REVISTA DO PROGRAMA DE PÓS-GRADUAÇÃO EM EDUCAÇÃO MATEMÁTICA DA UNIVERSIDADE FEDERAL DE MATO GROSSO DO SUL (UFMS)

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"I don't feel like I fit the math mold:" Identity Resources of Queer-Spectrum Students in Mathematics

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ABSTRACT

This paper presents findings from the qualitative portion of a larger mixed-methods study using thematic analysis with data from student focus groups focused on the experiences and mathematical identity of Queer-spectrum STEM students. Drawing on Nasir's identity resource constructs, this study sheds light on the material, relational, and ideational resources impacting Queer-spectrum students majoring in STEM. Four key findings emerged from the data: (1) smaller "safe spaces" within STEM environments fostered robust participation among Queer-spectrum students (2) resources supporting academic and social integration, such as Out in STEM, were crucial for empowerment and fostering a holistic sense of self, (3) peer and instructor relationships were crucial in fostering academic success but were often constrained in STEM settings resulting in limited role models and (4) the lack of positive ideational resources regarding normative STEM identities and historical discrimination contributed to a sense of exclusion among Queer-spectrum students. Efforts to diversify STEM must address these challenges by promoting supportive environments that value diverse identities. Future research should examine how identity resources are made available in diverse institutional contexts to better support Queer-spectrum students in developing robust math identities.

KEYWORDS: Math Identity, Queer, LGBTQIA.

RESUMO

Este artigo apresenta descobertas da parte qualitativa oriunda de um estudo mais abrangente que utilizou métodos mistos. Os resultados apresentados foram obtidos por meio de análise temática com dados de grupos focais de estudantes, para examinar as experiências e a identidade matemática de estudantes do espectro Queer em áreas de STEM (Ciência, Tecnologia, Engenharia e Matemática). Com base nos conceitos de recursos de identidade de Nasir, este estudo analisa os recursos materiais, relacionais e ideacionais que impactam os estudantes do espectro Queer em áreas de STEM. Quatro principais resultados emergiram dos dados coletados: (1) espaços menores e "seguros" dentro dos ambientes de STEM fomentaram uma participação robusta entre os estudantes do espectro Queer; (2) recursos que apoiam a integração acadêmica e social, como o *Out in STEM* [*Assumide em STEM*], foram cruciais para o empoderamento e para promover um senso de identidade holístico; (3) as relações com colegas e instrutores são essenciais para o sucesso acadêmico, mas frequentemente são limitadas nos contextos de STEM, resultando em poucos modelos de referência; e (4) a falta de recursos ideacionais positivos sobre identidades normativas em STEM e a discriminação histórica contribuíram para uma sensação de exclusão entre os

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estudantes do espectro Queer. Esforços para diversificar STEM devem abordar esses desafios, promovendo ambientes de apoio que valorizem identidades diversas. Pesquisas futuras devem examinar como os recursos de identidade são disponibilizados em contextos institucionais diversos para melhor apoiar estudantes do espectro Queer no desenvolvimento de identidades matemáticas sólidas.
PALAVRAS-CHAVE: Identidade Matemática, Queer, LGBTQIA.

Introduction

A majority of the research examining the experiences of Queer-spectrum undergraduate students primarily consists of campus climate studies that gauge the overall openness or hostility encountered by Queer-spectrum students and faculty (Wimberly, 2015). Generally speaking, campus climate research paints a chilly and even hostile climate for Queer-spectrum students, faculty, and staff. Queer-spectrum college students are more likely to describe their college campus as hostile, and rate their campus environment less positively than their straight peers (Rankin et al., 2010). Queer-spectrum students also report high rates of harassment (42% of all Lesbian, Gay and Bisexual students and 55% of Transgender students) and fear getting a bad grade because of a hostile classroom environment (11% of Lesbian, Gay and Bisexual students and 15% of Transgender students) (Wimberly, 2015). This hostile environment may limit college students' ability to reach their academic potential, as students report that a positive campus climate contributes to their academic success (Rankin *et al.*, 2010).

A review of recent literature on Queer experiences in STEM, "showcase an unwelcoming, hostile STEM culture, embedded in social norms that reinforced cisheteronormativity" (Marosi *et al.*, 2024, p. 1). Lopez and Chims (1993) interviewed undergraduate Gay and Lesbian students related to their identities, classroom experiences, relationships with instructors, and general learning issues. They found that students were often wary of coming out in large classrooms and introductory courses where they experienced hearing more offensive humor. Students noted that most instructors avoided talking about issues of sexuality and did not include them in the curriculum. It is noteworthy that these students, over 30 years ago, suggested that there was room within mathematics and physics to discuss sexuality (e.g., through biographies, and applied contexts), but that these disciplines often exclude the human dimension. As such it is not surprising then that Queer-spectrum students are less likely to take advanced math and science courses in secondary school (Gottfried *et al*., 2015) and more likely to leave STEM at the undergraduate level (Hughes, 2018).

Cooper and Brownell (2016), in one of the only studies that has examined how instructional practices in STEM are experienced by Queer-spectrum students, interviewed seven undergraduate Queer-spectrum students in an active learning biology classroom. Results from their study suggest Queer-spectrum students do not always experience the undergraduate biology classroom to be a welcoming or accepting place for their identities. Students reported subtle forms of homophobia, as well as a belief that their Queer-spectrum identity was irrelevant to the context of biology. Students reported that in contrast to traditional lectures, active-learning classes increase the relevance of their Queer-spectrum identities due to the increased interactions among peers during group work. This study, although in the context of biology, highlights the importance of how instructional practices, specifically peer-to-peer interactions, might be experienced uniquely by Queer-spectrum students.

Fischer (2013) explored how six undergraduate Queer-spectrum students affiliated with a local LGBT center integrated their Queer identity with their mathematical identity. Fischer documented that having support for one's Queer identity at school was found to relate to possessing a stronger mathematical identity. For example, having a Gay mathematics teacher as a role model, receiving tutoring supports at the LGBT center, and having Gay-straight alliances, supported students' success and engagement in mathematics. Alternatively, students who spoke of feeling sexualized in mathematics classrooms and not wanting to ask questions for fear of being labeled as that "Gay kid asking questions" presented challenges for engaging fully with their mathematical identity. Fischer suggested that educators need to support students' identity development through the "Queering" of mathematics (Mendick, 2006b) in order to make it less male-centric and to counter the absolutism and binary construction of mathematics.

Theoretical Framework

We leverage mathematical identity as the theoretical construct to understand how a Queer student's social identity is enacted and understood in relation to mathematical learning. Research related to mathematical identities has substantially grown over the last decade, resulting in various conceptions of the nature and definition of identity (Darragh, 2016; Langer-Osuna and Esmonde, 2017). Nasir (2011) defines identity as a sense of self that is constructed by available social categories and ascribed by social groups and settings. In this study, we define mathematical identity as the dispositions and deeply-held beliefs that individuals

develop, within their overall self-concept, about their ability to participate and perform effectively in mathematical contexts. Accounting for how individuals position themselves within or outside the community as potential creators of mathematics, as well as their beliefs about the nature of mathematics and its ability to change the conditions of individuals' lives.

Extending this conceptualization of mathematics identity, we seek to define a Queer Mathematical identity as one that promotes the development of both a mathematical identity and Queer identity. Thus, a Queer mathematical identity is one that allows Queer-spectrum students to fully participate and perform effectively in mathematical contexts as Queer individuals. Investigation into the mathematical identities of Queer-spectrum students requires understanding (1) their beliefs about participation and perceived ability, (2) their positionality within mathematical communities, and (3) how each of these are shaped by identity resources such as interpersonal and institutional structures (Leyva, 2017).

In particular, Nasir (2011) documents how particular learning environments provide access to identity resources, making some identities readily available to students and constraining others. Nasir (2011) defines three types of identity resources: material, relational, and ideational. Material resources refer to the physical environment, its organization, and the artifacts within that environment that support one's connection to mathematics. Nasir defined material resources as objects in the learning environment (e.g., chalkboard, computer) and others have expanded this to larger organizational and physical structures, such as the classroom and university structures (Hyater-Adams *et al.*, 2018). Relational resources refer to ways in which positive relationships with others afford a connection to the practice of mathematics. Ideational resources refer to the ideas about oneself and one's relationship to the practice of mathematics, as well as to what is valued in mathematics and who is considered a mathematician. This study draws on the identity resources made available to Queer-spectrum students to understand how they can develop practice-linked identities in STEM. As such this study aims to account for the resources that impact Queer mathematical identity formation by addressing the following research question: How do the material, relational, and ideational resources available to undergraduate Queer-spectrum STEM students impact their mathematical identity?

Methods

The result presented in this paper are part of a larger mixed-methods dissertation study (Voigt, 2020) focused on queer-spectrum student's experiences in

Mathematics. Phase one of the study leveraged large quantitative survey data from students enrolled in mathematics courses (Voigt, 2022) to examine variations among queer students. Phase two of the study used grounded-theory with individual interviews to identify discourses students held about their Queer-identity in relation to Mathematics (Voigt, 2024). Phase three of the study, the focus of this paper, leveraged focus groups to identify identity resources to support Queer-spectrum students in mathematics. The goal of the focus groups was two-fold: (1) by drawing on the sequential transformative design of the overall study, results from the previous stages were shared with students as a form of advocacy, and (2) students' discussions highlight various resources that support a sense of belonging, perceived ability, and success in mathematics based in their current environment.

Participants

An email was sent to the students who completed a survey in their mathematics course inviting them to participate in a focus group that would explore the experiences of Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, and Asexual (LGBTQIA) students. The email indicated that all were invited to participate even if they felt their identity has not impacted their experience or felt they had limited perspectives to share. We broadened our recruitment efforts by posting flyers around campus, asking instructors to distribute recruitment materials and recruited through LGBT student resource centers, Out in STEM (oSTEM), and various STEM student organizations. Eventually this resulted in focus groups at four universities composed of three to five students who represented a range of Queer-spectrum identities. Student self-selected pseudonyms and self-identified demographics is presented in Table 1.

Table 1. Queer-spectrum student focus group phase three participants and demographic information.

Pseudonym	Pronouns	Sexual Identity	Major	University
Naseem	She, Her, Hers	Not disclosed	Multimedia Business with Computer Science minor	Barres
Flora	She, Her, Hers	Asexual Aromantic	Health Communications	Barres
Meh	She, Her, Hers	Pansexual	Marine Biology	Barres
Erin	She, Her, Hers	Lesbian	Mechanical Engineering	Barres
Katherine	She, Her, Hers	Not disclosed	Statistics with Computer Science Minor	Barres
Isabella	She, Her, Hers	Asexual	Global Health	Ride
Fran	She, Her, Hers, They, Them, Theirs	Pansexual	Global Health	Ride
James	He, Him, His	Attracted to men	Mathematics and Chemistry	Ride
Tim	He, Him, His	Gay	Computer science	Ride
Swappi	He, Him, His	Gay	Molecular biology	Ride
Alexis	She, Her, Hers	Demisexual Panromantic	Biology	Turing

Chelsea	She, Her, Hers	Lesbian	Biology and Anthropology	Turing
Cat	She, Her, Hers	Bisexual	Computer Science	Turing
Jesse	He, Him, His	Gay	Mathematic and Earth and Ocean Science	Turing
Aidan	She, Her, Hers	Bisexual	Psychology	Carver
Luciana	She, Her, Hers	Asexual	Computer Science	Carver
Jonathan	He, Him, His	Gay	Mathematics	Carver

Source: own authorship.

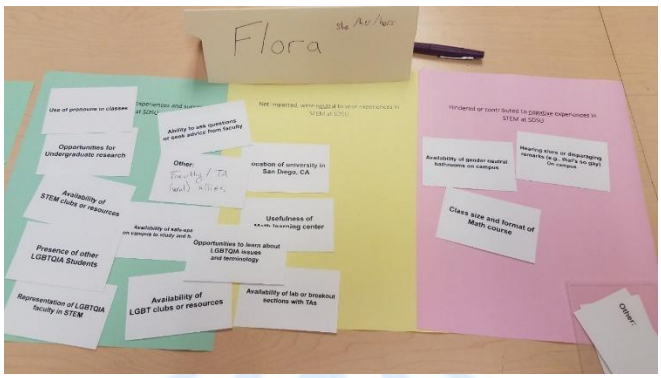
Data Collection

Focus groups were scheduled for 90 minutes and took place in the mathematics building at each university. Since attitudes and opinions are socially formed, focus groups helped provide deeper understanding as it was enacted in the day-to-day experiences of the students. The structure of the focus group was informed by the best practices outlined by Breen (2006) and was structured into three distinct parts (See Appendix A). The first part of the focus group was an exploration of emergent themes from the individual interviews collected during phase two of the study. The second part of the focus group was an identity resource matching activity (described in detail below). The third part of the focus group was an exploration of quantitative survey results from phase one of the study.

Students did a matching activity with identity resources to determining if those resources "contributed to positive experiences and success in STEM at [University]," "hindered or contributed to negative experiences in STEM at [University]," or "not impacted, were neutral to your experiences in STEM at [University]." The identity resources were generated based on emerging analysis from phase one and two of the larger study. Students had color-coded sheets in front of them and were asked to sort the identity resources accordingly (see example in Figure 1). Students were also given blank cards and encouraged to generate their own resources that impacted their STEM experiences. Students generated ten resources that hindered (Not knowing my peers, The Math/CS Department themselves, Having the feeling that I don't fit the math mold, Ethnic diversity of my major, The 'so when are you graduating' question, Being in college my 1sty year, Staff who are not prepared to serve historically underrepresented students, mentorship resources/opportunities, intimidated, the computer science TA's) and four resources that benefited (diverse teachers, connecting with faculty personally, on campus employment, Faculty/TA vocal allies). After all the students had sorted the identity resources, we facilitated a conversation starting with resources that were positive or benefited, followed by negative or hindered, and finally neutral (see results of each student in Figure 2). The

goal of the activity was not to focus on where students placed a particular resource but to elicit the underlying rationale and explanation for each resource.

Figure 1. Identity resource matching activity example for Flora.



Source: own authorship.

Figure 2. Focus group student responses to identity resource matching activity.

	Carver			Turing				Barres				Ride				
	Aidan	Luciana	Johnathan	Alex	Chelsea	Cat	Jesse	Naseem	Flora	Katherine	Meh	Timmy	James	Fran	Isabella	Swappi
Presence of other LGBTQIA students	N	B	N	B	B	B	B	B	B	B	B	N	B	B	N	B
Availability of safe-spaces on campus to study and hang-out	B	B	N	B	B	B	B	B	B	B	N	N	N	B	B	B
Opportunities to learn about LGBTQIA issues and terminology	N	-	B	B	B	B	B	B	N B	B	B	N	B	B	B	B
Availability of LGBT clubs or resources	N	N	N	B	B	B	B	B	B	B	B	N	N	B	B	B
Location of university	B	B	B	N	B	B	N	B	N	N	B	B	H B	H	B	B
Opportunities for undergraduate research	B	B	N	B	B	H	B	B	B	N	B	B	B	H	B	N
Availability of STEM clubs or resources	N	B	B	H	B	B	H	B	B	B	B	N	H B	N	B	N
Ability to ask questions or seek advice from faculty	B	B	B	H	H	B	B	B	B	H	N	N	B	N	B	H
Availability of lab or breakout sections with TAs	B	B	B	H	B	N	N	B	N	N	N	B	B	N	B	N
Representation of LGBTQIA faculty in STEM	N	B	H	H	H	B	H	B	B	N	H	N	B	B	B	B
Usefulness of Math learning center	B	N	B	N	N	B	B	N	N	N	N	N	N	N	B	N
Availability of gender-neutral bathrooms on campus	B	N	N	N	H	B	B	B	H	N	B	N	H	N	N	N
Use of pronouns in classes	B	B	N	N	H	N	H	N	B	N	H	N	B	H B	N	B
Class size and format of Math course	B	H	B	H	H	B	N	N	H	H	N	N	H	H	N	N
Hearing slurs or disparaging remarks (e.g., that's so gay) on campus	H	H	H	H	H	N	H	N	H	N	H	N	H	H	H	N

H: Hindered, N: Neutral, B: Benefited [experiences and success in STEM]. – unplaced resource

Source: own authorship.

Data Analysis

All of the focus groups were audio recorded and transcribed using the transcription software service Temi (Temi, 2017). The transcripts were then imported

into the qualitative coding software MAXQDA 2020 (Verbi Softwares, 2019). The analysis of the focus groups was guided by Nasir's (2011) identity resources constructs, which serve to highlight how educational settings make particular identities available while constraining others. We drew on the operational detentions outlined by Hyater-Adams and colleagues (2018), who further define subcodes of each identity resource related to whether these are positive, negative or neither, and whether the resources are internally attributed or externally attributed. We also organized the identity resource constructs depending on whether they occurred as a part of classroom-related resource or as an external resource that occurred within the broader educational settings. The analysis was then guided by the three identity resource constructs and an attribution of the setting in which they occurred. Each transcript was reviewed and assigned the codes to the "the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon" (Boyatzis, 1998, p. 68). The transcripts and codes were then reviewed paying attention to the most important and noteworthy themes, the level of agreement between participants, and any unexpected findings (Breen, 2006).

Results

We documented 24 identity resources discussed by students in the focus group, which was composed of nine material resources, nine relational resources, and six ideational resources (see Table 2 for summary). A complete description of each identity resource along with how students discussed and experienced these resources is available in Voigt (2020). In the following results section, we highlight four cross-cutting themes that emerged summarizing the impact and availability of these resources for Queer-spectrum STEM students. First, Queer-spectrum students' participation was fostered through the creation of smaller "safe spaces" and relationships in STEM. Second, Queer-spectrum student's sense of belonging was supported through resources that fostered academic and social integration. Third, relationships with peers and instructors was critical for fostering a sense of belonging and community but were often constrained in STEM settings. Fourth, the lack of positive ideational resources contributed to a lessened sense of both belonging and perceived ability.

Table 2. Identity resources by type and educational setting.

	Material	Relational	Ideational
Classroom-related resources	Classroom size and structure Course sequencing and scheduling Curriculum and terminology Appearance and decals	Classroom peers Queer peers Teaching assistants Instructors Student-initiated Study partners	Technical and neutral contexts Rigor and challenging courses STEM Straight white men
External resources	LGBT student resource centers STEM research labs Mathematical learning centers Facilities and gender-inclusive restrooms University climate and location	Queer and STEM student groups STEM student groups Queer student groups Out role models Other relationships	Diversity initiatives History of discrimination Queer Exclusion

Source: own authorship.

The Physical and Structural Environment as Smaller Safe Spaces

Results from the focus group suggest the physical environment and structures within STEM spaces can significantly influence Queer students' sense of safety, belonging, and ability to express their authentic selves.

Smaller Safe Spaces and Inclusive Facilities

Queer-spectrum students unanimously discussed the benefit of having smaller (physical and figurative) spaces deemed safer and the impact of inclusive facilities. Queer-spectrum students unanimously discussed the benefit of having smaller classes size in STEM as they provide a structure to develop peer connections and better understand the content. Chelsea highlighted the mechanism that allows for a more personal connection in smaller classes, namely that in large classes it’s difficult to know other students’ names or use pronouns to introduce yourself. Erin said that small class sections provide “more room to talk about your person…you can share a lot more information about yourself.” Erin recounted that in her small section math class, she got close with other students and it was the only time that another student came out as Transgender in any of her STEM courses. The structure of a small class and another student coming out, allowed Erin to also come out in that class supporting a Queer mathematical identity.

The use of appearance and visual indicators, such as decals and attire, also served as important mechanisms for Queer-spectrum students to express their identities and signal their belonging within STEM environments. These created

figurative "safe spaces" for other students “in the know” about Queer insignia (Hutson, 2010; Rothblum, 2014). Students described how their dress and appearance could either affirm their sense of acceptance or expose them to potential discrimination or harassment. James discussed how in STEM environments he will police himself and change his behavior to act less feminine, monitor his voice and dress so as not to “sound Gay.” Swappi, Fredo, and Jesse all described similar experiences of constraining the physicality of their Queerness, suggesting that queer men may have more negative experiences publicly displaying their sexuality within mathematics due to its heteronormative masculinity (Mendick, 2006; Leyva, 2022). Whereas, Meh, Katherine, and Flora described their appreciation for an oSTEM stickers as “beautiful” and “thank god for that sticker.” The students used the sticker to identify a belonging as both Queer-spectrum but also having an affiliation with the oSTEM community. As Erin described it, “Yeah, I would definitely be like more open to like talk about who I am to someone…If they had an oSTEM pin out I’d be like, I've never seen you before where did you get that?” Naseem discussed how such resources signal to other students that they can come out to her and develop friendships:

Having like these little like rainbow things or like the badge from the club. I feel like also like when I make friends from other classes, they see that. And once they see like a rainbow or whatever, they feel safe with me, so they come out to me. So, I've actually made other Queer friends who have, who are not active in the LGBT community.

Students discussed how the lack of gender-inclusive restrooms in STEM buildings contributed to a sense of exclusion and injustice within STEM. At Barres University, Flora and Meh discussed how they would often use the women’s restroom in the newly built engineering building because there weren’t any other women in that building, which they attributed to the lack of women representation in engineering. Furthermore, they discussed that in the older science building, the women’s bathrooms were only located in the basement of the building because “all of the nursing classes were in the basement when it was built.” This highlighted the gendered divisions and sexism within STEM that are manifested through physical facilities. Although Flora commented on her privilege to be able to use the women’s restroom, she said, “if I had like any other identity, like that would be a pain in my ass. Like it just, I'm so mad.” At Ride University, James shared a similar sentiment that he is upset that the chemistry building doesn’t have gender inclusive restrooms, and instead there is a sign stating gender-inclusive restrooms are located in a separate building “really far away.” These findings suggest that students are attuned

to the physical facilities within STEM buildings and the implicit messages they convey about Queer-spectrum student inclusion.

Timing and Sequencing of Math Courses as Potential Threats

The sequential nature of undergraduate mathematics courses was identified as both advantageous and challenging for Queer-spectrum students. On one hand, sequential courses allow for continuity in instruction and facilitate the formation of supportive communities with consistent peers and instructors. However, there are inherent risks associated with this structure, particularly regarding extended time to degree completion and increased pressure to adhere to normative timelines. Johnathan, James, and Cat shared that by having sequential courses, they were able to have the same instructor and peers for multiple courses, allowing for the formation of community and a sense of belonging. Johnathan said he has been able to make "math friends" because you end up having the same people in your classes and you have seen them in "eight classes at this point," allowing for you to be more communicative. In contrast, Cat shared how the sequencing can be especially problematic for Queer-spectrum students since "if you have one bad semester it really wipes you out," which can impact both your time to degree as well as desire to pursue a STEM degree.

Furthermore, the scheduling of STEM courses and exams in the evening raises safety concerns, particularly regarding the heightened risk of sexual assault on campus during these hours. Erin and Naseem discussed how all their engineering courses were at night, and that this elevated their awareness of potential sexual assault on campus. Naseem shared the following incident when they left their evening engineering course one night:

I was like walking home, I was crossing the street, someone watched me like in a car and like walking home and then this car goes in reverse at the rate of me walking. And I am like walking faster and then all of a sudden they give up because they were like the whole block and they were backing up and then that and then when I sped up they gave up and then they just left and I'm just like, 'did you almost die?'

Naseem said that this experience with evening courses is one of the reasons why she doesn't mind being misgendered because she is less likely to be the target of harassment, "Like if someone like walking out at night and people mistake me as a guy, it's like, okay great, you're probably not going to bug me then." Given that sexual assault and harassment rates are greater for Queer-spectrum students (Cantor *et al.*, 2015) and fear of sexual assault is greater at night (Day, 1999), the use evening courses in STEM appear problematic for Queer-spectrum students.

Nurturing Social and Academic Integration: Material and Relational Resources at the Intersection of Queer and STEM

Queer-spectrum students conveyed the greatest sense of belonging in STEM when engaged with resources that supported academic and social integration of their Queer mathematical identity. Two of the most affirming that students mentioned were Queer STEM student groups and STEM research labs. LGBT student resource centers and math learning centers were described as beneficial when linking to additional resources. Queer student groups and STEM student groups were typically described negatively for either feeling exclusionary or were not a “fit” for the perceived identity of the students.

Queer STEM student groups, notably Out in STEM (oSTEM), are increasingly prevalent across higher education institutions, with chapters in numerous universities. Students at Barres University described oSTEM's positive impact, including education on Queer issues, social networking, and empowerment through role models. Members like Flora and Erin credited oSTEM for enhancing their understanding of Queer terminology and issues, with Flora attributing her comfort in being out to her involvement with oSTEM. Naseem discussed how she wishes she would have joined oSTEM earlier, as that would have made her happier and been more involved in the Queer community. oSTEM helped foster social connections inside the group since making connections in the classroom were described as difficult. As Erin articulated, “Yes, most of my friends are probably in oSTEM…that's most of my social group because I can't make friends with people in class.” Erin attributed the regular meetings of the group and the social nature of the interactions for why friendships were easier to develop in oSTEM. Another potential factor for the creation of social relationships, is that students described the oSTEM leadership as mostly women, and while in the group you are not “assaulted” by seeing so many “dudes.” This speaks the intersectional nature of support desired by students. At Ride University, oSTEM's impact was more focused on empowerment and presenting successful role models, as noted by Swappi and Fran. Swappi found empowerment through seeing successful Queer faculty in STEM. Fran also attended a few oSTEM events, but for her, she wasn’t “comfortable with who I was yet" so she needed to step back from attending the events. As she became more comfortable, she said oSTEM helped provide a sense of empowerment because “I can just be who I am.” Fran's experience highlights that oSTEM's effectiveness may vary based on students' comfort with their Queer identity.

Queer-spectrum students reported benefits of having a dedicated STEM research lab, which included decorating the space with supportive decals, fostering connections with other Queer-spectrum students or post-docs, and supporting a stronger STEM affiliation. For instance being part of a STEM research lab, allowed Meh to connect with other Queer-spectrum STEM people. Meh mentioned the importance of a post-doctoral researcher in her lab that identified as a Transgender man. Meh said she “looked up to” and “loved” this person in their lab. The post-doctoral student listed their pronouns on their email signature, and this inspired Meh to do the same thing. Having another Queer-spectrum person in their lab made it “really easy in my lab to like be open.” Meh also used the physical space to plaster Queer inclusive notes and flyers. However, challenges such as interacting with less-inclusive lab members and difficulty in obtaining research positions were also noted by some participants.

LGBT student resource centers served as valuable resources for Queer-spectrum students in STEM, providing physical spaces for connection, study, and networking with other resources. Participants highlighted LGBT student resource center's role in facilitating connections with peers and staff, particularly through courses and study sessions. The centers offered a welcoming environment for relaxation and social interaction, where students felt comfortable discussing both academic and personal matters. Moreover, the centers provided a vital study space for STEM students, fostering academic and social integration outside the classroom. Cat described that having a physical safe space allowed her to study together with two members from her calculus course, which she described as a very positive experience. Access to these centers also connected students with other STEM-specific resources, such as mentorship programs and faculty ally listings. However, not all students are equally comfortable accessing these centers, with reasons ranging from social hesitancy to feelings of being an imposter within the Queer community. As Fran described it, “Am I like, Queer enough to be in this space right now? I feel like someone will judge you, like you shouldn't be here. And I'm like, but I swear, I'm a part of you guys.” Similar explanations were given for why students did not participate in Queer student groups. Isabella suggested that sometimes people let their queer identity overtake their other identities, especially STEM identities, leading to a divide or fracturing in social groups. These results suggest that Queer student groups are not functioning as the same safe space and retention mechanism

for Queer-spectrum STEM students that has been documented in the literature (Pitcher *et al.*, 2018).

STEM clubs, like Math Club, were perceived by Queer-spectrum students as exclusionary, reinforcing stereotypes of what it means to be a STEM person. Aidan and Luciana at Carver University expressed discomfort and a lack of belonging in the math club due to its rigid norms and unwelcoming atmosphere. Aidan said, “I don't feel comfortable going to STEM clubs” because “I don’t fit in with a math club” and “I don’t feel like I fit the math mold.” James at Ride University had a similar experience with his math club, feeling like it did not represent him, and others like him. “Oh my God, I'm the only Gay person in this club.” As a result, James questioned how he should act in the group,

Part of me wants to be like, be as Gay as possible, so people like acknowledge the presence of the community in the math department. But another part of me is like, well, you're not that Gay or like whatever, you know. So, it's like just be yourself.

This impacted James’s desire to use pronouns in the group but because no one else was using them he felt pressure not to use pronouns. James brought the lack of diversity in the math club to the attention of his advisor and suggested that they reach out to Society of Hispanic Professional Engineers (SHPE) or oSTEM. The advisor reaction was to say, “I don't know what those clubs are. And second if they want to participate, they would come.” James said this just demonstrated the hesitancy to promote diversity in mathematics and the math club. These findings underscore the need for STEM clubs to address issues of diversity and inclusion to foster a sense of belonging for Queer-spectrum students.

Relational Resources as Sources of Belonging and Community

Positive relationships with peers, instructors, and role models are critical for Queer students' success and well-being in STEM. These relationships provide support, mentorship, and a sense of community, countering the potential isolation and marginalization that Queer students may experience.

Missing Peer Connections

Queer-spectrum students often found traditional STEM courses to be non-social environments, hindering the development of relational resources with their peers. As Naseem described her mathematics courses, they were "not supposed to be a social environment," resulting in a lack of friendships within those classes. Luciana and Aidan described similar interactions in their STEM courses where they don’t interact often and don’t make friends or know the names of people in the

classes. Aidan described mathematics as a place to do your work and not a place to make friends. Despite this, students expressed a strong desire for smaller, more interactive learning environments, echoing Erin's preference for "small group interactions" over "boring lectures."

While some positive social interactions did occur, they were often facilitated by the perception of Queer-spectrum students as being naturally social, or by the collaborative nature of certain coursework. Jesse discussed how Queer-spectrum individuals are “really good at networking” and “finding connections with other people in classes” to work with even if they are not Queer-spectrum. John discussed how personally he was “overtly social” with the people in his mathematics class and will make friends with them even if he feels it’s intrusive cause he thinks STEM people are just more reserved. Jesse and John’s description casts Queer identity as an asset that can be leveraged for communicative and social interactions in STEM spaces. These interactions sometimes led to study groups, but as Flora noted, these were often impersonal, focused on "getting it done." Consequently, many students preferred forming dyadic study partnerships with close allies, providing a safe space for vulnerability and shared struggles.

These findings highlight the challenges Queer-spectrum students face in forming meaningful connections within traditional STEM classrooms. As Aidan observed, "given the chance, people do express their LGBTQIA identity in STEM classes, but we're not really given the chance." Creating more inclusive and interactive learning environments, and fostering opportunities for genuine social connections, could significantly improve the experiences for these students and promote their academic success and sense of belonging.

Instructor Role Models and Inclusive Pedagogy

The establishment of positive relationships with instructors emerged as a crucial factor in the experiences of Queer-spectrum students in STEM fields. Particularly impactful were instructors who demonstrated a holistic approach to student engagement that extended beyond academics. Luciana, reflecting on her mathematics instructor, highlighted his ability to "talk about STEM things but also like personal things," creating an inclusive classroom environment where she felt comfortable expressing her authentic self. Teaching assistants (TAs) also exerted considerable influence, especially when perceived to be Queer or actively supportive of Queer-spectrum identities. Their near-peer status and shared experiences contributed to increased approachability and deeper connections, as exemplified by

Luciana's experience with her transgender TA, "I could just talk more freely about who I am and what I'm struggling with outside of class." This resonates with previous research highlighting the positive academic outcomes associated with having a TA who shares a racial or gender identity with students.

Beyond individual connections, specific pedagogical practices also played a vital role in shaping the classroom experiences of queer-spectrum students. The simple act of using pronouns was identified as a significant inclusive practice that signaled allyship and fostered a sense of safety. The conspicuous absence of this practice in STEM classrooms, compared to its prevalence in other disciplines, was a source of frustration for students. As one student aptly put it, using pronouns "sets a different tone" and establishes an instructor as an "active ally."

Despite the positive impact of supportive instructors and TAs, the lack of openly Queer instructors in STEM fields remained a pressing concern. Students expressed a clear desire for greater representation and visibility of Queer individuals within STEM faculty. Chelsea emphasized the importance of role models, stating that the homogeneity of STEM departments "sends kind of an implicit message that like you can't succeed or you can't make it to that level." The presence of Queer role models in STEM not only challenges normative assumptions but also provides invaluable inspiration and validation for queer-spectrum students navigating these fields.

Lacking Ideational Resources to Support Queer STEM Identity

The ideas and perceptions that students hold about themselves, STEM, and the broader societal context can significantly influence their experiences. These ideational resources includes ideas about one’s position within mathematics, ideas about what mathematicians care about/value, ideas about your own mathematical abilities, and cultural perceptions about who is typically considered a mathematician. The ideational resources described by students largely hindered their STEM experiences, thus contributing to a diminished sense of success and sense of belonging.

Challenging the Dominant STEM Narrative of Straight White Men

Students discussed the prevailing identity of a typical STEM person, often characterized as a combination of white, straight, and cisgender men. Many students, like Chelsea, expressed discouragement at the homogeneity of STEM professors, primarily being cisgender white men. This perception contributed to feelings of not fitting in, intimidation, and exclusion from the field. Isabella highlighted

the additional challenges she faces as a cisgender woman, needing to work harder to prove herself in STEM classes. James and Erin noted some diversity in their STEM classes due to the university's racial diversity, countering the perception of STEM as predominantly White. However, students also discussed the underrepresentation of women and students of color in STEM, with Meh and Katherine noting pressures and feelings of exclusion associated with being the only woman or person of color in their classes. Additionally, Luciana mentioned the lack of Latinx role models, while Katherine highlighted the scarcity of Queer individuals in STEM, demonstrating how Queer-spectrum students perceive representation and inclusion in STEM through the lens of multiple underrepresented identities.

STEM's Rigor and Neutrality

Queer-spectrum students described STEM courses as inherently rigorous and challenging, a perception that could trigger imposter syndrome when not balanced with a narrative of productive struggle. The emphasis on technical computations and neutral contexts, while appreciated by some for its focus on objective problem-solving, was also seen as a potential barrier to inclusion. As Flora noted, "I really liked the objective or neutral discipline... but that's not always a bad thing." However, she acknowledged that this neutrality could "dampen your experience" if you are not inherently gifted and the environment excludes Queer individuals.

The pressure to succeed in STEM courses to prove their validity and combat imposter syndrome was a common theme among participants. James articulated this sentiment, stating, "Because we already had this idea that STEM is not for us or that it is harder to succeed in STEM as an LGBTQ person... there's already this idea that you will struggle." In contrast, Luciana shared her positive experience in a course that reframed struggle as a natural part of the learning process, allowing her identity to emerge in a more "inviting" environment.

The perceived lack of social engagement in STEM courses, coupled with the absence of discussions around social justice and identity, further complicated the experiences of queer-spectrum students. Alexis emphasized the impossibility of separating "objective quote-unquote scientific work from the people doing that work," calling for a more inclusive approach that acknowledges the impact of identity on STEM. Jesse echoed this sentiment, highlighting the need for anti-discrimination work in STEM to combat systemic biases.

In essence, the traditional framing of STEM as a purely technical and neutral field presented both opportunities and challenges for Queer-spectrum students.

While some valued the focus on objective problem-solving, others sought a more inclusive environment that acknowledged the role of identity and social justice in STEM. Reconciling these perspectives and fostering a sense of belonging for queer-spectrum students necessitates a shift toward pedagogical practices that value productive struggle, promote inclusivity, and recognize the multifaceted nature of individual identities within STEM.

Addressing Ongoing and Historical Discrimination

Current diversity initiatives in STEM fields were critiqued by focus group participants for their exclusion of Queer-spectrum individuals. While efforts to diversify STEM were acknowledged as necessary, they were seen as problematic due to their focus solely on gender and racial diversity. Chelsea expressed frustration, noting the absence of initiatives specifically targeting Queer individuals in STEM. Meh and Erin echoed this sentiment, highlighting the lack of attention to sexual identity in diversity efforts. Meh particularly emphasized the oversight in internship opportunities, where Queer identities were ignored. Naseem and Flora suggested that this omission may imply tolerance for homophobic and transphobic attitudes within STEM. The participants agreed that it was frustrating and concerning that Queer identities were not acknowledged in these initiatives, revealing tensions between outward support for diversity and a lack of genuine appreciation for the needs of Queer-spectrum individuals. Luciana described that STEM individuals “try to be diverse, but it’s always like a white woman” promoting a “scholarship for people of color” and that is the totality of them trying to be diverse.

Students also pointed to the historical discrimination of Queer-spectrum individuals in STEM as evidence that Queerness was not valued and included in STEM. For example, Alan Turing was discussed in two of the focus groups. Alan Turing was a prominent mathematician and computer scientist during the second world war who was influential in the development of theoretical computer science and algorithms. He was, however, prosecuted for being Gay, was chemically castrated, and ended up committing suicide. He has gained recent notoriety in popular culture through film and television (Levine, 2016). Jesse discussed the impact of Alan Turing as an indicator for the exclusion of Queerness in STEM,

Alan Turing and like he was like a world renowned, mathematician and like later prosecuted, prosecuted for being Gay. So, if there's like historically not a big like precedent for like LGBT inclusion in like math and mathematics.

Luciana and Erin also mentioned a history of exclusion and discrimination in STEM towards women and other minorities. These ideational resource show that historical discrimination of Queer-spectrum individuals is still serving as evidence for the exclusionary and hostile climate within STEM today. As such, STEM fields need to confront their past in order to promote a more inclusive STEM space for Queer-spectrum students.

Conclusion

This research investigated the material, relational, and ideational resources that contribute to or hinder the experiences of Queer-spectrum students in STEM. It revealed that these students often forge their own "safe spaces" within the larger STEM environment, favoring smaller, more intimate settings where they can freely associate and communicate about their experiences. Sociologist have studied safe spaces or free spaces, defining them as “small- scale settings within a community or movement that are removed from the direct control of dominant groups, are voluntarily participated in, and generate the cultural challenge that precedes or accompanies political mobilization” (Polletta, 1999, p. 1). Students in the focus groups discussed the ways in which they were forming and often preferred small-scale settings in STEM. This included the preference for small class sizes, small groupwork in the classroom, forming of study dyads, and benefiting from the course sequencing to allow for community building within the classroom. This was also manifested in utilizing LGBT student resources centers and STEM labs as study spaces which were smaller environments that fostered connections with other Queer-spectrum students. These spaces were also voluntarily entered by the students which may be why they created a safer space than those within the classroom which are not entered voluntarily. Even the use of decals to signal to others “in the know” about group belonging created a figurative space removed from the dominant group’s knowledge, that then fostered participation and relationship building among Queer-spectrum students. Lastly, the reason oSTEM might have had such a great impact on student experience is that not only does it create a smaller, removed, and voluntary space for student participation, but it also seeks to foster the political mobilization that challenges the dominant assumption that STEM is intended for Straight white men.

The ideational resources described by students largely hindered their STEM experiences, thus contributing to a diminished sense of success and sense of belonging in STEM. Queer-spectrum students described the “typical” STEM individual as a Straight white man, which positioned most of their identities outside

the normative expectation within STEM. This, combined with the lack of out role models, and a history of discrimination towards Queer people in STEM, created an environment that is perceived as exclusionary to Queer-spectrum individuals. Efforts to diversity STEM, while well intentioned, were mostly non-inclusive of sexual identity, contributing further to a sense of exclusion. Even the nature of the field as rigorous, technical, and presenting neutral contexts, either presented tensions within many Queer-spectrum students or contributed to the triggering of imposter syndrome. Given the lack of ideational resources, this is the one area that has the biggest potential for growth in supporting Queer-spectrum students.

Overall, this research highlights the complex interplay of resources that shape the experiences of queer-spectrum students in STEM. The creation of smaller, safe spaces, the fostering of both academic and social integration, and the disruption of normative assumptions within STEM are all essential for creating a more inclusive and supportive environment where these students can thrive. As we seek to support queer students develop robust math identities, we must create space for them to feel safe and thrive, foster a holistic and humanizing approach to teaching and learning, and disrupting the norms and assumptions within our discipline.

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Appendix A: Focus Group Protocol

Welcome & Instructions

Thank you for agreeing to participate in a discussion about LGBTQIA identity and experiences in STEM at <Institution>. I am seeking to understand factors related to both positive and negative experience while studying mathematics, especially accounting for the impact that sexual orientation, race and gender has for student's experience. While your views and personal experience are highly valued, your identity will not be disclosed to anyone outside the research team. I am going to ask you some questions about your experiences in mathematics at this university, especially as a LGBTQIA student. I hope these questions will stimulate discussion amongst you. I am here to facilitate the session by keeping track of time and making sure that all of the issues in which we are interested are discussed.

I am going to record the discussion, so please speak clearly and remember that the recorder will not pick up actions such as nodding in agreement, etc.

Overview of topic

The study will be used to identify specific things universities and mathematics departments can do to support more students in having positive experiences in mathematics and STEM, with a focus on supporting LGBTQIA students. This focus group will have four major parts:

- Ask everyone to share about their personal opinions about being LGBTQIA in STEM
- Reflect on some common themes that students have expressed about their view of mathematics/STEM and see how these are similar or dissimilar to your own.
- Examine student survey reports of math classroom experiences
- Discuss the factors at Cardinal University that do or do not promote inclusive spaces and success in Mathematics

Personal Experience

1. I would like to begin by having each of us introduce ourselves. What is your name (or pseudonym), current major, salient identities you feel comfortable sharing, and something interesting about yourself?
2. What motivated you to participate in this focus group?

Focus Group Part One

On the provided handout are some themes that capture what LGBTQIA students have shared during interviews about their views of mathematics and STEM and how those are impacted by identifying with being LGBTQIA. Take a few minutes to read over those themes. Then we will have a discussion related to these themes, especially which ones resonate with you, and why? How might they be similar or dissimilar to your own experience?

Emerging Themes of LGBTQIA students' views of STEM

1. Students described math as an **objective or neutral discipline,** which some said made them less comfortable being "out" in math classes, while others said this helped provide an escape from being reminded about discrimination.
2. Some students described having two **separate social groups**, their STEM friends or classmates and their LGBTQIA friends. Additionally, some LGBT students don't feel "Queer enough" or stereotypically gay and associated more with their STEM identity.

3. Math classrooms are seen as **solution oriented** (e.g., the goal is to calculate an answer) so discussions about LGBTQIA issues would be irrelevant to doing the mathematics, even if the curriculum included LGBTQIA context or Queer people. Since the ability to do mathematics is valued regardless of identity, anyone can succeed in mathematics.

4. STEM fields in general and mathematics in particular are seen as **less inclusive** compared to other disciplines. For example, STEM instructors don't introduce pronouns or develop personal connections with students, and STEM classes tend to be described as heteronormative with more straight white cisgendered men.

Focus Group Part Two

Institutional Factors

Next, I would like to turn and discuss the factors at Cardinal University that do or do not promote inclusive spaces and success in Mathematics. On the cards in front of you are some of the reported resources I heard based on interviews with students and survey reports. Take a minute to read over them, then I would like you to sort these in terms of which have contributed the most to your success and positive experiences at Cardinal University, those which have hindered or resulted in a negative experience, and those that have not had an impact or you have not experienced, at Cardinal University as you pursue a STEM degree. Please feel free to add any items to the card provided.

We will then have a discussion for how you view these supporting LGBTQIA students in STEM, and if there are other factors you think impact the experience of LGBTQIA students in STEM at Cardinal University.

Factors at Cardinal University that impact inclusive spaces and success in mathematics

- Presence of other Queer-spectrum students
- Availability of LGBT clubs or resources
- Availability of STEM clubs or resources
- Use of pronouns in classes
- Representation of Queer faculty in STEM
- Opportunities to learn about LGBT issues and terminology
- Location of university in [City, State]
- Opportunities for undergraduate research
- Availability of lab or breakout sections with TAs
- Ability to ask questions or seek advice from faculty
- Class size and format of Math course
- Availability of gender neutral bathrooms on campus
- Usefulness of Math learning center
- Hearing slurs or disparaging remarks (e.g., that's so gay) on campus
- Availability of safe-spaces on campus to study and hang-out

- Others:

Focus Group Part Three

Reports of LGBTQA student experience in math classrooms

In this part of the focus group, I would like to get your input on findings from surveys with over 1,300 LGBTQA undergraduate students and their description of math classes.

Engagement with peers

1. In thinking about your interactions with other students in your math class, why do you think identifying as LGBTQA results in students reporting working more in small groups?

2. Similarly, why do you think LGBTQA students feel more comfortable in offering constructive criticism of mathematical ideas?

Classroom Environment

1. LGBTQA student describe their math classes as being more hostile and exclusionary compared to straight peers, what do you think contributes to that?

2. Additionally, the greatest levels of exclusion are experienced by individuals who identify as asexual, followed by Queer women (Lesbian) and Queer women of color. What do you think contributes to those groups reporting higher levels of exclusion?

Impact of taking math courses

1. LGBTQA students report less confidence, enjoyment and interest in mathematics at the start of math class and as a result of taking the course? What do you think contributes to LGBTQA students being less confident and interested in math?

2. LGBTQA students report missing more math classes and not wanting to major in STEM. Is this similar to your own experience as you have been pursuing a STEM degree?

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