remained consistent and were retroactively applied when added to the coding scheme.

Table 2

First cycle coding scheme

Code Type	Definition	Example	Code

Process	Words that connote action in the qualitative data	"Definitely a lot of support in terms of getting up to speed on ... different modeling programs and understanding how to write abstracts for conferences"	Developing professionally (Instrumental social capital)
Descriptive	Word or phrase that describes the topic of a passage	"My lab is supportive in the sense of generally making sure that they gender me correctly with pronouns"	Gender affirmation
In vivo	Word or phrase of the *actual language* in the qualitative data	"There's also gendered aspects of professionalism or whatever, and I hate professionalism"	Professionalism

Note. Definitions are interpretations of the Saldaña et al. (2013) coding manuals definitions of these coding processes.

Our second coding cycle involved grouping the smaller, first cycle, codes into larger overarching themes of our theoretical framework utilizing focused coding. Through focused coding we grouped smaller codes (e.g., professionalism and gender expression) into larger, overarching codes that align with our theoretical framework (e.g., embracing fluidity and ambiguity). Second cycle coding, in conjunction with memos throughout the data analysis process and collaborative coding efforts within our research team served to shape a narrative of nonbinary graduate students' experiences in their STEM studies. We describe each theme aspect from the framework as defined by the source authors and its translation to our a priori codes in Table 3.

Table 3

Definitions of key themes that guide data analysis and interpretation.

Key aspect	Definition from source	A priori codes
Embracing Fluidity and Ambiguity	Exploring and valuing identity, beliefs and ideologies outside of a rigid binary framing (Dolan & Garvey, 2024)	Embracing fluidity/ ambiguity in identity
Worldmaking	Community driven dreaming/creation of a safe, joyful, liberated world (Dolan & Garvey, 2024)	Worldmaking

Social Capital	Social networks of cisgender, transgender and nonbinary alters providing gender-related identity supports and non-gender identity specific supports (Lin, 2001; Gentry et al., 2024). By combining Lin's social network framework with Devor's (2004) framework, Gentry et al. identified how cisgender and transgender and/or nonbinary alters provide supports that witness and mirror (see Figure 1).	Alter's gender Non-identity related support *Expressive supports* *Instrumental supports* Identity related support *Affirmation supports* *Kinship supports* *Advocating supports* *Insider knowledge*
Witnessing and Mirroring	Actions that affirm without sharing an identity (from cisgender witnesses) or that affirm while sharing an identity (from LGBTQ and TNBGNC mirrors; Gentry et al. 2024)	Witnessing from cisgender, heterosexual alters Mirroring from transgender and/or nonbinary alters

Quality

To ensure quality during data collection, the nonbinary researcher team carefully honed the interview protocol and team's interview skills. Before data collection, the researcher team underwent multiple qualitative training sessions to ensure researchers new to interview data collection had training and informal and formal practice. The team also performed two rounds of pilot interviews (with feedback from participants and more experienced qualitative researchers) on the alignment between the interview protocol and participant responses. Additionally, the team received guidance and feedback on the interview protocol from an expert on qualitative research and social capital. During this feedback period, the team revised the protocol to (1) better align the interview questions to the theoretical framework and research questions, (2) exclude social capital jargon and (3) foster a more comfortable interview experience for participants by sharing the story of the project in the introduction. During the interviews, researchers new to interviewing conducted their interview with a more experienced researcher, who provided feedback after the session. Since each team member shares some identities with each of the participants (at the very least, all nonbinary and STEM/STEM education graduate students), there was great care in having genuine dialogue with the participants about their social networks and experiences in their workplace.

To ensure quality in our data analysis process, we adhered to many of the traditional engineering education quality standards. We iteratively revised our coding scheme and reviewed previously coded material to ensure that the interpretations of codes and interview data remained consistent throughout the analysis process. In addition, we speak to how our research stands when compared to existing literature on nonbinary and cisgender STEM student experiences. Positioning our research within the larger conversations of STEM students' experiences with identity in their discipline supports the commonality of our findings and shows how our work

contributes to understanding the experiences of nonbinary STEM students. Finally, we ensured the rigor of our findings and recommendations by ensuring they are both explanatory of the lived experiences of nonbinary STEM graduate students and our recommendations are actionable and applicable to improving the support they receive in pursuit of their studies.

Results

Nonbinary Identity Supports Framework

Interviews revealed how nonbinary STEM graduate students utilized their social networks (consisting of TNBGNC, cis and nonbinary alters) to obtain identity-based expressive support in the form of validating their gender identity and encouraging them to persist in their graduate studies, as well as instrumental support in the form of advice on navigating STEM environments, writing articles, and preparing for conferences. The nature of support that they received was distinctly different from cisgender alters (faculty and peers) and nonbinary alters (peers). In the following paragraphs, we depict how participants described receiving identity-based support (i.e., affirmation, advocacy, insider knowledge, and kinship) from cisgender and TNBGNC alters.

Affirmation and Kinship Supports

Participants described receiving identity-based expressive support that varied based on the alter's gender identity. In our interviews, we saw that cisgender peers (witnesses) typically provided affirmation by using the participant's correct pronouns and normalizing their nonbinary identity. One participant, Sky, described their lab mate's willingness to use their preferred name and pronouns and recognize them as nonbinary: "As I've started using they/them pronouns, he easily switched to using those. Didn't bat an eye at it. When I started using [Sky] as a nickname, he was like "Okay, we'll use that". Sky emphasized the importance of their interactions, saying their lab mate's actions had been "helpful and affirming" and that it was "nice to know that [they are] not going to get friction from people [they] have to see every day." When prompted to expand on the significance of having cisgender peers witness them and validate their identity, Sky explained that "it's really important because if your workplace is stressful or harsh or toxic, then you're not going to come in and you're not doing to do your best work ... and not having to deal with stuff like that is really great." Because Sky received affirmation through gender validation, they were able to pursue their degree in the absence of a toxic laboratory work environment. Gili shared a similar example of support from a cisgender graduate student peer, explaining that they would "check in when people [were] dismissive or disrespectful about [their] identity. Anytime they perceived problems, that's when they [checked] in and [made] sure there wasn't something they were supposed to be doing." Gili's experience parallels Sky's, and shows how identity validation through affirmation by cisgender graduate student peers can positively impact their sense of belonging within their STEM environment.

We also found that nonbinary alters (mirrors) provided a variety of identity-based expressive supports through shared experiences (kinship). One common sentiment shared between two

participants, Jules and Z, was embracing the value of kinship in STEM academic spaces. Z shared the importance of working with another nonbinary student who related to them through a shared nonbinary identity, stating that initially they were "feeling very anxious about entering another engineering program" and "feeling very isolated" in the early stages of their studies. However, Z described a sense of "solidarity" with its nonbinary peer who recognized its pronouns on Discord, and opened up about their own nonbinary identity. It described feeling like "there was a safety net" that "wasn't there before because everyone in my department as a faculty or researcher [is] cis [and] straight" and that working with a nonbinary peer let it "loosen my shoulders [and] take up space." Jules shared a similar experience of kinship with another nonbinary graduate student. They explained that "it's comforting to know that there is also a trans person in science who I know, or specifically, an out trans person in science" who they "would feel comfortable reaching out to in a professional context." Jules further explained that they would "feel more isolated without them" and that their nonbinary peer also "provided [a sense of] community." Both Jules and Z shared the importance of kinship and connection with other nonbinary graduate students and explained how maintaining those relationships led to a positive impact on their emotional wellbeing.

Advocacy and Insider Knowledge

Participants described receiving advocacy and insider knowledge from cisgender witnesses and nonbinary mirrors. Both cisgender peers and faculty members advocated for participants to succeed in their studies and research. Luz described receiving support from their post-baccalaureate mentor in "applying for grad schools in terms of telling me I should reach out to professors ahead of time, … what to wear for an interview, [and] things that I should talk about when I'm interviewed." Luz described how valuable their mentor was in the graduate school application process, saying that "up until meeting, it felt like a lot of times I learned about something that I should have been doing three months earlier than I knew existed, [and that was] really frustrating." In addition to support from cisgender peers, participants discussed being advocated for by cisgender faculty, primarily their advisors. Z described being affirmed and advocated forwhile preparing for research dissemination. Z recalled their advisors' support:

> "Both my advisors do a really great job, despite being cis straight women, of making sure that I am always safe. I have considered applying to different internships, research opportunities, conferences, and they have been very real about what It is like to exist there as a queer person from what they've observed, despite not being queer. I think the most canon example of this is the [United Nations Climate Change Conference, Conference of Parties 28] … Next year its being held somewhere in the Middle East, and I expressed interest in going. … My advisors were very real about "this country, you cannot be queer. You will have to take your piercings out. You'll have to cover your tattoos. You cannot talk to anybody about being queer." … They're very aware, despite not being queer, of the harm that could come from being queer in certain spaces, and they don't want me to enter those spaces and change myself. Despite being straight and cis, they're killing the game."

Both Z and Luz describe how cisgender peers and faculty can provide advocacy support that better prepares them for graduate school and beyond through an understanding of academic institutions.

Nonbinary peers provided similar supports which resonated with our participants. Z and Cedar had similar sentiments regarding support from their nonbinary peers. Cedar shared the support they received from their nonbinary peers after being let go from their research group for being trans, "the friends and people I had supported were immediately jumping into action. … [They] helped email [and] set up meetings to meet new advisors. … Immediately I was able to learn about other advisors and different opportunities in the department, and within a month I was having meetings with new advisors, and I had found someone who wanted to work with me". Through the support of their nonbinary peers who were able to connect Cedar with potential advisors, they were able to find a supportive lab and continue their studies quickly. When asked to describe a person in their institution that supported them as a nonbinary scientist, Z discussed the support their nonbinary lab-mate provided regarding "getting up to speed on different modeling programs, understanding how to write abstracts for conferences, how to apply to conferences, write your abstracts, [and] a lot of the inside, secret stuff that I know no one tells you unless you enter academia and someone chooses to tell you." Z further elaborated on the nuanced experiences of receiving instrumental support from nonbinary compared to cisgender peers, sharing "the fact that it was this person that was pretty similar in age to me, same identities, and a lot of the same lived experiences, that meant a lot, rather than it just coming from someone that knew all of that, but also didn't align with me in that regard. I didn't realize it would hit just a little bit harder." Through Z's experience in receiving advocacy and insider knowledge from cisgender and nonbinary peers, they realized that receiving the same support from someone of shared experiences and identity was of greater significance.

Nonbinary Identity Development Model

Participants described embracing fluidity and ambiguity as navigating their nonbinary gender identities within the binary, rigid constraints of their STEM discipline's expectations of professionalism. By engaging with expectations for dress and behavior, our participants described pushing back against rigid and binary expectations of professionalism. Participants also highlighted how they actively constructed communities within their disciplines that engaged with the nuances of sex and gender, fostering supportive and inclusive environments for future nonbinary researchers. They described engaging with other researchers who share similar willingness to engage with the complexities of gender in their work and creating lab environments that support the identities and aspirations of current and future nonbinary students.

Embracing fluidity and ambiguity

In our interviews, participants described their experiences embracing fluidity and ambiguity beyond their gender identity and into sociopolitical critique. Z, Jules and Luz shared a common sentiment confronting the strictly enforced and gendered expectations of STEM professionalism. Z shared how tattoos are a form of "active gender affirmation" for it, and that it "[does] not hesitate to put all of them on display." When describing how they confront expectations of

professionalism in STEM conference settings Z explained, "when I go to a conference, I get [warm]. I'm going to wear a tank-top turtleneck and dress pants. … You're going to see my full sleeves [of tattoos] and for me that's part of my gender identity as a form of revolution." When discussing the expectations of academics Luz echoed a similar sentiment, explaining "there's also gendered aspects of professionalism … and I hate professionalism." Through pushing back against a binary and rigid expectation of professionalism in which their identity does not adhere, Luz embraces the fluidity and ambiguity of their identity. When prompted to expand on their disenchantment with professionalism, Luz elaborated:

> "You could define professionalism a number of ways … but professionalism of 'you need to wear expensive, gendered clothing to look professional' is wrong on so many levels. I don't agree with that or want that. Professionalism like, 'you can't talk about personal things in the workplace', where … some boundaries should be set, one of them should not be talking about mental health."

They further explained that they "very much don't want to be a professional, whatever that means" and that they are "stubborn in confronting things they don't agree with." Luz describes how professionalism in STEM academia is both inherently gendered and uncaring about the wellbeing of students and faculty. They then push back against this, claiming that they do not wish to be a professional if these are the standards that they must adhere to. Both Z and Luz discussed how they push back against the gendered expectations of professionalism in their work as STEM graduate students.

Worldmaking

Participants described their aspirations for creating communities of nonbinary individuals with intersectional identities. However, we infrequently saw examples of nonbinary graduate students in STEM having opportunities or the capacity to aspire to build nonbinary scientist communities. Instead, we frequently found that participants felt isolated as "the first" nonbinary person in the discipline or the only nonbinary student in their department. Often, these students shared frustration about facing tokenization, encountering additional emotional labor and minority stress, and navigating additional responsibilities due to being the only nonbinary person in their lab, department, or discipline. These sentiments parallel established research on the experiences of minoritized communities (Chow, 2024; Suarez et al., 2022; Williams et al., 2020).

The strongest case of worldmaking shared by our six participants was the willingness to create STEM research environments that engage with the complexities of gender and nonbinary scientist who has traditionally been absent from their research. One participant, Sky, discussed their motivation behind creating a space in STEM for other nonbinary individuals, explaining "I don't want to see other people struggle the way I have" and "if I can reduce that struggling in any way, shape or form, I will." This sentiment was shared in how Jules and Luz discussed the importance of acknowledging the nuances between sex and gender in STEM fields. Jules emphasized that "in the field of biology, … there's conflation between sex and gender" and how researchers "conflate sex-based traits with gender traits," making it difficult for "a trans person constantly interacting with that on a daily basis and potentially with people who don't navigate it

sensitively." Luz expressed frustration with how "people overlook how the way [scientists] speak about sex directly impacts patient health," and that they must be careful in "what I say in a manuscript or presentation … because I don't want to produce research that [will be] weaponized against my community." Luz further elaborates that they are "trying to spread more information about sex and how we think about sex" and that their "web of connections … hold similar ideas because they are … marginalized by the male-only research [field]," which they refer to as "allyship in terms of what we need to think about [as] normal." Through their work in STEM academia, Luz formed a community of others who share their understanding of the nuances between sex and gender which validates and supports the identities of current and future nonbinary scientists.

Discussion

It is important to understand how nonbinary STEM graduate students access affirmation and kinship and the impacts these supports have, so that we can better assist students pursuing STEM degrees and foster environments that promote their well-being and persistence. In our interviews, participants described receiving distinctly different forms of identity-based expressive supports from cisgender and TNBGNC alters. Kinship supports (obtained from TNBGNC alters) showed deeper emotional support than affirmation (from cisgender alters), such as nonbinary peers sharing experiences of navigating their gender identity in STEM. This aligns with the work of Gentry et al. (2024), where nonbinary engineering undergraduates expressed kinship from their nonbinary peers. Our participants similarly showed shared kinship with their nonbinary graduate student peers. By recognizing how nonbinary graduate students benefit from the affirmation and kinship of cisgender and nonbinary peers, student peers can better understand and enhance their efforts to support their nonbinary colleagues' wellbeing and ability to persist in their studies.

It is similarly crucial to recognize how nonbinary graduate students access advocacy and insider knowledge and the forms they take, so that we can better equip faculty and peers to help students navigate the expectations of STEM academics. Participants described accessing similar identity-based instrumental supports from cisgender and nonbinary alters. Cisgender peers and faculty, as well as nonbinary peers, provided support for the unique challenges of navigating STEM environments as a nonbinary graduate student.

The salience of insider knowledge provided by nonbinary peers to their fellow nonbinary STEM graduate students is valuable to interpreting how shared gender identities can enhance the effectiveness of mentorship and support systems in academic environments. Research has established that mentored relationships between a mentor and mentee who share gender identities increases the amount of psychosocial (expressive) and instrumental support received (Blake-Beard et al., 2011). In addition, mentors and mentees with similar gender-related experiences are perceived by mentees as being equipped to navigate the mentee's experiences (Li et al., 2018). Thus, our finding that nonbinary graduate students can more readily access support from their nonbinary peers aligns with established literature. Nonbinary STEM graduate students can leverage their understanding of the value of shared identity in providing instrumental support to better assist their nonbinary peers, while faculty members can apply this insight to cultivate more inclusive and impactful mentorship practices.

Understanding how nonbinary graduate students navigate the fluidity and ambiguity of their gender identities within the institutional structure of STEM education is critical for faculty seeking to create more inclusive practice and policy. Participants described engaging with fluidity and ambiguity through their gender expression and navigating the cisheteronormative standards of professionalism. They described their frustration with the gendered professionalism standards in academia, and how they must navigate a standard which does not accept or recognize their gender identity. Their experiences align with having to navigate the well-established socio-technical divide that exists within STEM (Kaufman-Ortiz & Rodriguez-Simmonds, 2022), or the incorrect assumption that STEM disciplines are distinctly technical and devoid of all social identities. Operating within a professional STEM environment that disregards nonbinary genders imposes undue stress on nonbinary students, requiring them to actively resist their exclusion. Therefore, STEM faculty must address policies that perpetuate binary frameworks, ensuring support for nonbinary graduate students as they navigate expressing their gender identities within the traditionally cisheteronormative academic and professional environments.

Beyond supporting nonbinary graduate students in navigating unfamiliar academic environments and attaining their degrees, faculty can foster nonbinary worldmaking and inclusive STEM research. We saw participants describe worldmaking through creating STEM research environments that acknowledge nonbinary identities and navigate the differences between sex and gender with nuance. Participants discussed the misalignment between their gender identities and the willingness for their STEM discipline to recognize the reductive nature of conflating sex and gender in their research (Johnson et al., 2009; Stuhlsatz et al., 2020). Multiple participants described their aspiration to progress the understandings of sex and gender in their STEM disciplines, and to incorporate the nuances in their studies. By pushing for these changes, participants aimed to foster a research culture in their discipline that values diverse gender identities, ultimately contributing to a more accurate understanding of their research and a more equitable environment for nonbinary researchers in the discipline. Cisgender faculty should encourage and facilitate nonbinary worldmaking by actively challenging reductive practices, advocating for nuanced understandings of sex and gender in research where applicable, and creating spaces that value and celebrate diverse gender identities.

Conclusions

In this study we explored the experiences of nonbinary STEM graduate students to better understand the unique challenges they face and the support systems they utilize within academic settings to succeed in attaining their degrees. Nonbinary STEM graduate students rely on support from cisgender faculty as well as cisgender and nonbinary peers to navigate STEM environments and persist in their studies. These students navigate their gender identities within the binary and rigid cultural expectations of STEM and create communities that further nuanced and nonbinary understandings of gender. Through understanding the ways nonbinary STEM graduate students navigate their studies, faculty and peers have opportunities to foster more inclusive academic environments that support their success. This work has implications in the construction of environments that support nonbinary STEM graduate students. Our work aims to broaden

participation in STEM by creating spaces that are welcoming for students of all gender identities through contributing to the understanding of the ways nonbinary STEM graduate students navigate their gender identities within academic contexts. We also encourage researchers to adopt frameworks like Gentry et al.'s (2024) nonbinary social supports conceptual framework and Dolan and Garvey's (2024) nonbinary identity development model to better understand and address the experiences of nonbinary individuals in STEM.

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